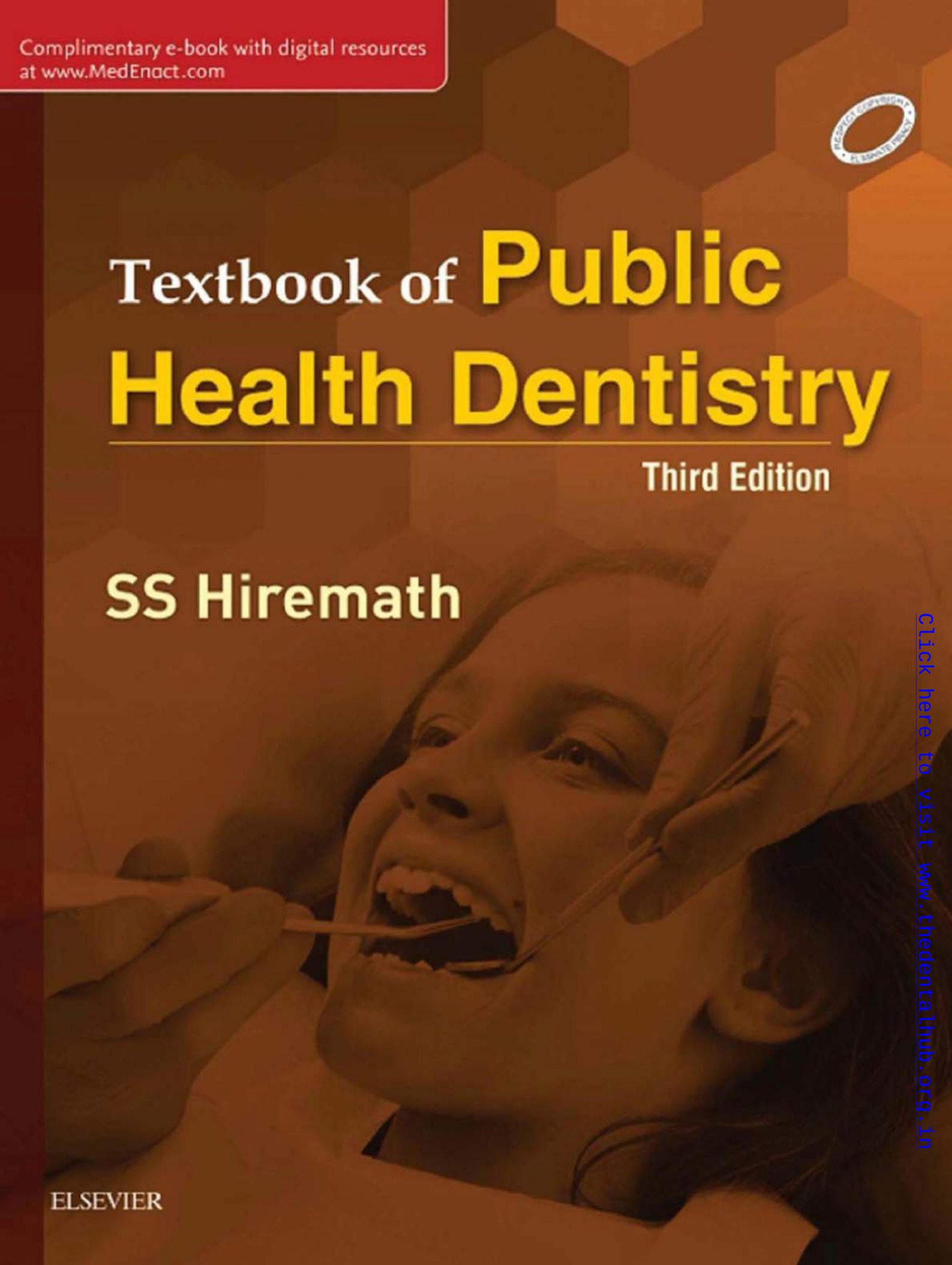
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Textbook of Public Health Dentistry

Third Edition

SS Hiremath



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Textbook of Public Health Dentistry

Third Edition

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Dedicated To

Revered Smt Gangamma Hiremath

"The soul that showered her energy
to bring me to life and protected me
throughout; the one with unsparing
moment cared me all through
to see what I am today."

(Reminiscing my mother to pay tribute to her on the occasion)

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Foreword

Dr RK Bali BDS (Pb), MPH (USA), DSc (H.C)
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I have a great pleasure in introducing and writing forward of this textbook.

A textbook covering a wide spectrum of topics in Public Health Dentistry is very much needed by the students and is valuable too. This speciality in dentistry encompasses several disciplines of General Public Health, Dental Public Health and Preventive dentistry, including Research methodology in keeping with the interest of the readers and syllabus of Dental Council of India. This textbook focuses on relevant topics of Public Health Dentistry.

The contributors have focused their attention on the basics and advanced aspects of every component of the practice of Public Health Dentistry. They have done full justice in providing authenticated and updated information of easy understanding. There is a much needed textbook of Public Health Dentistry for undergraduate students to provide a simplified version of the various components of the subject. I am sure it will be very useful and interesting to both teachers and students.

I have known Dr SS Hiremath for more than two decades, in fact ever since he has been involved in active teaching. Dr Hiremath is a committed and sincere amalgam of an inspiring teacher and above all a thorough gentleman. I strongly believe that he has done ample justice, along with other contributors, for this edition of the textbook.

I am sure this textbook has immense potential to become a standard and useful textbook for graduate and postgraduate students in India.

I congratulate Dr Hiremath and his good team of the contributors for bringing out this beautiful publication.



Dr RK Bali

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Preface to the Third Edition

The third edition of this book is aptly named *Textbook of Public Health Dentistry* and includes significant expansion and revision of the second edition.

The book consists of four parts, namely Public Health, Dental Public Health, Preventive Dentistry and Research Methodology and Biostatistics, keeping in view of recent policies, programs and concepts within the framework of syllabus prescribed by Dental Council of India.

Part 1 deals with various aspects of Public Health providing sound basis for the understanding of dental public health. The chapter on Concepts of Health and Disease and Prevention provides an insight into various concepts of health and disease which is essential for understanding prevention. As per Galen, health precedes disease and this statement holds good as long as we practice preventive medicine or dentistry. Sustainable Development Goals (SDG) have been added.

Epidemiology is the basic science of public health. Epidemiology with its principles, approaches and methods helps in better understanding of disease in terms of time, place and person, tests causal association if any. The contribution of epidemiology has been immense in the practice of medicine.

The impact of environment on health is a subject of debate at international forums. Man-made activities, globalization, urbanization and industrialization no doubt have made advances in economic and technological front but has caused significant impact on the environment and, in turn, on health. Environmental health hazards are recognized, similarly need for pollution control and waste disposal. The current edition has taken into account these issues during the revision.

Health education in Part 1 discusses on principles, levels and approaches whereas oral health education focuses on educational theories, models and concepts of oral health education with brief note on oral health education programs.

The 30th World Health Assembly of World Health Organization came out with a landmark resolution of "Health for All by 2000" which was reaffirmed at Alma Ata Conference in 1978. It was resolved that primary health care was the means to achieve this goal. The chapter on Primary Health Care unfolds core activities, strategic imperatives and discusses practical problems with the implementation of primary health care. India is a signatory of Alma Ata Declaration, and its efforts in this direction are emphasized.

Since independence, the Government of India has undertaken many health initiatives and one amongst these initiatives are national health programs. These programs are based on public health problems in India and launched with co-operation and technical assistance from international agencies. The chapter on National Health Programs gives a concise account of various current programs operating in India.

The chapters on International and National Health Agencies has been systematically updated keeping in mind its contributions for the betterment of humanity at large.

The chapter on Hospital Administration has been thoroughly revised highlighting the nuances of administration in a hospital set-up with an emphasis on medico-legal aspects are discussed.

Successful practice of public health needs a thorough understanding of social and behavioural sciences. The chapter of Behavioural Sciences has been revised comprehensively covering components, scope and use of behavioural sciences with emphasis on sociology, psychology and anthropology.

Part 2 deals with various aspects of Dental Public Health and helps students to understand subject in this discipline of dentistry. In the chapter, Introduction to Dental Public Health, history of dentistry followed by aims and objectives and scope of dental care is discussed. Historically, dental public health made its beginning in the later part of 18th century and became a specialty in midpart of 20th century. Dental public health is relevant to all aspects of dental care, from the assessment of need through the development of care, to the evaluation of treatment.

The chapters on Epidemiology of Dental Caries, Periodontal Diseases and Oral Cancer throw light on classical studies, descriptive data on these diseases.

Food has been linked with health and disease for centuries. Diet and nutrition form cornerstone of health promotion measures. The chapter on Nutrition and Oral Health deals with nutrients and its effect on oral health and methods of assessment and counseling.

The chapter on Surveying and Oral Health Surveys provides step-by-step description of conducting a survey and emphasizes on basic oral health survey methodology developed by WHO to bring about uniformity in data collection, which has undergone lot of modifications since 1971 and continues to guide policy makers, administrators and planners in the assessment of oral health status and monitoring over a period of time. This includes features of 1997 as well as 2013 proforma.

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Measurement of a disease helps in quantification and also enables comparisons with other populations and over time. The chapter on Indices has been meticulously reviewed considering the properties, purposes and objectives of indices in general followed by detailed discussion on most commonly used indices in oral epidemiology.

Traditionally, payment has been fee for service two party system. The chapter on Financing Dental Care has been revised systematically. It deals with structure of dental practice followed by various methods of financing dental care. Payment in Indian scenario is also reviewed.

Dental needs and resources play a vital role in planning oral health programme. The chapter on Dental Needs and Resources discusses Bradshaw's concept of needs, types of need, demand for treatment, manpower and scope of service that can be rendered.

School health service forms a priority service in most of the countries. However oral health is often overlooked in developing countries. The chapter on School Dental Health Programmes deals with different aspects of school dental health programs, with emphasis on school-based preventive programs, health promoting schools and evaluation of such programs.

Practice of dentistry not only needs technical skills but also administrative skills. One should be aware of law of land that regulates dental practice. Similarly duties and obligations towards patients, colleagues and community should be inculcated during the training period. Chapter on Dental Practice Management includes concept of dental ergonomics. Similarly the chapters on Ethics in Dentistry, Dentist Act, DCI and IDA, and Consumer Protection Act have been updated comprehensively.

Dental examination has been critical determinant in the search of identity of individual human remains. The chapter on Forensic Odontology deals with forensic (legal) aspect of dentistry tracing the history and highlighting the principles and methods of dental identification with relevant description.

Part 3 deals with preventive dentistry, an important tool of public health. Introduction to Preventive Dentistry provides concepts and principles and scope of preventive dentistry.

A chapter on Dental Caries deals with aetiology, theories and concepts, types of caries, role of microbes and saliva in caries process. However, most of the evidence points towards role of diet (refined carbohydrates). Hence diet and dental caries has been dealt in detail linking diet and dental caries, sugars and sugar substitutes and dietary counseling.

Various methods have been developed to assess caries risk and caries activity. The chapter on Caries Risk assessment has been updated with relevant caries risk assessment tools which helps in identifying patients at risk and manage appropriately. The scope and prospects of developing caries vaccine has been explored in the chapter on Caries Vaccine.

Fluoride has been cornerstone of Preventive Dentistry since 1940s. Systemic and topical fluorides have been effective in reducing the incidence of dental caries. The chapter on Fluorides provides insight into various aspects of Fluorides including dental fluorosis and defluoridation whereas A Global Perspective on Application of Fluoride Technology gives current global scenario of fluorides considering various systemic and topical fluorides and importance on developing policy on fluoride.

Newer methods and techniques are incorporated in the discipline of preventive dentistry. Minimal Intervention Dentistry has revolutionalised the management of dental caries. Pit and Fissure Sealants, Preventive Resin Restoration, Minimal Invasive Dentistry have changed our outlook, and procedures are more biological. Similarly, development of Atraumatic Restorative Treatment (ART) has proved to be a boon in developing and underdeveloped countries in the management of dental caries, especially for disadvantaged populations. Recent advances in concepts and approaches are added as required.

Greek historian Erasmus has stated 'Prevention is better than cure' and also a saying goes "an ounce of prevention is better than pound of treatment". Separate chapters on Prevention of Dental Caries, Periodontal Disease, Dental Trauma and Malocclusion give an account of different methods and approaches available for prevention of these diseases. Prevention of Dental Caries has been meticulously revised with a practical perspective.

Occupational Hazards in Dentistry deal with different types of hazards and their management. The chapter on Infection Control in Dental Care Setting is revised highlighting about the importance of infection control and guidelines to control.

Part 4 provides insight into research methodology and biostatistics. Different types of design, ethical consideration, presentation, analysis and interpretation of data are discussed.

Appendices include useful definitions and glossary, case history proforma, WHO oral health assessment forms (1997 and 2013), facts and figures on fluoride and tobacco and other useful information.

Some of the topics contributed by highly experienced colleagues from other dental institutions bring greater depth to the subject. This book deliberately takes a broader perspective of Public Health Dentistry.

I am quite confident and sincerely hope this book will continue to serve like a useful text not only for undergraduates, interns, postgraduates but also for dental public health professionals for whom it is intended.

SS Hiremath

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Preface to the First Edition

Preventive and Community Dentistry forms the cornerstone of dental education and oral health promotion. A need was felt since long for a comprehensive book which can provide a broad perspective on the challenges in the delivery of oral health care to the community and in planning appropriate strategies to meet those challenges. This book attempts to fulfill this need.

Based on the syllabus prescribed by Dental Council of India, the book covers various aspects of public health, dental public health, preventive dentistry and research methodology. It discusses all the topics in a systematic and logical manner and also highlights the changing concepts and contemporary issues in the field. In particular, the discussion of Dental caries and Fluorides in preventive dentistry is quite exhaustive and also includes the relevant recent advances and innovations. Suitable tables, flowcharts, diagrams and photographs are included throughout the book for an easier understanding of the subject.

An important feature of the book is the inclusion of additional chapters on Forensic dentistry, Hospital administration, Occupational hazards, Nutrition and oral health, Minimal intervention dentistry and Dental practice management. These chapters are vital for a richer understanding of community dentistry and I sincerely hope that both students and teachers find them equally useful.

Further, some useful information like facts about tobacco, fluorides and clinical case proforma are included separately under the Appendices. All these features make the book quite comprehensive in scope and contemporary in approach.

Prevention of dental diseases is possible, but a great deal has to be done to achieve it. For this goal to become a reality, a rigorous implementation of the preventive dentistry is a must. Therefore, the role of preventive dentistry is crucial for sound oral health. Keeping this in mind, a sincere effort has been made in this book to cover the whole spectrum of preventive practice at both individual and community levels.

Several practitioners and academics have contributed to this book. They are all experts in their respective areas and have earnestly striven to produce a stimulating and up-to-date account of the basic concepts in community and preventive dentistry.

I sincerely hope that this book serves as a useful text to undergraduate students, interns, postgraduate and health professionals in preventive and community dentistry. I also hope that I have lived up to the words of Amos Bronson Alcot, "That is a good book which is opened with expectations, and closed with delight and profit."

SS Hiremath

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Acknowledgements

At the outset, I would like to express my gratitude to a lot of people without whose involvement (in this venture), my book would not have been available now.

Two very distinguished academic personalities viz Dr BK Venkataraman, formerly Principal Government Dental College, Bengaluru and Dr S Ramanand Shetty, Hon'ble Vice-Chancellor, Rajiv Gandhi University of Health Sciences, Karnataka showed their loving interest in my academic career. I express my gratitude to both of them while I prepare the present work for publication.

I mention with love the encouragement of Dr RK Bali, the Former President, Dental Council of India and the President Emirates of Indian Association of Public Health Dentistry to my work in the field of Public Health Dentistry. I am immensely thankful to him for writing the nice foreword for this textbook.

And a few distinguished great teachers like Dr Dara S Amar, Dr Shivaram, Dr MR Shankar Aradhya have been with me to give useful suggestions and guidance while the project was through deserve my sincere thanks. My sincere gratitude to Dr Pruthvish, Dr Jayant Kumar, Dr Amit Chattopadhyay, Dr Narendernath, Dr Astha, Dr Nanda Kumar, Dr Shivraj, Dr Vijaya Prakash Mathur and Dr Vartika Kathuria Monga, join the above contributors to make the book verily academic.

I am privileged to have a thorough co-operation and understanding from Dr Manjunath Puranik, and Dr Pushpanjali who joined my project of this book writing so willingly from the beginning of first edition of this book. They remained a strong source of moral support to me throughout the development of project. I must express my heartfelt thanks to them.

My work depended on making available the suitable source material on various details of subjects and updating which was undertaken by Dr Ramya and Dr Sushi. They did this job so happily and gave me unconditional support for my project. They must be warmly congratulated and thanked.

Editing and reviewing of a work is painstaking; a great responsibility too. Dr Anitha, Dr Archana, Dr Sowmya, Dr Priyadarshini, Dr Sakeena, Dr Shilpasree, Dr Shabana, Dr Shwetha, Dr Renuka Piddennavar and Dr Randheer showed great patience in helping me to properly manage the task on hand. A heartfelt thanks to all of them.

At the same time I wish to recognise and appreciate the support extended by postgraduate students Dr Sonali, Dr Ankita, Dr Madhushree, Dr Malavika, Dr Vaibhav Gupta and Dr Sneha Shenoy. My special thanks are due to them.

Reviewing and updating material in the growing field like Dental science is challenging to keep track. Dr Naveen, Dr Fareed, and Dr Jagannath made my work more authentic. Hearty thanks to all of them.

At this juncture I should necessarily recall the staff co-operation from the Department of Preventive and Community Dentistry, Government Dental College and Research Institute, Bengaluru. Especially, Dr Yashoda R Dr Namitha Shanbhag, Dr Uma SR, and Postgraduate students Dr Shailee and Dr Ashwini Biradar who all provided continuous support to my previous work. My grateful thanks to all of them.

A great sense of appreciation and thanks overwhelms me when I remember Dr Gurmukh and Dr Kevin PG student, for their unstinted support and help rendered during the preparation of the manuscript.

I wish to remember the academic support of Dr Manjunath R, Dr Sadanand, Dr Manjunath C, Dr Sangeetha and Dr Utkal whose participation in preparing the earlier text was a labour of love. My thanks are due to them.

I wish to congratulate and thank the dynamic publisher, RELX India Pvt. Ltd. for associating with my academic activity. In this connection, least I would not forget, I must place on record the services of Ms Nimisha Goswami, Manager–Content Strategist, Mr Anand Jha, Project Manager–Medicine and Dentistry, and Goldy Bhatnagar, Sr Content Development Specialist, for their wonderful coordination while editing the manuscript of the book. Sincere thanks and great appreciations to all of them.

From the family Dr RS Hiremath, my eldest brother deserves a special mention when my book will be ready for publication. It is with reverence and absolute love, I remember Dr RS Hiremath for making me achieve so much in life.

Speaking of my family, Umadevi my wife and children Dr Suman Bharat Kumar (USA) and Mr Gurudev Hiremath (USA) must be mentioned particularly because their love and total support to me while I was engaging myself in this stupendous task of writing the book were unique. They deserve my special thanks.

It is one occasion that calls for expressing my deepest feelings of respect to all those professional colleagues, friends and other well-wishers who at several stages of my work encouraged and gave suggestions to me and that was my good fortune. Hence, all such persons must be thanked at this moment. My sincere thanks to all of them, a duty on my part.

Motivation to my work happens to be the almighty god whose kindness was my experience throughout the project. For such a shower of blessings from the unique force, I remain devoted.

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1

Concepts of Health and Disease and Prevention

Manjunath P Puranik

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INTRODUCTION

Health is a common concern in most communities. In fact, all communities have their concepts of health as a part of their customs and traditions. Health continues to be a neglected issue despite hypocrisy.

Of late health has been considered as a fundamental right. Health is indispensable to the fulfilment of basic human needs and for better quality of life. Health-related quality of life has been used to measure the effects of numerous diseases, disorders, disabilities, in diverse populations. This approach can identify subgroups with poor physical or mental health and help to direct policies or programmes to improve their health.

Traditionally health has been considered as an absence of the disease and if someone was free from disease, then that person was considered healthy. This concept is known as biomedical concept, and it has a basis in the "germ theory of the disease." Moreover, modern medicine is preoccupied with the study of disease and its complications, but neglect the study of health and healthy status. Due to this, our ignorance about health and healthy status still continues to exist. Unfortunately there is no single yardstick either for assessing or measuring health.

CHANGING CONCEPTS OF HEALTH

Health is perceived in different ways giving rise to various concepts of health (Box 1.1).

Box 1.1 Changing Concepts of Health

1. Biomedical concept
2. Ecological concept
3. Psychological concept
4. Holistic concept

Biomedical Concept

As per this concept, health means "absence of disease." In this concept human body is considered as a machine and the outcome that is the breakdown of the machine is compared to disease. The doctor is responsible for the repair of the machine. Developments in medical and social sciences led to the conclusion that the biomedical concept of health was inadequate.

Ecological Concept

Health is perceived as a dynamic equilibrium between man and his environment, and maladjustment of the man to environment is disease. Ecological and cultural adaptations determine the occurrence of disease, availability of food and the population dynamics.

Psychosocial Concept

Health, besides being a biomedical phenomenon, is also influenced by social, psychological, cultural, economic and political factors of the people concerned. Thus health is biological as well as psychosocial phenomenon.

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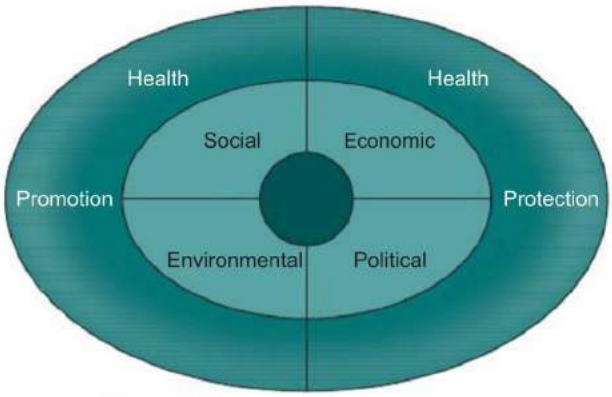


Figure 1.1 Holistic concept of health.

Holistic Concept

This concept considers the influence of social, economic, political and environmental factors on health and wellbeing (Fig. 1.1). Holistic concept is an integrated or multidimensional process involving the wellbeing of the human being as a whole in context of his or her environment. The emphasis is on the health promotion.

DEFINITIONS OF HEALTH

World Health Organization (WHO) definition of health has been considered for a clear understanding of health.

WHO Definition—1948

"Health is a state of complete physical, mental and social wellbeing and not merely an absence of disease or infirmity."

In the past few decades, this definition has been supplemented by "the ability to lead a socially and economically productive life." WHO definition of health provides a dynamic concept. It refers to a condition that may exist in some individuals but not in everyone all the time; it is not usually observed in groups of human beings and in communities. The concept of health as defined by WHO is broad and positive in its implications; it sets the standard of "positive" health. It represents the aspirations of people and characterizes an overall objective or goal towards which countries should strive.

Operational Definition of Health

To enable direct measurement, a WHO study group viewed health as being of two orders. *In a broad sense*, health can be seen as "a condition or quality of the human organism expressing the adequate functioning of the organism in given conditions, genetic or environmental." *In a narrow sense*, health means: (a) there is no obvious evidence of disease, and that a person is functioning normally, and (b) several organs of the body are functioning adequately themselves and in relation to one another, which implies a kind of equilibrium or homeostasis.

New Philosophy of Health

A new philosophy of health has emerged, of late. It is felt that health is a fundamental human right and a worldwide social goal. It is the essence of productive life. Health is intersectoral and involves individuals, state and international responsibility. Health and its maintenance are a major social investment and an integral part of development and is central to the concept of quality of life.

DIMENSIONS OF HEALTH

Health is multidimensional. Although these dimensions are interrelated, each has its own nature (Fig. 1.2).

Physical Dimension

Physical dimension implies the concept of "perfect functioning" of the body. It considers health as a state in which every cell and every organ are functioning at optimal capability and in perfect harmony with the body.

Mental Dimension

Mental health is the capability to respond to many diverse experiences of life with a sense of purpose. It has been defined as "a state of balance between the individual and the surrounding world, a state of harmony between oneself and others, coexistence between the realities of the self and that of other people and that of the environment."

Social Dimension

In social wellbeing there exists harmony and integration with the individual, between each individual and other members of society, and between individuals and the world in which they live. It has been defined as the "quantity and quality of an individual's interpersonal ties and the extent of involvement with the community."

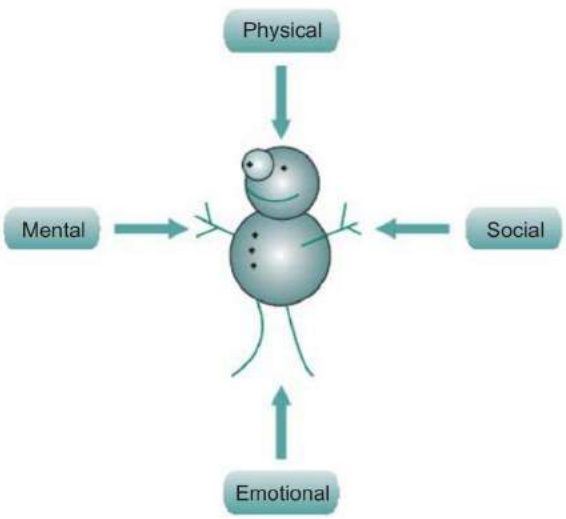


Figure 1.2 Dimensions of health.

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Spiritual Dimension

It is that part of the individual that strives for meaning and purpose in life. It is the intangible "something" that transcends physiology and psychology.

Emotional Dimension

Emotional health relates to "feeling." This dimension reflects emotional aspects of humanness.

Vocational Dimension

Occupation plays an important role in enhancing both physical and mental health. Physical work is frequently associated with an improvement in physical capability. Achievements and self-realization in work are a basis of gratification and enhanced self-esteem.

Others

A few other dimensions have also been suggested such as philosophical dimension, cultural dimension, socioeconomic dimension, environmental dimension, educational dimension, nutritional dimension and so on.

CONCEPT OF WELLBEING

"Wellbeing" of an individual or groups has objective and subjective components. The objective components are "standard of living" or "level of living." The subjective component of wellbeing is the "quality of life (Box 1.2)."

Standard of Living

As per WHO, "Income and occupation, standards of housing, sanitation and nutrition, the level of provision of health, educational, recreational and other services may all be used individually as measures of socioeconomic status, and collectively as an index of the 'standard of living'."

Level of Living

As per United Nations documents "level of living" consists of nine components: health, food consumption, education, occupation and working conditions, housing, social security, clothing, recreation and leisure and human rights.

Quality of Life

Quality of life as defined by WHO, "The condition of life resulting from combination of the effects of the complete range of factors such as those determining health, happiness (including comfort in the physical environment and a satisfying occupation), education, social and intellectual attainments, freedom of action, justice and freedom of expression."

Physical Quality of Life Index

Physical Quality of Life Index (PQLI) includes three indicators such as infant mortality, life expectancy at age one and literacy. These three components measure the results rather than inputs. For each component, performance of individual countries is measured on a scale of 0 to 100, where 0 corresponds to an absolutely defined "worst" performance, and 100 represents an absolutely defined "best" performance. PQLI measures the results of social, economic and political policies.

Human Developmental Index

Human Developmental Index (HDI) includes longevity (life expectancy at birth), knowledge (adult literacy rate and mean years of schooling) and income (real GDP per capita in purchasing power parity in US dollars). The HDI value ranges from 0 to 1.

Box 1.2 Concept of Wellbeing

1. **Standard of living**
2. **Level of living**
3. **Quality of life**
4. **Physical quality of life index**
5. **Human developmental index**

SPECTRUM OF HEALTH

This concept of health emphasizes that health of an individual is a dynamic phenomenon and a process of continuous change, subject to repeated, fine variations (Fig. 1.3). Transition from optimum health to ill health is often gradual, and where one state ends and other begins is a matter of judgment. Different stages are positive health, better health, freedom from sickness, unrecognized sickness, mild sickness, severe sickness and death (Box 1.3).

DETERMINANTS OF HEALTH

Health is influenced by multiple factors (Box 1.4 and Fig. 1.4) that lie both within the individual and externally. Genetic factors and environmental factors interact, and the result may be health promoting or otherwise.

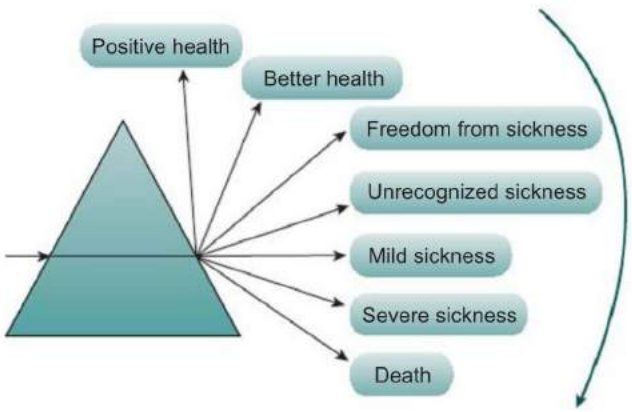


Figure 1.3 Spectrum of health.

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Box 1.3 Spectrum of Health

6. **Severe sickness**
7. **Death**

Box 1.4 Determinants of Health

1. **Biological determinants**
2. **Behavioural and sociocultural conditions**
3. **Environmental factors**
4. **Socioeconomic conditions**
5. **Health services**
6. **Ageing of population**
7. **Gender**
8. **Other factors**



Figure 1.4 Determinants of health.

Biological Determinants

Physical and mental traits of human beings are to some extent determined by the nature of the genes at the time of conception. The state of health therefore depends partly on the genetic constitution of man or woman and his or her relationship with his environment—an environment that transforms genetic potentialities into phenotypic realities.

Behavioural and Sociocultural Conditions

Health requires promotion of healthy lifestyle. Evidence indicates that there is an association between health and lifestyle of individuals. Modern health problems especially in the developed countries and in developing countries are mainly due to changes in lifestyles. Healthy lifestyle includes adequate nutrition, enough sleep, sufficient physical activity, etc. Health is a result of an individual's lifestyle and a factor in determining it.

Environmental Factors

Environment has a direct influence on the physical, mental and social wellbeing of those living in it. Environmental factors range from housing, water supply, psychosocial stress and family structure through social and economic support systems to the organization of health and social welfare services in the community.

Socioeconomic Conditions

Socioeconomic conditions such as the following influence health:

- *Economic status:* Economic situation in a country is an important factor in morbidity, increasing life expectancy and improving quality of life, family size and pattern of disease and deviant behaviour in the community.
- *Education:* Illiteracy correlates with poverty, malnutrition, ill health, high infant and child mortality rates. Education, to some extent, neutralizes the effects of poverty on health, irrespective of health facilities.
- *Occupation:* Productive work provides satisfaction, promotes health and improves quality of life.
- *Political system:* This can shape community health services by taking timely decisions relating to resource allocation, human resources policy, choice of technology and the degree at which health services are made available and accessible to different sections of the society.

Health Services

The purpose of health services is to improve the health status of population. Health services must reach the masses, be distributed equitably, be socially acceptable and be economically accessible. Health services can also be seen as essential for social and economic development. The health services, no matter how technically elegant or cost-effective, are ultimately relevant only if they improve health.

Ageing of the Population

A major concern of rapidly ageing population is increased prevalence of chronic diseases and disabilities that deserve special attention.

Gender

Women's health is gaining importance in areas such as nutrition, reproductive health, health consequences of violence, ageing, lifestyle related conditions and the occupational environment. Policy makers are aware of women's health issues, and encourage their inclusion in all development.

Other Factors

Information and communication technology provides instant access to medical information serving the needs of many health professionals, biomedical researchers and the public. Similarly intersectoral coordination and adoption of policies in the economic and social fields influence health.

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RESPONSIBILITY FOR HEALTH

Health involves joint efforts of the individual, the community, the state and at the international level to protect and promote health (Box 1.5).

Individual Responsibility

Health is essentially an individual responsibility one has to earn and maintain by oneself, must accept the responsibilities, known as "self-care." It refers to those activities that individuals carry out in promoting their own health, preventing their own disease, limiting their own illness and restoring their own health. These activities are undertaken without professional assistance, although individuals are informed by technical knowledge and skills.

Community Responsibility

This needs a more active participation of families and communities in planning, implementation, utilization, function and evaluation of health services. Emphasis has shifted from health care for the people to health care by the people. Community can participate by providing facilities, manpower, logistic support and possible funds and actively involving in planning, management and evaluation, and by using the health services.

State Responsibility

State assumes responsibility for health and welfare of its citizens. Constitution of India states that health is a State responsibility. India is also signatory to the Alma Ata Declaration of 1978. As a result there is a greater degree of state involvement in management of health services, and establishment of nationwide systems of health services with emphasis on primary health care approach.

International Responsibility

Cooperation of governments, people, national and international organizations both within and outside the United Nations in achieving health goals is the need of the hour.

Eradication of smallpox, "Health for All" goals and movement against smoking and AIDS are a few initiatives reflecting international responsibility for control of disease and promotion of health.

Box 1.5 Responsibility for Health

1. **Individual responsibility**
2. **Community responsibility**
3. **State responsibility**
4. **International responsibility**

INDICATORS OF HEALTH

As per WHO guidelines, indicators are *variables* that help to measure changes. Indicators should be valid, reliable and objective, sensitive, specific, feasible and relevant. But few indicators comply with all these criteria. Therefore, measurements of health have been made in terms of illness (or lack of health), the consequences of ill health (e.g. morbidity, disability), and economic, occupational and domestic factors that promote ill health. The indicators are given in Box 1.6.

Box 1.6 Indicators of Health

1. **Mortality indicators**
2. **Morbidity indicators**
3. **Disability rates**
4. **Nutritional status indicators**
5. **Health care delivery indicators**
6. **Utilization rates**
7. **Indicators of social and mental health**
8. **Environmental indicators**
9. **Socioeconomic indicators**
10. **Health policy indicators**
11. **Indicators of quality of life**
12. **Other indicators**

Mortality Indicators

Mortality indicators represent the traditional measures of health status:

- *Crude death rate:* "the number of deaths per 1000 population per year in a given community." A decrease in death rate provides a good tool for assessing the overall health improvement in a population. It is an indirect measure of health status.
- *Expectation of life:* Life expectancy at birth is "the average number of years that will be lived by those born alive into a population if the current age-specific mortality rates persist." An increase in the expectation of life is regarded, inferentially as an improvement in health status. It can be considered as a positive health indicator. It is a global health indicator.
- *Infant mortality rate:* "the ratio of deaths under 1 year of age in a given year to the total number of live births in the same year; usually expressed as a rate per 1000 live births." It is one of the most accepted indicators of health status not only of infants, but also of whole population and of the socioeconomic conditions under which they live.
- *Child mortality rate:* "the number of deaths at ages 1-4 years in a given year, per 1000 children in that age group at the mid point of the year concerned." It is related to insufficient nutrition, low coverage by immunization, adverse environmental exposure and other exogenous agents.
- *Under-5 proportionate mortality rate:* "the proportion of total deaths occurring in the under-5 age group." This rate can be used to reflect both infant and child mortality rates.
- *Maternal (puerperal) mortality rate:* Maternal (puerperal) mortality accounts for the greatest proportion of deaths among women of reproductive age.
- *Disease-specific mortality rate:* Mortality rates can be computed for specific diseases.

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- *Proportional mortality rate:* This estimates the burden of a disease in the community.

Morbidity Indicators

Morbidity indicators supplement mortality data to describe the health status of a population. Morbidity rates are incidence and prevalence, notification rates, attendance rates at outpatient departments, health centres, admission, readmission and discharge rates, duration of stay in hospital and spells of sickness or absence from work or school.

Disability Rates

Disability rates related to illness and injury supplement mortality and morbidity indicators. The commonly used disability rates are: (i) event-type indicators, and (ii) person-type indicators.

- *Event-type indicators:* Number of days of restricted activity, bed disability days and work-loss days (or school loss days) within a specified period.
- *Person-type indicators:* Limitation of mobility and limitation of activity.

Sullivan's index. This index is calculated by subtracting from the life expectancy the probable duration of bed disability and inability to perform major activities, according to cross-sectional data from the population surveys.

HALE (Health-adjusted life expectancy). HALE is based on life expectancy at birth but includes an adjustment for time spent in poor health.

DALY (Disability-adjusted life expectancy). DALY is a measure of the burden of disease in a defined population and the effectiveness of the interventions. DALY expresses years of life lost to premature death and years lived with disability adjusted for the severity of the disability.

Nutritional Status Indicators

Nutritional status is a positive health indicator. It consists of anthropometric measurements of preschool children (e.g. weight and height, mid-arm circumference), heights and weights of children at school entry and prevalence of low birth weight (less than 2.5 kg).

Health Care Delivery Indicators

Includes doctor–population ratio, doctor–nurse ratio, population–bed ratio, population per health/subcentre and population per traditional birth attendant.

Utilization Rates

Utilization of services, or actual coverage, is expressed as the proportion of people in need of a service to who actually receive it in a given period, usually a year. It gives some indication of the care needed by a population. Therefore it indicates the health status of the population such as immunization, antenatal care, deliveries supervised by a trained birth attendant, methods of family planning and utilization of inpatient facilities, etc.

Indicators of Social and Mental Health

Indirect measures, such as indicators of social and mental health are used. Suicide, homicide, other acts of violence and other crime, road traffic accidents (RTA), juvenile delinquency, alcohol and drug abuse, smoking, consumption of tranquillizers, obesity, are some indicators.

Environmental Indicators

These reflect the quality of physical and biological environment in which the people live and where diseases occur. Indicators relating to pollution of air and water, radiation, solid wastes, noise, exposure to toxic substances in food or drink, etc. are included.

Socioeconomic Indicators

These are indirect indicators of health. Population increase, per capita GNP, level of unemployment, dependency ratio, literacy rates, especially female literacy rates, family size, housing: the number of persons per room and per capita "calorie" availability are included.

Health Policy Indicators

Political commitment is reflected by "allocation of adequate resources." Proportion of gross national product (GNP) spent on health services, health-related activities and proportion of total health resources devoted to primary health care are some of the indicators.

Indicators of Quality of Life

Attention has shifted more towards concern about the quality of life enjoyed by individuals and communities. The physical quality of life index is one such index.

Other Indicators

- *Social indicators:* Social indicators, as defined by the United Nations Statistical Office, have been divided into 12 categories: population; family formation, families and households; learning and educational services; earning activities; distribution of income, consumption and accumulation; social security and welfare services; health services and nutrition; housing and its environment; public order and safety; time use; leisure and culture and social stratification and mobility.
- *Basic needs indicators:* Basic needs indicators used by ILO, include calorie consumption; access to water; life expectancy; deaths due to disease; illiteracy, doctors and nurses per population; rooms per person; GNP per capita.
- *"Health for All" ndicators:* For monitoring progress towards the goal of "AD Health for All by 2000" by the WHO.
- *Millennium development goal indicators:* Millennium development goal adopted by the United Nations in the

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year 2000 has provided an opportunity for concerted action to improve global health.

HEALTH SERVICE PHILOSOPHIES

Health Care

Health care is defined as "a multitude of services rendered to individuals, families or communities by the agents of health services or professions, for the purpose of promoting, maintaining, monitoring or restoring health." Health care should be appropriate, comprehensive, adequate, available, accessible, affordable and feasible. It can be delivered by appropriate planning of health systems with the aim of health development. Health systems are based on contemporary ideas and concepts and available resources.

Levels of Health Care (Fig. 1.5)

Primary health care. It is the first level of contact between the individual and the health system where essential or primary health care is rendered.

Secondary health care. More complex problems are dealt with. This care comprises curative services that are provided by the district hospitals and community health centres. It is the first referral level in the health system.

Tertiary health care. Super specialist care is provided by regional/central level institutions. These institutions provide planning and managerial skills and teaching for specialized staff. In addition, tertiary level supports and complements the actions carried out at the primary level.

Health Team Concept

Practice of modern medicine has become a team of many groups of workers, both professional and non-professional such as physicians, nurses, social workers, health assistants, trained *dais*, village health guides and nongovernmental organizations (NGOs).

Health team has been defined as "a group of persons who share a common health goal and common objectives, determined by community needs and toward the achievement of which each member of the team contributes in accordance to her/his competence and skills, and respecting the functions of the other."

The auxiliary is an essential member of the team. Many functions of the physician can be performed by auxiliaries after suitable training. An auxiliary worker has been defined as one "who has less than full professional qualifications in a particular field and is supervised by a professional worker."

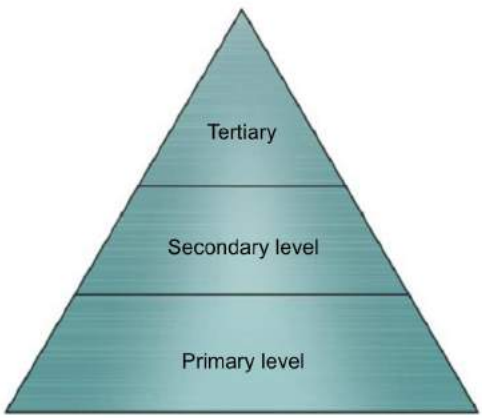


Figure 1.5 Levels of health care.

Health for All

There was a growing concern about the unacceptably low levels of health status of the majority of the world's population, especially the rural poor and the gross disparities in health between the rich and poor, urban and rural population, both between and within countries.

In May 1977, World Health Assembly declared that the main social goal of governments and WHO in the coming years should be the "attainment by all the people of the world by the year 2000 AD of a level of health that will permit them to lead a socially and economically productive life." This goal has come to be popularly known as "Health for all by the year 2000."

The important principle in this concept is "equity in health," which means all people should have an opportunity to enjoy good health.

Primary Health Care

The concept of primary health care came into limelight in 1978 following an international conference in Alma Ata, erstwhile USSR. It has been defined as:

"Essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and the country can afford to maintain at every stage of their development in the spirit of self-determination."

Primary health care approach is based on principles of social equity, nationwide coverage, self-reliance, intersectoral coordination and people's involvement in the planning and implementation of health programmes in pursuit of common health goals.

Elements

- Education about prevailing health problems and methods of preventing and controlling them
- Promotion of food supply and proper nutrition
- An adequate supply of safe water and basic sanitation/maternal and child health care, including family planning
- Immunization against infectious diseases
- Prevention and control of endemic diseases
- Appropriate treatment of common diseases and injuries
- Provision of essential drugs.

The concept of primary health care involves a concerted effort to provide the rural population of developing countries with at least minimum of primary health care services. Government of India being signatory to

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Alma Ata declaration has pledged itself to provide primary health care.

Millennium Development Goals

The Millennium Development Goals (MDGs) are eight goals to be achieved by 2015 that address to the world's main development challenges. The MDGs are drawn from the actions and targets enlisted in the **Millennium Declaration** which was adopted by 189 nations and was signed by 147 heads of state and governments during the **UN Millennium Summit** in September 2000.

The eight MDGs can be broken down into **21 quantifiable targets** that are measured by **60 indicators**.

Goal 1: Eradicate extreme poverty and hunger
Goal 2: Achieve universal primary education
Goal 3: Promote gender equality and empower women
Goal 4: Reduce child mortality
Goal 5: Improve maternal health
Goal 6: Combat HIV/AIDS, malaria and other disease
Goal 7: Ensure environmental sustainability
Goal 8: Develop a global partnership for development

The MDGs:

- Synthesize, in a single package, many of the most important commitments made separately at the international conferences and summits of the 1990s;
- Recognize explicitly the interdependence between growth, poverty reduction and sustainable development;
- Acknowledge that development rests on the foundations of democratic governance, the rule of law, respect for human rights and peace and security;
- Are based on time-bound and measurable targets accompanied by indicators for monitoring progress and
- Bring together, in the eighth goal, the responsibilities of developing countries with those of developed countries, founded on a global partnership endorsed at the International Conference on Financing for Development in Monterrey, Mexico in March 2002, and again at the Johannesburg World Summit on Sustainable Development in August 2002.

Indicators

Target 1.A: Reduce by half, the proportion of people living on less than $1 a day
Target 1.B: Achieve full and productive employment and decent work for all, including women and young people
Target 1.C: Reduce by half the proportion of people who suffer from hunger
Target 2.A: Ensure that all boys and girls complete a full course of primary schooling
Target 3.A: Eliminate gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015
Target 4.A: Reduce by two-thirds the mortality rate among children under five
Target 5.A: Reduce by three-quarters the maternal mortality ratio
Target 5.B: Achieve, by 2015, universal access to reproductive health
Target 6.A: Halt and begin to reverse the spread of HIV/AIDS
Target 6.B: Achieve, by 2010, universal access to treatment for HIV/AIDS for all those who need it
Target 6.C: Halt and begin to reverse the incidence of malaria and other major diseases
Target 7.A: Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources
Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss
Target 7.C: Reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation
Target 7.D: Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020
Target 8.A: Develop further an open, rule-based, predictable, nondiscriminatory trading and financial system
Target 8.B: Address the special needs of the least developed countries
Target 8.C: Address the special needs of landlocked developing countries and small island developing states (through the Programme of Action for the Sustainable Development of Small Island Developing States and the outcome of the twenty-second special session of the General Assembly)
Target 8.D: Deal comprehensively with the debt problems of developing countries through national and international measures in order to make debt sustainable in the long term

Implementation of the MDGs

In 2001, UN Secretary General presented the Road Map Towards the Implementation of the United Nations Millennium Declaration, an integrated and comprehensive overview of the situation, outlining potential strategies for action designed to meet the goals and commitments of the Millennium Declaration.

In 2002, the annual report focused on progress made in the prevention of armed conflict and the treatment and prevention of diseases, including HIV/AIDS and malaria. In 2003, emphasis was placed on strategies for development and strategies for sustainable development. In 2004, it was on bridging the digital divide and curbing transnational crime. In 2005, the Secretary General prepared the first comprehensive five-yearly reports on progress towards achieving the MDGs. The report reviews the implementation of decisions taken at the international conferences and special sessions on the least developed countries, progress on HIV/AIDS and financing for development and sustainable development.

Sustainable Development Goals (SDG)

On 25 September 2015, the United Nations (UN) General Assembly adopted the new development agenda "transforming our world: the 2030 agenda for sustainable development." The new agenda is of unprecedented scope and ambition, and applicable to all countries.

Sustainable development goals comprise a broad range of economic, social and environmental objectives, as well as offering the promise of more peaceful and inclusive societies. The 17 goals and 169 targets, including one specific goal for health with 13 targets, have many

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linkages and cross-cutting elements, reflecting the integrated approach that underpins the SDGs.

The 17 SDGs

1. End poverty in all its forms everywhere
2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture
3. Ensure healthy lives and promote wellbeing for all at all ages
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. Achieve gender equality and empower all women and girls
6. Ensure availability and sustainable management of water and sanitation for all
7. Ensure access to affordable, reliable, sustainable and modern energy for all
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. Reduce inequality within and among countries
11. Make cities and human settlements inclusive, safe, resilient and sustainable
12. Ensure sustainable consumption and production patterns
13. Take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

CONCEPT OF DISEASE

There have been many attempts to define disease. As per Webster's Dictionary, disease is "a condition in which body or health is impaired, a departure from a state of health, an alteration of the human body, interrupting the performance of vital functions."

The term "disease" literally means without ease. Disease (uneasiness) is when something is wrong with body function. "Illness" refers not only to the presence of a specific disease, but also to the individual's perceptions and behaviour in response to the disease, as well as the impact of that disease on the psychosocial environment. "Sickness" refers to a state of social dysfunction.

CONCEPT OF CAUSATION

Discoveries in microbiology superseded various concepts of disease causation which were in vogue, e.g. the supernatural theory of disease, the theory of humours, the concept of contagion and the theory of spontaneous generation.

Germ Theory of Disease

The concept of cause embodied in the germ theory of disease is generally referred to as a **one-to-one** relationship between causal agent and disease. However it is now recognized that a disease is caused by a number of factors, rather than single agent alone.



Epidemiological Triad

Besides the factors relating to the host and agent there are factors which are equally important to determine whether or not disease will occur in the exposed host. This led to broader concept of disease causation of epidemiological triad: agent, host and environment (Fig. 1.6).

Multifactorial Causation

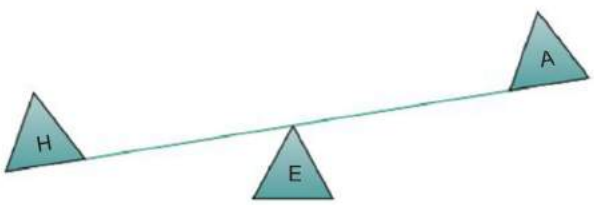
Pettenkofer of Munich (1819–1901) was an early proponent of this concept.

Many diseases neither could be explained on the basis of the germ theory of disease nor could they be prevented by the traditional methods of isolation, immunization or improvements in sanitation. It was realized that social, economic, cultural, genetic and psychological factors are equally important in the etiology of the disease (Fig. 1.7).

The rationale of understanding multiple factors of disease is to quantify and place them in priority sequence (prioritization) for modification or melioration to prevent or control disease. This concept presents multiple approaches for prevention and control of disease.

Web of Causation

This model is appropriate for the study of chronic disease, where the disease agent is the outcome of interaction of multiple factors. As per MacMahon and Pugh "Web of causation" considers all the predisposing factors of any type and their complex interrelationship with each other. Elimination of just only one link or chain



A–Agent
H–Host
E–Environment

Figure 1.6 Epidemiological triad wherein environment acts as a fulcrum between host and the agent.

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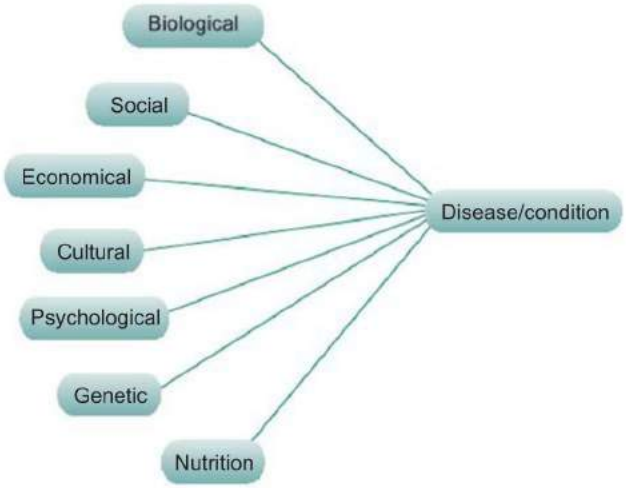


Figure 1.7 Multifactorial causation.

may be sufficient to control the disease, provided that link is sufficiently vital in the pathogenetic process. Hence, individual factors are by no means are of equal weight. Relative importance of these factors may be expressed in terms of "relative risk."

NATURAL HISTORY OF DISEASE

Natural history of causation describes the evolution of the disease over time from the earliest stage to its termination as recovery, disability or death, in the absence of treatment or prevention. The epidemiologist is in a unique position to fill the gaps in knowledge about the natural history of disease by studying the natural history of disease in the community.

Natural history of disease consists of two phases: prepathogenesis (the process in the environment) and pathogenesis (the process in man).

Prepathogenesis Phase

In this phase the disease agent has not yet entered man, but the factors that favour its interaction with the human host already exist in the environment. An interaction of agent, host and environment initiate the disease process. The agent, host and environment operating in combination determine the onset of distribution of disease in the community.

Pathogenesis Phase

The pathogenesis phase begins with the entry of the disease "agent" in the susceptible human host. The disease agent multiplies and induces tissue and physiological changes and the disease progresses through a period of incubation and later early and late pathogenesis. The outcome of the disease may be recovery, disability or death. The pathogenesis phase may be modified by interventional measures such as immunization and chemotherapy.

Agent Factors

Agent- "a substance, living or non-living, or a force, tangible or intangible, the excessive presence or relative lack of which may initiate or perpetuate a disease process." A disease may have a single agent, a number of independent multiple agents or a complex of two or more factors whose combined presence is essential for development of the disease. Disease agents may be biological, nutrient, physical, chemical, exogenous (arising outside of human host), mechanical, absence or insufficiency or excess of a factor necessary to health and disease.

Host Factors (Intrinsic)

Host factors may be demographic characteristics such as age, sex, ethnicity; biological characteristics such as genetic factors, biochemical levels of the blood, immunological factors and physiological function of different organ systems of the body; social and economic characteristics such as socioeconomic status, education, occupation, stress, marital status, housing, etc. and lifestyle factors such as personality traits, nutrition, physical exercise, habits, behavioural patterns, etc.

Environmental Factors (Extrinsic)

Environmental factors have a vital role in health and disease. The external or macro environment is defined as "all that which is external to the individual human host, living and nonliving and with which he/she is in constant interaction—this includes all of man's external surroundings such as air, water, food, housing, etc. The environment of man has been divided into three components; physical, biological and psychosocial.

1. *Physical environment:* refers to nonliving things and physical factors (e.g. air, water, soil, housing, climate, geography, heat, light, noise, debris, radiation, etc.) with which man is in constant interaction. Man is living today in a highly complicated environment which is getting more complicated as man is becoming more ingenious.
2. *Biological environment:* consists of living things such as viruses and other microbial agents, insects, rodents, animals and plants which surround man in a harmonious interrelationship. When for any reason, this harmonious relationship is disturbed ill health results in the area of biological environment.
3. *Psychosocial environment:* includes a complex of psychosocial factors which are defined as "those factors affecting personal health, health care and community wellbeing that stem from the psychosocial make-up of individuals and the structure and functions of social groups." Cultural (values, customs, habits) beliefs, attitudes, morals, religion, education, lifestyle, community life, health services, social and political organization are included. The laws of the land, customs, attitudes, beliefs, traditions regulate the interactions among groups of individuals and families.

Risk Factors

The term "risk factor" may be an attribute or exposure that is significantly associated with development of disease

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or a determinant that can be modified by intervention, thereby reducing the possibility of occurrence of disease or other specified outcomes. Risk factors are often suggestive, but absolute proof of cause and effect between a risk factor and disease is usually lacking.

Combination of risk factors in the same individual may be purely additive or synergistic. Risk factors may be causative as in smoking for lung cancer or they may be merely contributory to the undesired outcome such as lack of physical exercise is a risk factor for coronary heart disease.

Risk factors are modifiable or unmodifiable. Smoking, hypertension, elevated serum cholesterol, physical activity, obesity, etc. can be modified. The unmodifiable or immutable risk factors such as age, sex, race, family history and genetic factors are not subject to change. They act more as signals in alerting health professionals and other personnel to the possible outcome.

Epidemiological methods are needed to identify risk factors and estimate the degree of risk. The detection of risk factors should be considered before prevention or intervention.

Risk Groups

World Health Organization has promoted risk approach to identify "risk groups" or "target groups" in the population by certain defined criteria and direct appropriate action to them first. The risk approach is an administrative device for increasing the efficiency of health care services within the limits of existing resources.

Spectrum of Disease

The term "spectrum of disease" refers to variations in the manifestations of disease with subclinical infections at one end; illnesses ranging in severity from mild to severe in the middle, and at the other end are fatal illnesses. The spectrum of disease is also referred to as the "gradient of infection." In infectious conditions the sequence of events can be interrupted by early diagnosis and treatment or by preventive measures.

Iceberg of Disease

According to this concept, disease in a community represents an iceberg. The visible portion of the iceberg represents clinical cases seen by the physician. The huge submerged portion of the iceberg corresponds to the hidden mass of disease, latent, inapparent, presymptomatic and undiagnosed cases and carriers in the community. One of the major restraint in the study of chronic diseases of unknown aetiology is the lack of methods to detect the subclinical state—the base of the iceberg (Fig. 1.8).

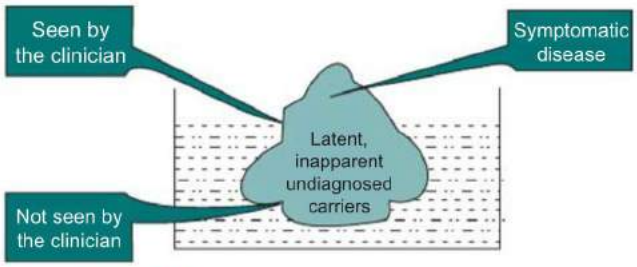


Figure 1.8 Iceberg concept of the disease.

DISEASE CLASSIFICATION

There was a wide variation among countries in the criteria and standards adopted for diagnosis of diseases and their notification, making it difficult for comparison. A system of classification was needed whereby diseases could be grouped according to certain common characteristics that would facilitate statistical study of disease phenomena. This formed the basis for international classification of diseases (ICD) produced by WHO and accepted for national and international use.

CHANGING PATTERN OF DISEASE

The factors which play a role in changing patterns of disease are multiple. They include: changing lifestyles and living standards, demographic factors, urbanization and industrialization, medical interventions, maintenance of people with transmissible genetic defects and widespread effects of technology on ecology.

Developed Countries

During past 80 years, developed world has experienced a dramatic change in the pattern of disease. The greatest part of this development has been decline of many of the infectious diseases (e.g. tuberculosis, typhoid fever, polio, diphtheria). However problems of a different nature have also achieved ascendancy, e.g. coronary heart disease, cancer and accidents.

There has been a steady increase in mental disorders (Alzheimer's disease), alcoholism and drug abuse and obesity. Environmental health problems due to industrialization and growing urbanization are assuming importance.

Developing Countries

In a typical developing country, about 40% of deaths are from infectious, parasitic and respiratory diseases compared to 8% in developed countries. On the other hand, an increase in the frequency of "new" health problems such as coronary heart disease, hypertension, cancer, diabetes and accidents are seen. The emerging picture is a mixture of the old and "modern" diseases.

COMMUNITY DIAGNOSIS AND TREATMENT

Community Diagnosis

Community diagnosis may be defined as the pattern of disease in a community described in terms of the important factors which influence this pattern.

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Community diagnosis is based on collection and interpretation of the relevant data such as the age and sex distribution of a population; the distribution of population by social groups; vital statistical rates such as birth rate and death rate and incidence and prevalence of important diseases of the area.

Community Treatment

Community treatment or community health action is the sum of steps decided upon to meet the health needs of the community taking into account the resources available and the wishes of the people, as revealed by community diagnosis. Action may be taken at three levels: at the level of the individual, at the level of family and at the level of the community. Improvements of water supplies, immunization, health education, control of specific diseases, health legislation are examples of community health action or interventions.

CONCEPTS OF CONTROL

Disease Control

Ongoing operations aimed at reducing the incidence of disease, the duration of disease and consequently the risk of transmission, effects of infection, including both physical and psychosocial complications and financial burden to the community. The disease "agent" is permitted to persist in the community at a level where it ceases to be a public health problem according to the tolerance of the local population.

Disease Elimination

"Elimination" is used to describe interruption of transmission of disease, e.g. elimination of measles, polio and diphtheria from large geographic regions or areas.

Disease Eradication

Eradication of disease implies termination of all transmission of infection by extermination of the infectious agent. As of now, smallpox is the only disease that has been eradicated.

Monitoring and Surveillance

Monitoring is "the performance and analysis of routine measurements aimed at detecting changes in the environment or health status of population," such as monitoring air pollution, water quality, growth and nutritional status, etc. Surveillance is defined as "continuous scrutiny of the factors that determine the occurrence and distribution of disease and other conditions of ill-health," such as epidemiological surveillance, demographic surveillance, nutritional surveillance, etc. Surveillance provides information about new and changing trends in the health status of a population, and leads to redefinition of objectives and timely warning of public health disasters so that interventions can be mobilized.

Sentinel Surveillance

Sentinel surveillance is a method for identifying the missing cases and thereby providing or supplementing missing/notified case. Sentinel data is extrapolated to the entire population to estimate disease prevalence in the total population.

Evaluation of Control

Evaluation is the process by which results are compared with intended objectives, or more simply the assessment of how well a programme is performing. Evaluation may be crucial in identifying the health benefits derived (impact on morbidity, mortality, sequelae, patient satisfaction). Evaluation can be useful in identifying performance difficulties.

CONCEPTS OF PREVENTION

Successful prevention depends upon knowledge of causation, dynamics of transmission, identification of risk factors and risk groups, availability of prophylactic or early detection and treatment measures; an organization for applying these measures to appropriate persons or groups, and continuous evaluation and development of procedures applied. The objective is to intercept or oppose the "cause" and thereby the disease process.

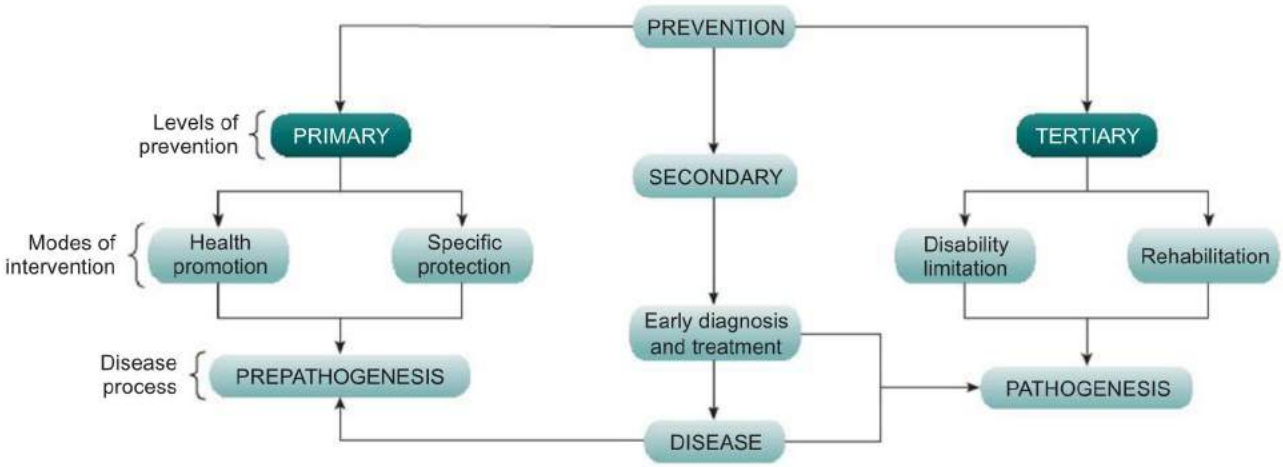
Levels of Prevention

Prevention can be achieved in terms of four levels: (1) primordial prevention; (2) primary prevention; (3) secondary prevention and (4) tertiary prevention (Flowchart 1.1).

1. *Primordial prevention:* Primordial prevention is prevention of emergence or development of risk factors in countries or population groups in which they have not yet appeared. In primordial prevention, efforts are directed towards discouraging children from adopting harmful lifestyles. The main intervention in primordial prevention is through individual and mass education.
2. *Primary prevention:* Primary prevention is a desirable goal that relies on holistic approach and signifies intervention in the prepathogenesis phase of a disease or health problem or other departure from health. It can be defined as "action taken prior to the onset of disease, which removes the possibility that a disease will ever occur."

   Primary prevention is concerned with an individual's attitude towards life and health and the initiative he or she takes about positive and responsible measures for himself or herself, his or her family and his or her community. It may be accomplished by measures designed to promote general health and wellbeing, and quality of life of people or by specific protective measures. WHO has recommended the population (mass) strategy or high-risk strategy approach for primary prevention of chronic diseases where the risk factors are established:
   a. Population (mass) strategy: It is directed at the whole population irrespective of individual risk levels and is aimed at towards socioeconomic, behavioural and lifestyle changes.

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Flowchart 1.1 Levels of prevention and disease process.

b. High-risk strategy: aims to bring preventive care to individuals at special risk. This requires detection of individuals at high risk by the optimum use of clinical methods.

3. *Secondary prevention:* Secondary prevention can be defined as "action which halts the progress of a disease at its incipient stage and prevents complications." Specific interventions are early diagnosis and adequate treatment. Governments usually initiate health programmes at the level of secondary prevention. Drawback of secondary prevention is that the individual has already been subjected to mental anguish, physical pain; and the community to loss of productivity.
4. *Tertiary prevention:* Tertiary prevention can be defined as "all measures available to reduce or limit impairments and disabilities, minimize suffering caused by existing departure from good health, and to promote the patient's adjustment to irremediable conditions." The specific modes of interventions are disability limitation and rehabilitation.

MODES OF INTERVENTION

Five modes of intervention have been described which form a continuum corresponding to the natural history of any disease: (i) health promotion, (ii) specific protection, (iii) early diagnosis and treatment, (iv) disability limitation and (v) rehabilitation.

Health Promotion

Health promotion is "the process of enabling people to increase control over and improve health." It is not directed against any particular disease, but is intended to strengthen the host through a variety of approaches (interventions) such as health education, environmental modifications, nutritional interventions, lifestyle and behavioural changes.

- *Health education:* A large number of diseases could be prevented with little or no medical intervention if people were adequately informed about them and if they were encouraged to take necessary precautions in time. Targets for educational efforts may include general public, patients, priority groups, health providers, community leaders and decision makers.
- *Environmental modifications:* Provision of safe water; installation of sanitary latrines; control of insects and rodents; improvement of housing, etc.
- *Nutritional interventions:* refers to food distribution and nutrition improvement of vulnerable groups; child feeding programmes; food fortification; nutrition education, etc.
- *Lifestyle and behavioural changes:* Action of prevention in this case is one of individual and community responsibility for health, and the physician and health worker act as an educator than a therapist.

Specific Protection

Some of the currently available interventions aimed at specific protection are: immunization, use of specific nutrients, chemoprophylaxis, protection against occupational hazards, protection against accidents, protection from carcinogens, avoidance of allergens, control of specific hazards in general environment and control of consumer product quality and safety of foods, drugs, cosmetics, etc.

Health protection. Health protection is defined as "the provision of conditions for normal mental and physical functioning of the human being individually and in the group. It includes promotion of health, prevention of sickness and curative and restorative medicine in all its aspects." Health protection covers a much wider field of health activities than specific protection.

Early Diagnosis and Treatment

As per WHO Expert Committee early detection of health impairment is "the detection of disturbances of homeostatic and compensatory mechanism while biochemical, morphological, and functional changes are still reversible."

Early detection and treatment are the main interventions of disease control. Earlier a disease is diagnosed

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and treated the better it is from the point of view of prognosis and preventing the occurrence of further cases (secondary cases) or any long-term disability.

Disability Limitation

Main objective of this intervention is to prevent or halt the transition of the disease process from impairment to handicap. Intervention in disability will often be social or environmental as well as medical. While impairment which is the earliest stage has a large medical component, disability and handicap which are later stages have large social and environmental components in terms of dependence and social cost.

Disability prevention. It relates to efforts in all levels of prevention aimed at reducing the occurrence of impairment or disability limitation by appropriate treatment or preventing the transition of disability into handicap.

Rehabilitation

Rehabilitation has been defined as "the combined and coordinated use of medical, social, educational and vocational measures for training and retraining the individual to the highest possible level of functional ability." It includes all measures—aimed at reducing the impact of disabling and handicapping conditions and at enabling the disabled and handicapped to achieve social integration. Rehabilitation includes medical rehabilitation (restoration of function), vocational rehabilitation (restoration of the capacity to earn a livelihood), social rehabilitation (restoration of family and social relationships) and psychological rehabilitation (restoration of personal dignity and confidence).

CONCLUSION

As the time progresses, old concepts and principles make way for the new. Similarly as medical advances conquer infectious diseases behavioural diseases emerge. Ecological factors influence the geographic distribution of disease.

Health is a relative concept and health standards vary—among cultures, social classes and age groups. Instead of setting universal health goals, each country should decide on its own standards for a given set of prevailing conditions, resources and limitations, and then look into ways to achieve that level. The developing countries such as Sri Lanka, Costa Rica demonstrate spectacularly the way in which health forms part of development. This was possible because the efforts in the field of health were simultaneously reinforced by developments in other sectors such as education, social welfare and land reforms.

Health calls for joint efforts of the individual, the community, the state and at the international level to protect and promote health. Health development contributes to and results from social and economic development. Health policies based on health services research should concentrate on human aspiration and values, commitments, assessment of current situation and an image of a desired future situation.

REVIEW QUESTIONS

1. Define health. Discuss the determinants, dimensions and indicators of health.
2. Define prevention. Discuss levels of prevention and modes of intervention.
3. Write notes on:
   a. Health spectrum
   b. Theories of disease causation
   c. Epidemiological triad
   d. Natural history of disease
   e. Iceberg phenomenon
   f. Risk factors and risk groups
   g. Changing concepts of health
   h. Concept of wellbeing
   i. Quality of life
   j. Disease control, elimination and eradication

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General Epidemiology

2

Prithvish and BS Nanda Kumar

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INTRODUCTION

It was observed many years ago that those communities in which natural level of fluoride was less had more people suffering from dental caries than those communities in which level of fluoride was higher. These observations led to evolution of recognizing the importance of fluoridation of water for prevention of dental caries.

During smallpox outbreaks Edward Jenner observed that dairy maids who were diagnosed with cow pox developed milder form of smallpox or did not develop smallpox at all. This led to the development of vaccine against smallpox (Fig. 2.1), which is considered as one of the major public health achievements.

John Snow in London noticed that the houses of the individuals developing cholera received their water supply from two different sources, despite all the other conditions being same. This led him to investigate and identify contaminated water as the causative agent as well to pinpoint the source of contaminated water supply. Only later, the bacteriological basis of cholera was identified as *Vibrio cholerae*.

All this was possible by application of principles of epidemiology. Epidemiology made slow progress since then owing to a diverse set of reasons. But, over the last three decades, epidemiology has progressed rapidly to become one of the indispensable sciences of modern learning. Dentists need to be aware of this basic science to lessen the burden of morbidity, disability and mortality. Let us know the definitions, differences between clinical medicine and epidemiology, objectives of epidemiology, disease frequency, distribution of disease, determinants of disease and basic approaches of epidemiology in this chapter.



Figure 2.1 Development of vaccine against smallpox.

Definition

The study of the distribution and determinants of health related states or events in specified populations, and application of this study to control of health problems[1].

Perkins, 1873: that branch of medical science that treats epidemics.
Frost, 1927: the science of mass phenomena of infectious diseases.
Greenwood, 1934: the study of disease, any disease, as a mass phenomenon.
MacMohan, 1950: the study of distribution and determinants of disease frequency in man.

EPIDEMIOLOGY AND CLINICAL MEDICINE

Features of epidemiology vis-à-vis clinical medicine are depicted in Table 2.1.

[1]John M Last, Dictionary of Epidemiology. (3rd edn). 1998.

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Table 2.1 Epidemiology versus clinical medicine

Epidemiology	Clinical Medicine
• Unit of study is a defined population or population at risk	• Unit of study is case or cases
• Concerned with those who are sick and those who are healthy	• Often concerned with those who are sick
• Investigator goes to the community	• Patient comes to a doctor
• Using relevant data, epidemiologist seeks to identify source of infection, mode of spread, or an aetiological factor to determine future trend or recommend control measures	• Seeks diagnosis, derives prognosis, prescribes specific treatment
• Conceptual, tables and graphs used	• Perceived as reports

Objectives of Epidemiology

1. To describe the distribution and magnitude of health and disease problems in the population.
2. To identify the determinants aetiological factors—risk factors in the population.
3. To provide the data essential for planning, implementation and evaluation of services for prevention, control and treatment of disease or to setting up of priorities for these services.

In order to fulfil these objectives, descriptive studies, analytical studies, experimental or interventional studies are undertaken.

The ultimate aim of epidemiology is to promote and preserve health and eliminate or reduce morbidity and its consequences.

SCOPE OF EPIDEMIOLOGY

Modern Challenges and Opportunities in Epidemiology Include

- Applying advances from molecular biology increasing attention to ethical issues
- Measuring and communicating weak associations
- Measuring outcomes and quality of health care
- Setting priorities and measuring progress
- Investigating public health outbreaks
- Adaptation of gains in the field of information, communication and technology
- Preventing chronic disease outbreaks and other "modern epidemics"
- Measuring the effects of public health interventions
- Informing public health policies
- Increasing epidemiologic capacity in applied settings

EPIDEMIOLOGY IN DIFFERENT SETTINGS

As epidemiology continues to develop and to expand into new areas, the field has diversified into many forms: **Surveillance, "shoe-leather" epidemiology** (outbreak investigations), and epidemic control.

Microbial epidemiology—biology and ecology of pathogenic microorganisms, their lifecycles, and their interactions with their human and nonhuman hosts. **Descriptive epidemiology**—examination of patterns of occurrence of disease and injury and their determinants.
"Risk factor" epidemiology—searching for exposure-disease associations that may provide insights into aetiology and avenues for prevention.
Clinical epidemiology and the evaluation of health care—assess accuracy, efficacy, effectiveness, and unintended consequences of methods of prevention, early detection, diagnosis, treatment, and management of health conditions.
Molecular epidemiology—investigating disease at the molecular level to precisely characterize pathological processes and exposures, to elucidate mechanisms of pathogenesis, and to identify precursor conditions. **Genetic epidemiology**—the confluence of molecular biology, population studies, and statistical models with an emphasis on heritable influences on disease susceptibility and expression.
Big epidemiology—multisite collaborative trials, such as the Hypertension Detection and Follow-up Programme (HDFP), Coronary Primary Prevention Trial (CPPT), Multiple Risk Factor Intervention Trial (MRFIT), Women's Health Initiative (WHI).
Entrepreneurial epidemiology—building institutions and careers by winning research funding and facilities.
Testimonial epidemiology—giving depositions and testifying in court or in legislative hearings on the state of epidemiologic evidence on a matter of dispute.
Social epidemiology—interpersonal and community level factors influencing health at the population level.
Global epidemiology—assessing the effects of human activity on the ecosystem that supports life on earth.

Scientific Elements of Epidemiology

- Aetiology
- Pathogenesis
- Prevention

THE EPIDEMIOLOGIC TRIAD

The concept of interaction of agent, host and environment for disease causation has helped epidemiologists to understand health and disease better. These constitute epidemiological triad.(Fig. 2-2)

Agents: Biologic agents, nutrient agents, physical agents, chemical agents, mechanical agents, social agents, absence or deprivation of specific factors constitute agent factors.

Host factors include demographic and biological characteristics, social and economic characteristics and lifestyle factors.

Vector factors: In case of vector borne diseases the bionomic of vector and its ecology play an important role.

Macro environment is defined as all that is external to the individual human host, living and nonliving and with which he or she is in constant interaction. Physical, social

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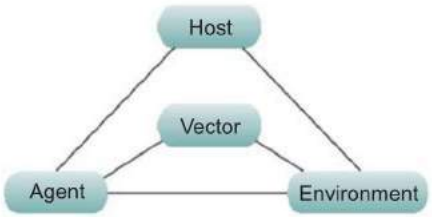


Figure 2.2 Epidemiologic triad.

and biological environment constitute the three facets of macro environment.

Just because the germ of tuberculosis is there, man will not get disease. The host environment of immunity and external environment facilitatory to spread the germs is required for the person to manifest the disease. This applies to both communicable and noncommunicable diseases.

Epidemiologic triad, multifactorial causation of disease, concept of natural history of disease, levels of prevention and modes of intervention are described in detail in Chapter 1 of this book. These form the important back-drop to elucidate disease causation using epidemiological methods.

Disease Frequency

Measurement of frequency of disease, disability or death and summarizing this information as rates and ratio—incidence rate, prevalence rate, etc. is an important area.

Measurement of health-related events and states—health needs, demands, activities, tasks, health care utilisation are other measures.

Basic tool of epidemiology is biostatistics and this discipline focuses on these measures.

Distribution of Disease

Disease or health status is not uniformly distributed. It may be more in one place or geographical area and less in other area. It may be common in particular season or particular decade and less in other seasons or other decades. It may affect only children or yet another age group. Hence, one needs to assess the occurrence of an event in all dimensions namely time, place and person.

Epidemiologist looks at why diseases do not occur uniformly, why variations occur in patterns. An enquiry into this may help identify cause of disease occurrence.

This aspect is called descriptive epidemiology. By this, it may be possible to doubt or guess likely the cause and a theory may be formulated.

Determinants of Disease

Epidemiologist seeks to examine the hypothesis by scientific methods. This is called analytical epidemiology. This will develop sound health intervention programmes and strategies.

Asking questions and making comparisons constitute the approach of an epidemiologist:

- Asking questions may provide clues to cause or aetiology of disease, e.g. What is the event, what is its magnitude, where did it happen, when did it happen, who were affected, why did it happen?
- Making comparisons will help draw inferences to support asking questions. This comparison may be:
  - between those with the disease and those without the disease;
  - those with risk factor and
  - those not exposed to risk factor and
  - comparison between individuals.

Matching, randomization and standardization are certain techniques which will be used to make drawing comparisons meaningful and scientifically sound.

MEASUREMENTS IN EPIDEMIOLOGY

Disease frequencies which help comparisons between populations, between subgroups of populations, are essential to epidemiology. Disease magnitude is expressed by the epidemiologist's rate, ratio or proportion. Let us examine what these mean.

Rate

Rate is frequency of a disease or characteristics expressed per unit size of the population. Further specification will be the time during which the cases have occurred.

Rate will have a numerator, a denominator and a specification of time. Numerator will be part of denominator. The denominator is called related or reference population.

It is generally calculated by dividing the number of events (deaths or disease onsets) by the total time period during which individual members are in the study population (e.g. person years) or by dividing the number of persons with a characteristic (e.g. disease) by the population at risk (the total number of persons in the group or population), and then multiplying by 100, 1000 or another convenient figure. There is an increasing tendency to use the term "rate" only for true rates whose denominators are person time units and to use the term "proportions" for other measures.

If the numerator limits to particular age, sex or racial group, the denominator also should be similarly restricted. If the denominator is restricted to those persons who are capable of having or contracting disease, it is sometimes referred to as population at risk.

The denominator of a rate may not be population in the ordinary demographic sense. For example hospitals may express its maternal mortality as the number of maternal deaths per thousand deliveries. The women delivered do not form a geographic population, but they do make up a group within which deaths have occurred.

Similarly, case fatality rate is the number of deaths due to a disease per so many persons with that disease—here individuals with the disease constitute the observed population.

Denominator is always important for an epidemiologist. If the numerator is confined to a category—e.g. males, the denominator should be similarly restricted—e.g. sex-specific and age-specific rates.

Denominators related to population include: midyear population, population at risk, person time, person

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distance and population subgroups according to age, sex, occupation, social class, etc.

If numerator is not part of denominator, it becomes a ratio. A proportion is a ratio that indicates the relation in magnitude of part of the whole. Proportion is usually expressed as a percentage.

Death rate. Number of deaths in one year/mid year population × 1000

Crude rates are the actual observed rates. They are also called unstandardized rates.

Specific rates. These are actual observed rates due to specific causes, e.g. tuberculosis, in specific age/sex groups or during specific time periods, e.g. annual, monthly or weekly rates.

Standardized rates are obtained by direct or indirect methods of standardization or adjustment which will help make comparisons between populations. If we want to compare death rates of two populations with different age composition, crude death rate will not be useful. Answer for this is age adjustment or age standardization. Adjustment can be made for age, sex, parity, race, etc.

Direct standardization. A standard population is defined as one for which number for each sex and age group is known. Age-specific rates of population whose crude death rate is to be adjusted is applied to the standard population. Expected number of deaths or events in the standard population is obtained for each age group. These are added together to give expected total deaths. Dividing the expected total number of deaths by the total of the standard population yields standardized or age adjusted rate.

Indirect standardization. Use of standard mortality ratio facilitates indirect standardization. Standard mortality ratio (SMR) is a ratio of the total number of deaths that occur in the study group to the number of deaths that would have been expected to occur if that study group had experienced the death rates of standard/ reference population.

$$SMR = (\text{Observed deaths})/(\text{Expected deaths}) \times 100$$

Other methods of standardization include calculation of index death rate, use of life tables, regression techniques and multivariate analysis (refer to books given under Bibliography).

Ratio

Number of persons affected relative to number of unaffected persons—not relative to total population is called ratio. Actually one quantity is divided by another quantity and specification of time may be a period or it may be instantaneous, e.g. number of children with dental caries/number of children with malnutrition. Other examples include sex ratio, dentist–population ratio, etc.

Proportions or proportional rates. Number of cases of a disease is sometimes expressed relative to the total number of all cases of all diseases, rather than to the total population. For example number of deaths ascribed to a particular disease may be expressed as a proportion of all deaths. This value is known as proportional mortality rate.

Measurement of Morbidity

Any departure, subjective or objective from a state of physiological wellbeing is referred to as morbidity.

Sickness, illness, disability refers to morbidity. It can be measured in terms of three units: persons who were ill, the illnesses or period of spell of illness that these persons experienced, and the duration—weeks, days, etc. of these illnesses.

Disease frequency is measured by incidence and prevalence. Disability rate or average duration of illness may help in assessment of disability. Severity of disease is reflected in case fatality rate.

Incidence

If incidence of a disease is increasing, it may indicate failure or ineffectiveness of control measure of a disease and need for better/new health control measure. Decreased incidence may indicate effectiveness of control measure.

The incidence of a disease is the number of new cases of a disease which come into being during a specified period of time. It is given by the formula:

(Number of new cases of specific disease during a given period)/(population at risk during that period) × 1000

It can also refer to new spells or episodes. In that case, formula will be:

(Number of spells of sickness starting in a defined period)/(mean number of persons exposed to risk in that period) × 1000

Attack rate is an incidence rate useful when the population is exposed to risk for a short period of time. It is given by the formula:

(Number of new cases of a specified disease during a specified time interval)/(total population at risk during the same time interval) × 100

A secondary attack rate is a measure in which numerator consists of a disease which occurs within the same household following the occurrence of a first or primary case. It is usually used in studies of infectious disease, and there is a stated or implied time limitation that on the basis of incubation period of the particular disease indicates that the secondary cases are probably derived from primary case. For diseases conferring prolonged immunity, the denominator in a secondary attack rate usually excludes persons who have previously had the disease.

Prevalence

Prevalence rates help to estimate the burden of disease in the community and identify potentially high-risk populations. They are essentially helpful to plan beds, rehabilitation facilities, manpower needs, etc.

Point prevalence of disease is a census type of measure. It is the frequency of disease at a designated point in time.

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The numerator includes persons having the disease at the given moment, irrespective of length of time which has elapsed from the beginning of the illness to the time when the point prevalence is measured. The denominator is the total population—affected and unaffected within which the disease is ascertained. In contrast to incidence rates which measures events, point prevalence rates are measures of what prevails or exists.

Period prevalence is a measure that expresses total number of cases of a disease known to have existed at some time during a specified period. It is the sum of point prevalence and incidence.

The word prevalence refers to point prevalence from now onwards. Period prevalence is of limited usefulness since epidemiologist and the administrator need information whether the cases are new or old. Period prevalence data are more useful when incidence and point prevalence are separated.

Prevalence rate is given by the formula:

(Number of current case – old and new of a specified disease at a point of time)/(estimated population at the same point of time) × 100

Prevalence may be expressed specific for sex, age, other relevant factors or attributes.

Prevalence depends upon two factors: incidence and duration of illness. P varies as the product of I and D. In the theoretical circumstance that incidence and duration remained constant over time, the disease is said to be stable and the relation between prevalence, incidence and duration would be such that P equals the product of I and D.

Another relation that exists if the disease is stable or nearly so is case fatality rate which can be measured by dividing mortality rate by incidence rate:

$$F = M / I$$

Specification of time is essential for both prevalence and incidence rates. Specifying time may be by:

- Calendar time—e.g. usually one year. Age—e.g. by fifth year.
- Referring to an event like during premarital examination, during postnatal period, etc.

Incidence rates are superior to prevalence rates for elucidation of causal factors.

Morbidity rates and ratio reflect disease burden in the community and often are the starting point towards identifying causal factors. They are helpful tools for monitoring and evaluation of disease control activities. They provide more clinical information compared to mortality data.

Measurement of Mortality

During the course of an individual's life, many records are created which contain information relevant to health status. These include legal and medical records. Epidemiologists often start their enquiry with mortality data. Mortality means death and we are referring to statistics related to death. We can identify following as sources of data:

1. Statistics related to vital events: birth, death and marriage certificates
2. Data from insurance companies
3. Hospital records
4. Data from specific case registries, e.g. cancer registry, Down syndrome registry, mental health registry
5. Special disease surveys, e.g. survey for polio lameness, measles, neonatal tetanus, etc.
6. Routine reporting system from the primary health care system.

Each source of data has its own merits and demerits. Death certificate is the basis of mortality data. For ensuring national and international comparability, it is very necessary to have a uniform and standardised system of recording and classifying deaths. In India, death is to be reported by the family where death occurs within 3 days of occurrence to the local *panchayat*/municipality. Also, in order to improve quality of information on infant mortality and maternal mortality, a set of additional questions are a special feature in our country.

Incomplete reporting of deaths, lack of accuracy, lack of uniformity, choosing a single cause of death, changing coding systems affect the accuracy of mortality data. Despite these limitations, causes of death are important and widely used for a number of purposes. Apart from providing important clues for epidemiological research, mortality data are useful for:

- Explaining trends and differentials in overall mortality
- Indicating priorities for health action
- Allocation of resources for strategic interventions
- Assessment and monitoring of public health programmes.

Mortality Rates and Ratio

Crude death rate. Number of deaths from all causes per 1000 estimated mid year population in 1 year in a given place is referred to as crude death rate. This can be depicted by the formula:

(Number of deaths during the year)/(mid year population) × 1000

Crude death rates have a major disadvantage—with populations which differ by age, sex, race, etc. death rates loose comparability. Next useful information is obtained by age-specific death rates. Advantage of death rate is portrayal of mortality in a single figure.

Specific death rates. Specific death rates may be age-specific death rates, sex-specific death rates, age-and sex-specific death rates, specific to income, housing, race, religion, etc. Specific death rates are obtained in countries where civil registration system of deaths is satisfactory.

Examples:

Specific death rate due to avian influenza = (Number of deaths from avian influenza during a calendar year)/(mid year population) × 1000

Specific death rate for males = (Number of deaths among males during a calendar year)/(mid year population of males) × 1000

Case fatality rate. Case fatality rate denotes killing power of a disease. It is simply the ratio of deaths to cases. It is

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typically used in acute infections like cholera, food poisoning, measles, etc.

Case fatality is closely related to virulence. Case fatality rate is given by the formula:

Case fatality rate = (Total number of deaths due to a particular disease)/(total number of case due to the same disease) × 100

Proportional mortality rate. Proportional mortality rate refers to number of deaths due to a particular cause per 100/1000 total deaths. It may be computed for a specific age group also.

Examples:

Proportional mortality from communicable diseases = (Number of deaths from communicable diseases)/(total deaths from all causes) × 100

Proportional mortality for persons under 15 years = (Number of deaths under 15 years in the given year)/(total number of deaths during the same year) × 100

Proportional mortality data are used when population data are not available. Proportional mortality rate does not indicate the risk of members of the population contracting or dying from the disease. Proportional mortality data will be more useful, if computed for each age group and sex wise.

Survival rate:

Survival rate = (Total number of patients alive after 5 years)/(total number of patients diagnosed or treated) × 100

It is a method of describing prognosis. This rate has special importance in cancer studies. Survival analysis is an important technique for arriving at these measures.

EPIDEMIOLOGICAL METHODS

Primary concern of an epidemiologist is to study disease occurrence among people. Factors and circumstances to which people are exposed may throw light on cause of the disease. Epidemiologist employs carefully designed methods to find out cause of disease occurrence. The methods he or she employs can be classified as:

1. Observational studies
   a. Descriptive studies
   b. Analytical studies
      - Case-control studies
      - Cohort studies
2. Experimental/interventional studies
   Randomized control studies, field trials—community trials.

Descriptive Studies

Steps in conducting a descriptive study. Descriptive studies form the first step in any process of investigation. These studies are concerned with observing the distribution of disease or health related events in populations with which the disease in question seems to be associated. The steps are

- Defining the population
- Defining disease under study
- Describing the disease
- Measurement of disease
- Comparing with known indices
- Formulation of hypothesis

- **Defining the population.** Defined population may be the whole population or a representative sample which constitutes the denominator. It can also be a specially selected group such as age and sex groups, occupational groups, hospital patients, school children, small community, etc. It is preferable that a health facility is closely located for medical services required.
- **Defining disease under study.** Epidemiologist looks at an operational definition of disease in question—a definition by which the disease can be identified and measured. Definition may not be as precise as that of a physician, but adequate enough to identify with sufficient accuracy, e.g. presence of red, enlarged tonsils with white exudates on which *Streptococcus pyogenes* grows predominantly can be a case definition for streptococcal tonsillitis.
- **Describing the disease.** Disease is examined by the epidemiologist by asking three questions:
  - When is the disease occurring—time distribution?
  - Where is it occurring—place distribution?
  - Who is getting the disease—person distribution?

1. Time Distribution

Short-term fluctuations. An epidemic is defined as the occurrence in the community or region of cases of an illness or health related events in excess of normal expectancy. Epidemicity is relative to usual frequency of the disease in the same area, among the specified population, at the same season of the year.

Few terminologies:

a. Common Source Epidemics

- Common source, single epidemics: Exposure to disease agent is brief and essentially simultaneous, the resultant cases all develop within one incubation period of the disease, e.g. food poisoning.
- Common source, continuous or repeated exposure epidemics: Sometimes the exposure from the same source may be prolonged—continuous, repeated or intermittent, e.g. gonococcal infection from a female sex worker.
- Propagated epidemics: A propagated epidemic results from person to person transmission of an infectious agent. The epidemic shows a gradual rise and tails off over a much longer time. The speed of spread depends on herd immunity, opportunities for contact and secondary attack rate, e.g. epidemics of poliomyelitis, hepatitis A, etc.

b. Periodic Fluctuations

- Seasonal fluctuations: Seasonal variation is a well known characteristics of many infectious diseases, e.g. measles is usually at its height in early spring, upper respiratory infections usually show an upward trend during winter months, diarrhoeal disorders are common during summer months, etc.
- Cyclic fluctuations: Some diseases occur in cycles of short periods of time, e.g. measles once in 2 to 3 years

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before immunisation era, traffic accidents during weekends.

c. Long-Term or Secular Trends

The term secular trend refers to changes in the occurrence of disease over a long period of time—years or decades, e.g. diabetes, cardiovascular disease, lung cancer have shown consistent upward trend over the last 50 years.

By surveillance or monitoring of time trends, the epidemiologist asks questions, makes comparisons to determine:

- Which are the emerging health problems?
- Whether these changes are due to change in the aetiological agent, method of reporting, better diagnosis, treatment, environmental determinants, case fatality, change in age distribution, socioeconomic status, habits, etc.

The epidemiologist provides advice to the health administrator for prevention and control based on his or her inferences.

2. Place Distribution

Geographic differences in disease prevalence are an important dimension of descriptive studies. These differences are determined by agent, host and environment factors. Classic examples include:

- International variations, e.g. there is marked difference in occurrence of cancer throughout the world. Cancer of stomach is very common in Japan, but less common in the US. Examination of variations may give clue to causation.
- National variations, e.g. distribution of endemic goitre, lathyrism, fluorosis, guineaworm disease, malaria, leprosy, nutritional deficiency show variations in our country in different states. Findings may give clue to recommend appropriate control measures based on prevalent public health priorities.
- Rural – urban differences, e.g. chronic bronchitis, lung cancer, cardiovascular diseases, mental illness, drug dependence appear to be more common in urban areas, and skin diseases, zoonotic diseases, worm infestations appear to be more common in rural areas. Findings may give clue to identify risk groups and risk factors.
- Local distributions, e.g. spot maps help in identifying clustering of cases within small geographical areas. Clustering of cases of cholera led John Snow in London to incriminate water supply as cause of cholera transmission in London. Findings may indicate clues to causation.

Migration studies. Large scale migrations of human populations from one country to another provide a unique opportunity to find out role of genetic and environmental factors in the disease causation.

Migrant studies may be conducted by comparing disease and death rates for migrants with those of their kin who have stayed at home. Another way is to compare death and disease rates of local population, e.g. migrant studies have shown that men of Japanese ancestry living in the USA experience a higher rate of coronary artery disease than do Japanese in Japan (Fig. 2.3).

Twin studies. Studies on twins are another method to elucidate role of genetic/environmental factors in the causation of disease.

3. Person Distribution

Study of host factors in relation to disease occurrence is an important component of descriptive epidemiology. Variation of disease frequency with respect to following factors may give clue to aetiology/understanding of natural history of disease.

a. *Age:* This is an important host factor strongly related to disease occurrence, e.g. measles is common in children, cancer in middle age and degenerative diseases in old age.
b. *Sex:* Sex ratio, sex-specific morbidity and mortality rates have helped epidemiologists. Male:female ratio (4:1) in the prevalence of lung cancer has helped to identify smoking as a risk factor for lung cancer. Variations have been ascribed to basic biological differences including sex-linked genetic inheritance, cultural and behavioural differences, different roles in social setting.
c. *Race:* Differences in disease occurrence have been noticed among population of different ethnic or racial origin, e.g. sickle cell anaemia, tuberculosis, hypertension, coronary heart disease, etc.
d. *Other factors:* These include marital status, occupation, social class, behaviour, stress, migration, etc.

Measurement of Disease

Cross-sectional studies. Cross-sectional study is the simplest form of observational study. It is based on single examination of cross-section of population at one point of time. Cross-sectional study is also called prevalence study. If the sampling methodology is accurate, results can be projected to the entire population. They are more useful for chronic illnesses, e.g. hypertension.

Cross-sectional studies save on time and resources, but provide very little information about natural history of disease and incidence of illness.

Longitudinal studies. Longitudinal studies involve repeated observations on the same population over a period of time. They are time consuming, cost intensive. But, they

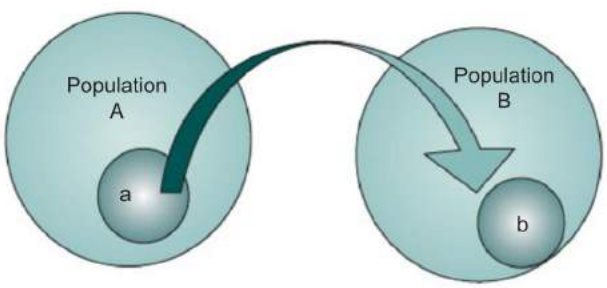


Figure 2.3 Migration studies.

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provide information on incidence, risk factors and natural history of diseases.

- **Comparing with known indices.** By computing various rates, ratio and proportions, making comparison with different population groups and subgroups, it will be possible to arrive at clues to aetiology/understanding natural history/identify or define groups at risk of developing disease.
- **Formulation of hypothesis.** A hypothesis is a supposition arrived from observation/reflection. It can be accepted or rejected using the techniques of analytical epidemiology. The success of a research project depends upon soundness of hypothesis.

Example of a hypothesis: Smoking of 30 to 40 cigarettes a day causes lung cancer in 10% of smokers after 20 years of exposure.

Descriptive epidemiological studies provide data regarding disease burden in the community, provide clues to formulate hypothesis, provide background data for preventive and curative services.

ANALYTICAL STUDIES

Case-control and Cohort Studies

Once the hypothesis is formulated, testing the hypothesis will be done by analytical studies. Analytical studies basically look at whether there is statistical association between suspected cause and its effect, and, if such an association were to exist, is it statistically significant?

In *case-control studies* one will start from effect and then proceed to cause. In *cohort studies*, one will look at cause and proceed to effect. Case-control studies are done after the disease manifests. In cohort studies one will study before the disease manifests and proceed to study over a period of time for the disease to occur.

Steps in case-control study will involve selection of cases—those with the disease, selection of controls—those without the disease, matching of cases and controls with respect to known variables like age, sex, socioeconomic status, etc. measurement of exposure and analysis to find out exposure rates among cases and controls with respect to suspected factor and estimate the disease risk associated with exposure. This is called odds ratio.

Cohort means a group of people sharing a common experience. Cohort studies are often prospective studies, they can be retrospective also, or a combination of both prospective and retrospective components can be brought in. Cohort studies involve selection of study subjects, obtaining data on exposure, selection of comparison groups, follow-up and analysis. Here incidence rates among those exposed to the suspected factor and incidence rates among those not exposed is calculated and estimation of risk—relative risk, attributable risk and population attributable risk are calculated.

Case-control Study

Three distinct features of case-control study are:

1. Both exposure and outcome have occurred before start of the study
2. The study proceeds backwards from effect to cause
3. It uses control or comparison group to support or refute an inference.

Framework of Case-control Study

Suspected Risk Factor	Case Disease Present	Control Disease Absent	Total
Present	a	B	a + b
Absent	c	D	c + d
Total	a + c	b + c	

Basic Steps in a Case-control Study

1. Selection of cases and controls
2. Matching
3. Measurement of exposure
4. Analysis and interpretation.

Example

	Case with Lung Cancer	Control without Lung Cancer	Total
Smokers less than 5 cigarettes a day	33 (a)	55 (b)	88 (a + b)
Non-smokers	2 (c)	27 (d)	29 (c + d)
Total	35 (a + c)	82 (b + c)	117

The first step is to find out

1. Exposure rates among cases

$$a/(a + c) = 33/35 = 94.2\%$$

2. Exposure rate among the controls

$$b/(b + d) = 55/82 = 67\%$$

We find out if the exposure rate among the cases is more than the controls.

Then we have to see if this is significant, i.e. we must see if the exposure rate among the cases is significantly more than the controls. This is done by using the **chi-square test.**

It is significant if p is less than 0.05.

3. Next is to estimate the odds ratio.

Odds ratio. It is a measure of strength of association between the risk factor and outcome. The derivation of the odds ratio is based on three assumptions:

- The disease being investigated is relatively rare
- The cases must be representative of those with the disease
- The controls must be representative of those without the disease.

$$\text{Odds ratio} = a.d / b.c$$

$$33 \times 27/55 \times 2 = 8.1$$

People who smoke less than five cigarettes per day showed a risk of having lung cancer 8.1 times higher as compared to non smokers.

Example of a case-control study. Thalidomide, a barbiturate was implicated for resulting in causing deformed babies in those

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who have consumed the same during pregnancy. A retrospective study of 46 mothers who delivered deformed babies showed that 41 were found to have thalidomide during early pregnancy. This was compared with 300 mothers who had delivered normal babies. None of these mothers had taken thalidomide.

Laboratory experiments confirmed that thalidomide was teratogenic in experimental studies.

Cohort Study

Steps in a cohort study:

- Selection of study subjects
- Obtaining data on exposure
- Selection of comparison groups
- Follow-up
- Example
- Analysis.

Example

	CHD Develops	CHD does not Develop	Total
Smokers	84 (a)	2916 (b)	3000 (a + b)
Non smokers	87 (c)	4913 (d)	5000 (c + d)
Total	171 (a + c)	7829 (b + c)	8000

The first step is to find out,

The incidence rates of CHD (coronary heart disease) among smokers, i.e. a/(a + b)

$$84/3000 = 28 \text{ per } 1000$$

The incidence rates of CHD among non smokers, i.e. c/(c + d)

$$87/5000 = 17.4 \text{ per } 1000$$

Then, we must determine if the incidence rate among the smokers is significantly more than among the non-smokers by using the chi-square test.

Next step is to calculate the relative risk.

Relative risk (RR). It is ratio of incidence of the disease among the exposed and incidence among the non-exposed. It is an important measure of the strength of the association which is a major consideration in deriving causal inferences. It is a direct measure of the strength of association between a suspected cause and effect:

RR = (Incidence of disease among exposed)/(Incidence of disease among non exposed)

$$a/(a + b)/c/(c + d) = 28/17.4 = 1.6$$

If RR is more than 1, then there is a positive association between suspected cause and effect. If RR is equal to 1, then there is no association between suspected cause and effect.

Smokers develop CHD 1.6 times more than non-smokers.

Attributable risk (AR). This is defined as amount or proportion of disease incidence that can be attributed to a specific exposure. It indicates to what extent the disease under study can be attributed to the exposure:

AR = (Incidence of disease among exposed) − (Incidence of disease among nonexposed)/(Incidence of disease among exposed)

$$AR = 28 - 17.4/28 = 10.6/28 = 0.379 = 37.9\%$$

37. 9% of CHD among the smokers was due to smoking.

Population attributable risk (PAR). It is the incidence of the disease in total population minus incidence of the disease among those who are not exposed to the suspected causal factor. It provides an estimate of the amount by which a disease could be reduced in that population if the suspected factor was eliminated or modified. It is important from public health point of view.

PAR = (Incidence of disease in total population) − (Incidence in nonexposed)/(Incidence of disease in total population)

To find out the PAR we need following data:

- Incidence among the smokers = 28/1000
- Incidence among the non-smokers = 17.4/1000
- Proportion of the total population of smoker if we have this information, i.e. we take that the total population of smoker is 44%, then we can know that non-smokers constitute 56%.

Then incidence in the total population can be calculated by the following formula:

Incidence in smokers × (% of smokers in population) + incidence in non smokers × (% of non smokers on the population)

$$28/1000 \times 0.44 + 17.4/1000 \times 0.56 = 22.1/1000$$

Then substituting in the formula of PAR

PAR = (Incidence of disease in total population–incidence in non exposed)/(Incidence of disease in total population)

$$(22.1 - 17.4)/(22.1) = 21.3\%$$

Thus, 21.3% of incidence of CHD in total population can be attributed to smokers and if an effective prevention programme for elimination of smoking is undertaken, the best we could get by eliminating smoking in that population is that we would be able to prevent 21.3% of the incidence of CHD in that total population.

Example of a cohort study. 23,000 pill users aged 15 to 49 years and similar number of controls were brought under observation by 1400 general practitioners in England. During follow-up, diagnosis of episodes of illness and information about pregnancies and deaths were collected. Study showed that the risk of hypertension increases and risk of benign breast disease decreases with neither dose of norethisterone acetate in the combined pill. Increased mortality due to cardiovascular diseases among pill users was confirmed.

Usually, many case-control studies are done before cohort studies are planned. Latter is cost intensive and time consuming compared to case-control study. No risks to subjects are noticed in case-control studies whereas

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Table 2.2 Salient differences between case-control and cohort studies

Case-Control Studies	Cohort Studies
• Proceeds from effect to cause	• Proceeds from cause to effect
• Starts with the disease	• Starts with people exposed to risk factor
• Rate of exposure among exposed and those not exposed is studied	• Tests frequency of disease among those exposed and those not exposed
• First approach to testing hypothesis	• Reserved for testing precisely defined hypothesis
• Involve small number of subjects	• Involves large number of subjects
• Less time and resources	• More time and cost intensive
• Suitable for rare diseases	• Difficult to conduct for rare diseases
• Yields odds ratio	• Yields incidence rates, relative risk, absolute risk and population attributable risk
• Cannot yield information about diseases one other than selected for	• Information about more than disease is possible

ethical issues come in case of cohort studies (Table 2.2). In case-control studies, ethical issues will be minimal.

Experimental Studies

Experimental studies aim to provide scientific proof of risk factors/aetiology. Another objective is to provide a method of measuring the effectiveness and efficiency of health services for prevention and control, treatment of disease and improve health of the community. They are like cohort studies, with direct control of the intervening factor—introduction or withdrawal of a factor. They have the added disadvantage of cost, ethics and feasibility.

In early part of the century, animal experiments were the focus, but human experiments with volunteers took the focus subsequently as animal studies need to be followed with studies on human beings. Before launching human experiments, benefits of the experiments have to be weighed against possible consequences of the experiments. WHO in 1980, introduced a strict code of conduct for experimental studies. Experimental studies are of two types: randomized control studies and nonrandomized control studies.

Randomized Control Studies

Essential elements of a randomized control study are: drawing up a strict protocol, selecting reference and experimental populations, randomization, manipulation or intervention, follow-up and assessment of outcome. Randomization is a statistical procedure where participants are allocated into groups called study and control groups to receive or not to receive an experimental therapeutic or preventive procedure, manoeuvre or intervention. Randomization is an attempt to avoid bias and allow comparability. But, when one matches, one can match only the known factors. In randomization, those factors will be distributed equally between the groups.

Study designs include *concurrent parallel and crossover type of study designs*. In the former, study and control groups will be studied parallel whereas in the latter all the participants will have the benefit of treatment after a particular period because the control group becomes study group. Types of randomized control studies are:

Clinical trials, e.g. drug trials. *Preventive trials*, e.g. trials of vaccines. *Risk factor trials*, e.g. trials of risk factors of cardiovascular disease, e.g. tobacco use, physical activity, diet, etc. *Cessation experiments*, e.g. smoking cessation experiments for studying lung cancer.

Trial of aetiological agents, e.g. oxygen therapy in a condition called detrimental fibroplasia. *Evaluation of health services*, e.g. domiciliary treatment in tuberculosis was established as a cost-effective approach compared to institutional management which was helpful for all developing countries.

What is bias? Bias is systematic error that comes in. Bias on the part of participants if they know they belong to study group—participant bias; bias because of observer if he or she knows that he or she is dealing with study group—observer bias; bias because of investigator—investigator bias, if he or she knows he or she is dealing with study group. In order to prevent this, a technique called blinding is adopted.

Concept of blinding. Single blind trial means participant will not know whether he or she belongs to study group or control group. In double blind studies, both the participant and the observer will not be aware. In triple blind study, the participant, observer as well as the investigator will not be aware who belongs to control group and who belongs to study group. Blinding is not required if expected outcome is death.

Nonrandomized Control Studies

In nonrandomized control studies, approach is crude. One has to resort to this when human experiments become not possible through randomized control trials. For example, direct experimentation for lung cancer has not been possible as we cannot introduce cancer viruses, as of date. Some experiments can be possible only on community wide basis, e.g. community trials of fluoridation. Thirdly, cancer cervix—randomized control trials require long-term observation.

Uncontrolled trials, trials without control groups or with historical controls experience of earlier treated patients, e.g. pap smear studies.

Natural experiments e.g. observation among smokers and nonsmokers for disease in them, e.g. lung cancer. Other examples include study on migrants, religious groups, atomic bombing in Japan, famines, earth quakes, etc. John Snow's experiment that revealed that cholera is water-borne disease, etc.

Before and after comparison studies without control, e.g. introduction of seatbelt legislation was following a study

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before and after the introduction of seatbelts in vehicles, addition of fluorine to drinking water and observation before and after. Data regarding incidence of disease, diagnostic criteria, adoption of preventive measures over a large area and large scale reduction because of preventive measure are needed.

Before and after comparison studies with control, e.g. seatbelt legislation, its use and effects were studied in the region where it was introduced and compared with region where it was not introduced, which offered a natural control group.

Studies of medical care and health services, planning and evaluation of health services have engaged the attention of epidemiologists—for taking up these types of studies.

ASSOCIATION, RELATIONSHIP AND CAUSATION

Descriptive studies help in formulating a hypothesis. Analytical and experimental studies help in accepting or refuting a hypothesis which elucidates risk factors or aetiology/value of preventive or curative interventions. Next step is studying association further and to find out whether the association or relationship is causal.

If two factors occur more frequently together than is expected by chance, we say an association is likely to exist. For an epidemiologist, what is important is he or she knows how strong and relevant the association to be called causal.

One uses the terminologies—spurious association, indirectly causal association, and directly causal association.

Sometimes, we notice relationship or association, but it is not real. Such an association is called spurious association. In one of the studies in Great Britain, it was observed that perinatal mortality was higher in hospitals compared to home deliveries. Truth is—normal deliveries tend to be at home and difficult deliveries happened in referral hospitals which indicate that mothers with high risk were attended and association observed is spurious.

Let us take the association between high altitude and endemic goitre. Endemic goitre is not due to high altitude, but due to low iodine content in soil/water which is the cause of association. Statistical association between high altitude and goitre is not necessarily causal. Example here indicates *indirectly causal association.*

If we have a factor which is associated with the cause, it causes no ambiguity. But, if associated with both cause and outcome, it is often referred to as a confounding factor or variable.

Let us look at directly causal association. If change in A results in change in B, it is causal. If disease B is present, cause A also must be present. This one relationship—if exists is useful. This may not be the case always. Haemolytic streptococci may cause streptococcal tonsillitis, erysipelas or scarlet fever.

Often we have situations like we see in lung cancer and smoking. Smoking, exposure to asbestos and air pollution can cause lung cancer. Model I suggests all three causative factors may independently make changes at cellular level and cause lung cancer. Model II suggests it may be the synergistic effect of all three factors mentioned earlier, though they may independently cause lung cancer.

One to one relationship is often over simplification, it appears. Cause being necessary and sufficient to produce a disease is true, but may not always be reached always. Following is an attempt to describe additional criteria to determine causation.

Let us take example of smoking and lung cancer. About 50 retrospective studies and 9 prospective studies were to establish this relationship or association, to date. Lung cancer occurs among long standing smokers. Smoking precedes lung cancer. A is followed by B. There is time sequence—temporal association exists.

More the number of years of smoking, more the number of cigarettes, chances of developing lung cancer is more. Relative risk is high and there is dose-response relationship between smoking and lung cancer—strength of the association exists.

Smoking is a risk factor for lung cancer, oral cavity cancerous state, and cardiovascular disease. But association between smoking and lung cancer is so specific and established that it supports causality—specificity of the association exists.

Repeated retrospective and prospective studies have established beyond doubt the relationship between smoking and lung cancer consistently. There is consistency of association.

It is not difficult to visualise that inhalation of hot smoke into the lungs and deposition of a chemical carcinogen over time, building up to a threshold level and initiating neoplastic changes. Experimental studies in animals have established possibilities of developing neoplastic changes with lung tobacco extracts. Carcinogens have been identified from smoke. All indicate biological credibility—biological plausibility of association.

Historically, smokers have developed lung cancer. Lung cancer is common in men. Lung cancer has been noticed among women who smoke and less morbidity noticed among non smokers. Available facts indicate—coherence of association.

It is probably not possible to conduct direct human experiments to prove relationship between smoking and lung cancer. But evidence accumulated earlier is adequate enough to establish causality.

As students of dentistry, can we use these examples to pursue research into many diseases for which cause is not known!

USES OF EPIDEMIOLOGY

- It will be of interest to know uses of epidemiology. Firstly, epidemiology helps to study historically rise and fall of diseases. Best examples: newer diseases— Lassa fever, Legionnaires disease, severe acute respiratory syndrome (SARS), HIV/AIDS, avian flu were better understood by epidemiological methods. By studying time trends and knowing disease profiles it will be possible to make future projections and identify emerging health problems.

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- By epidemiological methods we will be able to make a *community diagnosis,* know the disease burden which helps in prioritisation of public health problems so that it will be possible to match the resources with the need. Knowing disease burden, creating benchmark for evaluation, knowing more clearly about disease distribution are possible by epidemiological methods.
- Planning and evaluation becomes possible by epidemiological methods. Health service evaluation, trials of drugs and vaccines—all become possible by epidemiological methods.
- Epidemiology will help calculate individual risks and chances of contracting diseases. This will help develop preventive programmes in the community.
- By the application of epidemiological methods, it will be possible to elucidate aetiological/causal factors—an important role of epidemiology.
- Medical syndromes are identified by observing frequently associated findings in individual patients. Using epidemiological methods it will be possible to identify new syndromes/syndrome complexes, and it will be possible to completely study the natural history of disease.
- Epidemiological methods help to study and complete natural history of diseases. One of the best examples is because of epidemiological methods it was possible to call cardiovascular diseases to occur in epidemics, and also develop coronary care units because of epidemiological findings.
- By epidemiologic methods, it will be possible to undertake trials of drugs/vaccines/new methods of prevention.

SCREENING FOR DENTAL DISEASE

Introduction

Globally morbidity patterns are rapidly changing and are closely linked to lifestyle, lack of adequate physical activity, widespread use of tobacco and increased consumption of alcohol. In addition to socioenvironmental determinants, oral diseases are largely related to these risk factors resulting in morbidity and mortality. Healthy lifestyles in turn act as protective factors, such as appropriate exposure to fluorides and good oral hygiene.

The most of the oral diseases are preventable to a large extent if they are detected earlier. Historically, the routine annual health check-ups were meant for early detection and diagnosis of the so called hidden diseases. They are basically meant for saving the physicians' and dentists' time for diagnosis and treatment and also avoiding expensive laboratory tests and other diagnostic aids.

Oral diseases qualify as major public health problems owing to their high prevalence and incidence in all regions of the world, as for all diseases, the greatest burden of oral diseases is on underprevileged and socially marginalized populations. The severe impact in terms of pain and suffering, impairment of function and effect on quality of life must also be considered.

Traditional treatment of oral diseases is extremely costly in several industrialized countries and not feasible in most low-income and middle-income countries. Hence periodic screening is recommended for oral diseases.

Concepts of Screening

The active search for disease among apparently healthy people is a fundamental aspect of prevention. Historically, the annual health examinations were meant for the early detection of hidden disease. To bring such examinations within the reach of large masses of people with minimal expenditures of time and money, a number of alternative approaches have come into use. They are based primarily on conserving the doctor's time for diagnosis and treatment and having paramedical personnel to administer simple, inexpensive laboratory tests and operate other measuring devises.

Definition. Screening of a disease is defined as the search for unrecognized disease or defect by means of rapidly applied tests, examinations or other procedures in apparently healthy individuals.

Difference between Screening Test and a Diagnostic Test

Screening Test	Diagnostic Test
1. Done on apparently healthy	Done on those with indications or sick
2. Applied to groups	Applied to single patients, all diseases are considered
3. Test results are arbitrary and final	Diagnosis is not final but modified in light of new evidence, diagnosis is the sum of all evidence
4. Based on one criterion or cut-off point	Based on evaluation of a number of symptoms, signs and laboratory findings
5. Less accurate	More accurate
6. Less expensive	More expensive
7. Not a basis for treatment	Used as a basis for treatment
8. The initiative comes from the investigator or agency providing care	The initiative comes from a patient with a complaint

Lead Time Concept

Lead time is the advantage gained in due to the screening test wherein the disease is identified in the incipient stage so as to treat it appropriately in the early phases of natural history and prevent adverse health outcomes (Fig. 2.4).

Since screening involves a large number of people and resources it is imperative that certain basic aspects are considered before implementing the programme on a large scale.

Criteria for Screening

World Health Organization guidelines were published in 1968, but are still applicable.

1. The condition should be an important health problem.

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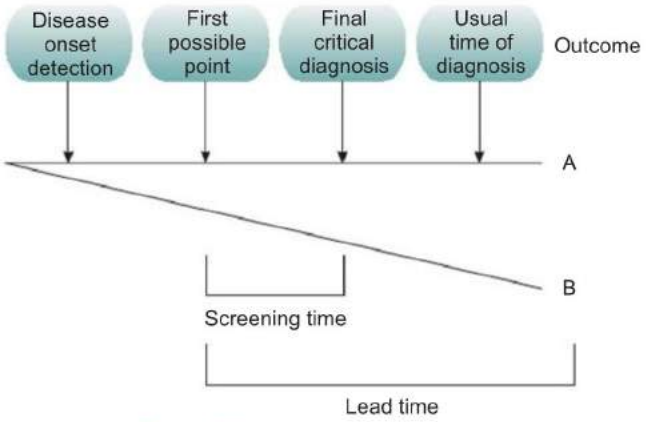


Figure 2.4 Concept of lead time.

2. There should be a treatment for the condition.
3. Facilities for diagnosis and treatment should be available.
4. There should be a latent stage of the disease.
5. There should be a test or examination for the condition.
6. The test should be acceptable to the population.
7. The natural history of the disease should be adequately understood.
8. There should be an agreed policy on whom to treat.
9. The total cost of finding a case should be economically balanced in relation to medical expenditure as a whole.
10. Case-finding should be a continuous process, not just a "once and for all" project.

Types of Screening

1. Population based (mass screening)
2. High risk screening
3. Selective screening

Population based (mass screening) may be considered wherein screening programme is extended to the whole population irrespective of risk such as annual school dental check-up programme.

High risk screening may be confined to specific groups such as screening for cancers among smokers.

Selective screening: Screening tests can, of course, be used in different ways, varying from single examination applied to individuals to batteries of tests offered to whole populations. They may also, as already indicated, be either indiscriminate or selective.

Similarly, multistage and multiple screening may be considered as a measure of evaluation and control of misclassification error in the detection of diseases such as hypertension and so on.

Validity of Screening Tests

Validity of a test is defined as its ability to distinguish between who has a disease and who does not. ***Sensitivity*** is the ability to identify correctly those who have the disease. ***Specificity*** is the ability to identify correctly those who do not have the disease. ***Predictive values*** of result of a screening test are the proportions of people correctly labelled as diseased and nondiseased by the test.

Reliability or ***repeatability*** of a test means the ability of that test to replicate or reproduce the results obtained when the test is repeated.

In screening we end up with groups classified only on basis of their test results such as positives and negatives. In real life we have no information regarding their true disease status, which is the reason for the screening. To calculate the sensitivity and specificity of a test, we must know who really has the disease; who does not from another source than the test we are using. We have to compare our test results with some gold standard regarding the disease status of each individual in the population. This may be the result of another test that has been in use, or it may be the result of a more definitive, and often more invasive, test. Thus in order to quantitatively assess the sensitivity and specificity of a test, we must have another source of truth with which to compare the test results.

Tests with dichotomous results (positive or negative)—ideally we would like all of the tested subjects to fall into the two groups—true positives and true negatives, i.e. people with the disease who are correctly called positive by the test and people without the disease who are correctly called negative by the test, respectively. But this is a rare case, and some people who do not have the disease are erroneously called positive by the test (false positives), and some people with the disease are erroneously called negative (false negatives).

Test Results	Population	
	With Disease	**Without Disease**
Positive	True positive (TP) i.e. have disease and have positive test	False positive (FP) i.e. no disease but have positive test
Negative	False negative (FN) i.e. have disease but have negative test	True negative (TN) i.e. no disease & have negative test

Sensitivity = TP/TP + FN Specificity = TN/TN + FP

Comparison of the Results of a Dichotomous Test with Disease Status

The ROC (receiver operating curve) curve is a graphic representation of the relationship between sensitivity and specificity for a diagnostic test. It provides a simple tool for applying the predictive value method to the choice of a positivity criterion.

- **Drawing the curve:** The ROC curve is constructed by plotting the true positive rate (sensitivity) against the false positive rate (1-specificity) for several choices of a positivity criterion (Fig. 2.5).
- **Using the curve to locate the positive criterion:** The upper-left corner represents a perfect diagnostic test. At this point, both sensitivity and specificity are 100%, that is, all diseased individuals are identified, all healthy individuals are labelled disease-free, and no disease-free individuals are labelled diseased.
  - When the cost of a false positive and false negative test result are equal, set the positivity criterion equal

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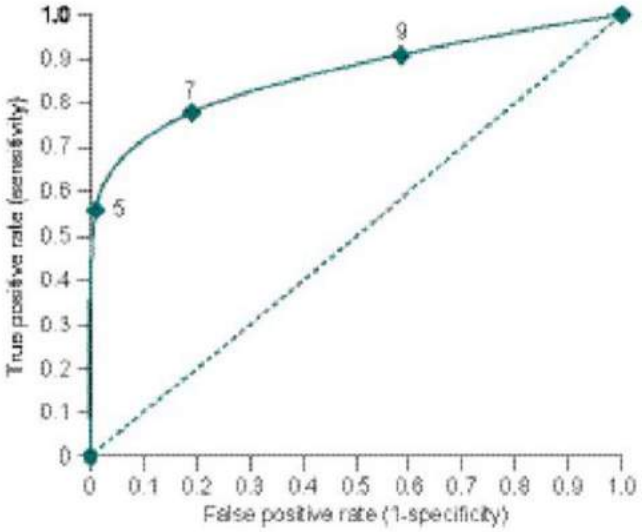


Figure 2.5 ROC curve.

to the point on the ROC curve closest to the upper-left corner. At this point, the discriminative ability of the test is maximized and the number of erroneous diagnoses is minimized.

- When a false positive result is especially undesirable, set the positivity criterion equal to the point farthest to the left on the ROC curve.
- When a false negative result is especially undesirable, set the positivity criterion equal to a value towards the right on the ROC curve. At the point on the ROC curve farthest to the right; all patients with the disease are detected by the diagnostic test.

- Using the curve to compare two tests: ROC curves can also be used to compare two diagnostic tests. The area under the curve represents the overall accuracy of a test; the larger the area, the better the test.
  - The ROC curve for a test that conveys no information falls on the diagonal running from lower left to upper right.
  - In comparing two ROC curves, the one closest to the upperleft corner (i.e. the curve with the greatest total area below and to the right of it) has the greater sensitivity and specificity and hence is the more accurate of the two.

Predictive value of a test: So far we discussed about how good is a test in identifying people with the disease and without the disease correctly, which were the characteristics of a test being used, which is particularly important in screening free-living populations. But in a clinical setting, when a physician performs various tests from history taking, physical examination, laboratory tests, X-rays, ECGs, and other procedures, it is important to know after administering the test to a patient if the result is positive or negative, what is the likelihood that the patient has the disease or does not have the disease. Thus it is important in a clinical setting for us to know what proportion of the patients who test positive actually have the disease in question, which is called the ***positive predictive value*** of the test. Similarly, if the test result is negative, the probability that this patient does not have the disease is called as the ***negative predictive value*** of that test.

Disease Prevalence	Test Results	Sick	Not Sick	Total	PPV (Positive Predictive Value)
1%	+	99	495	594	99/594 = 17%
	-	1	9,405	9,406	
	Total	100	9,900	10,000	
5%	+	495	475	970	495/970 = 51%
	-	5	9,025	9,030	
	Total	500	9,500	10,000	

The predictive value is affected by two factors, the *prevalence of the disease* in the population tested and, when the disease is infrequent, the *specificity of the test* being used.

Relationship between predictive value and disease prevalence—

Example: Sensitivity—99%
Specificity—95%

Most of the gain in predictive value occurs with increase in prevalence at the lowest rates of disease prevalence.

Why this relation is important is because of the following factors.

1. Screening test is productive and effective when done in high risk population.
2. Such persons are more motivated to participate in the screening.
3. After the test they will be more receptive for advice.

Bias in Screening

1. Selection biases
   a. Referral/volunteer bias
   b. Length-biased sampling/prognostic selection
2. Lead time bias
3. Over diagnosis bias

1a. Referral bias In deriving a conclusion about benefits of screening, the first question we might ask is whether there was a selection bias in terms of who was screened and who was not. We would like to be able to assume that those who were screened had the same characteristics as those who were not screened. However, many differences exist in the characteristics of those who participate in screening or other health programmes and those who do not. Many studies have shown volunteers to be healthier than the general population and to be more likely to comply with medical recommendations. It is also possible that volunteers may include many people who are at high risk and who volunteer for screening because they have anxieties based on a positive family history or lifestyle characteristics. The problem is that we do not know in which direction the selection bias might operate and how it might affect the study results. This problem of selection bias which significantly affects the interpretation of findings is best addressed by carrying out the comparison with a randomized experimental study in which care should be taken that the two groups have comparable initial prognostic profiles.

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1b. Length-biased sampling This type of selection problem does not relate to who comes for screening but rather to the type of disease that is detected by the screening. Screening tends to selectively identify those cases that have longer preclinical phases of illness. Consequently, even if the subsequent therapy had no effect, screening would still selectively identify persons with a long preclinical phase, and consequently a long clinical phase (i.e. those with a better prognosis). These people would have a better prognosis even if there were no screening programme or even if there were no true benefits from screening.

This problem can be addressed by using an experimental randomized design in which care is taken to keep the groups comparable in terms of the lengths of the detectable preclinical phase of illness, which may not be so easy. In addition to this, survival should be examined for all members of each group, the screened and unscreened. In screened group, survival should be calculated for those in whom disease is detected by screening and for those in whom disease is detected between screening examinations, which are referred to as interval cases.

2. Lead time bias The problem of an illusion of better survival only because of earlier detection is called the lead time bias.

Thus, even if there is no true benefit from early detection of a disease, there will appear to be a benefit associated with screening, even if death is not delayed, because of an earlier point of diagnosis from which survival is measured. Lead time associated with early detection suggests the appearance of a benefit in the form of enhanced survival, therefore it must be taken into account in interpreting the results of nonrandomized evaluations.

The problem is that the apparently better survival is not a result of screened people living longer, but it is rather a result of diagnosis being made at an earlier point in the natural history of their disease.

Consequently, in any comparison of screened and unscreened populations we must make an allowance for an estimated lead time in an attempt to identify any prolongation of survival above and beyond that resulting from the artifact of lead time. If early detection is truly associated with improved survival, survival in the screened group should be greater than survival in the control group plus the lead time. We therefore have to generate some estimate of the lead time for the disease being studied. Another strategy is to compare mortality from the disease in the entire screened group with that in the unscreened group, rather than just the case fatality rate in those in whom disease was detected by screening.

3. Over diagnosis bias At times, persons who initiate a screening programme have almost limitless enthusiasm for the programme. For example if the cytologists reading the pap smears overread the smears, the result is that normal women are included in the group thought to have positive pap smears. Consequently the abnormal group will be diluted with women who are free of disease. By this one could get a false impression of increased rates of detection and diagnosis of early-stage disease as a result of the screening. In addition, the results would represent an inflated estimate of survival after screening in persons thought to have cancer, because many of the persons with a diagnosis of cancer would actually not have cancer, and would therefore have a good survival. So it is essential that the diagnostic process be rigorously standardized in such studies.

Application of Screening Tests in Dental Sciences

Screening tests in dental sciences may be utilized for twin purposes namely at a pre-diagnostic and at an early diagnostic stage. High risk groups are identified and are subjected to health promotion and specific protection measures at a pre-diagnostic stage.

According to global caries initiative priority action areas target the eradication of early childhood caries in children under 3 years of age and focus on primary and secondary prevention of caries and health promotion activities.

Early Detection Programme

Awareness cum screening camps can be organized periodically with the support of governmental and voluntary organizations. Public education is the fervently pursued activity. Self–examination methods should be emphasized, particularly of oral cavity along with need for quitting tobacco.

Village level cancer control programme volunteers can be trained to create awareness on cancer, early signs, in advocating and motivating people to undergo diagnostic screening tests, therapy and to extend financial support. The village level volunteers are usually trained in a 1–day programme and supplied with material to be distributed among the public for a period of 3 weeks. Members among the public who suspect any cancer or precancerous condition are motivated to undergo physical examination by a medical team in a camp organized by them. A cancer screening camp is most productive only if conducted within 2 weeks after an awareness programme.

Evaluation of Screening Programmes

Proper evaluation of screening programmes is a must before its application. Randomized control trials, uncontrolled trials, and other methods like case-control studies help in this.

Screening has lot of potential. Construction of accurate tests that are both sensitive and specific is a challenge.

Thus it is evident that screening for diseases occupies an important position in the public health dentistry and helps in the early detection and management of several life-threatening morbidities. Appropriate and judicious use of the tool would go a long way in effective and efficient use of the limited resources in health care.

INVESTIGATION OF AN EPIDEMIC

Occurrence of an epidemic indicates shift in balance of agent, host and environment. Emergencies caused by

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Table 2.3 Steps in investigation of an epidemic

Particulars of Steps	Description
Verification of diagnosis	Report may be spurious and misinterpretation of signs and symptoms by public may occur. First step is to confirm the diagnosis by rapid clinical and laboratory examination in small number of subjects. This is the first step. Epidemiological investigations should not be delayed.
Confirmation of existence of an epidemic	An epidemic is said to exist if the frequency is in excess of normal expectations. Comparing disease frequency in the same period during previous years will support this. Sometimes it may be obvious—food poisoning, gastroenteritis, etc.
Defining the population at risk • Obtaining map of the area • Counting the population	Obtaining the map, preparing the map landmarks, roads, dwellings, numbering the houses, etc. With the help of lay health workers/or health workers one needs to do a survey. This is essential to constitute the denominator population to estimate attack rates and other measures.
Rapid search for all cases and their characteristics • Medical survey	Medical survey must be carried out in the defined area to identify all including those who have not sought medical care.
Epidemiological case sheet	An epidemiological case sheet is to be designed based on findings of rapid enquiry— name, age, sex, occupation, social class, travel, history of previous exposure, time of onset of disease, signs, symptoms, personal contacts at home, work, school, special mass caterings attended, exposure to water, food, milk, drink, etc. in common, history of receiving injections, blood products, etc.—whatever is relevant to the situation. Information is collected systematically by training health workers/lay health workers.
Searching for more cases	Search for secondary cases should be done in hospitals, schools, work places, by enquiring patients about other persons—till outbreak is over.
Data analysis • Time distribution • Place distribution • Person distribution	Preparation of chronological picture and drawing an epidemic curve will be useful to infer type of epidemic. Preparation of spot map—geographic distribution of cases and observing any clustering of case. Analysis of data according to age, sex, socioeconomic class, occupation, common experience of taking food together, etc.
Formulation of hypothesis	Possible source, cause, possible mode of spread, enabling environmental factors are determined and a supposition or hypothesis is made.
Testing of hypothesis	All reasonable hypotheses are examined, attack rates in different groups are compared and attempt is made to draw inferences.
Evaluation of ecological features	Changes in temperature, humidity, etc. Inspection of eating houses and vendors, water sources, population movement, population dynamics of vectors, animals are studied and findings recorded.
Further investigation of population at risk. Writing a report	A detailed study of population at risk including clinical, laboratory and other methods may be necessary. Report should be complete and convincing. It may be necessary to implement temporary control measures at the beginning of the epidemic based on facts available—which may be modified based on new facts.

epidemics remain one of the most important challenges. The objectives of epidemic investigation are:

- To define the magnitude of the epidemic outbreak and involvement in terms of time, place and person distribution.
- To determine the conditions and factors responsible.
- To identify the cause, source of infection, mode of spread and to determine measures for prevention and control.
- To make recommendations to prevent recurrence.

It is desired to have an orderly procedure or practical guidelines as outlined in the following, applicable for almost any situation. Some of the steps can be done concurrently (Table 2.3).

An epidemiological investigation is more than collection of established facts. It includes their orderly arrangement.

REVIEW QUESTIONS

1. Define epidemiology and discuss the epidemiological triad in detail.
2. What are the tools of epidemiology?
3. Define hypothesis, mention different types of hypothesis and discuss its importance.
4. Describe in detail the steps involved in RCT.
5. What is relative risk and attributable risk?
6. What is bias and what are the different types of bias?
7. Define nonrandomized control studies.
8. Define screening. What are the different types of screening?

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3 Environmental Health

Prithvish and K Pushpanjali

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DEFINITION OF ENVIRONMENTAL HEALTH

"It is the study of the impact and health effects on human beings by all physical, chemical, social and psychological factors." These factors can exist outside the body and is called the external environment, while some of the factors can be inside the body (e.g. attitude, feelings, etc.) and is called internal environment. Both environments are equally important and interact with each other.

COMPONENTS OF ENVIRONMENTAL HEALTH

- Physical components are water, air, soil, sound, radiation, light, temperature, humidity, etc. and environmental health deals with how each of these affect the general health, oral and dental health and what can be done to prevent the harmful effects.
- Socioeconomic and cultural components are society norms and rules, customs, tradition, etc. These may affect importance of dental health care compared to other human needs.
- Psychological components are mainly concerned with attitude towards dental health and the resulting behavioural changes following dental health programmes.

GENERAL IMPACT OF ENVIRONMENT ON HEALTH

- Direct impact on dental health, e.g. fluoride levels in water leading to dental caries and dental fluorosis.
- Indirect impact on dental health, e.g. lack of adequate clean water, which prevents regular oral washing and cleanliness, etc.
- Short-term impact on dental health, e.g. lack of calcium, improper brushing of teeth, etc.
- Long-term impact on dental health, e.g. presence of lead contamination in water and food, leading to chronic periodontal problems and mottling of teeth, etc.

SPECIFIC ENVIRONMENTAL HEALTH EFFECTS

- Specific environmental causes such as specific water and food contaminants (e.g. lead) leading to dental problems.
- Synergistic (combined) effects of two or more environmental factors, which combine together to increase the impact on dental health rather than the effect of each factor by itself, e.g. more rapid tooth enamel erosion due to increased fluoride levels combined with increased lead contamination of water and food.
- Environmental "pollution" can occur due to an excess of a natural or man-made chemical in the external atmosphere, which may or may not result in a disease.
- Environmental "contamination" results in disease and is due to the presence of a specific disease causing substance in the atmosphere.
- Other environmental factors such as noise, sound, light, radiation, etc. can affect health in general which may aggravate dental problems.

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METHODS OF IDENTIFYING ENVIRONMENTAL POLLUTION/ CONTAMINATION

- *By observational studies:* This is done by a descriptive survey in terms of describing the environmental factors by quantitative and qualitative methodologies.
- *By analytical studies:* Following a descriptive survey, specific methods are used to differentiate whether an environmental factor is merely associated (i.e. coincidental occurrence) with the dental health problems or it is the causation (i.e. directly responsible) of the dental disorder.
- *By monitoring specific parameters:* Certain environmental factors (e.g. bacteriological quality of water) are measured periodically in order to see that they do not exceed the tolerable levels for maintaining health. This ensures follow-up of the benefits derived from community dental health programme.
- *By studying human behavioural patterns:* Psychologists and behavioural scientists record the changing patterns of human behaviour and how they cope with the altered environment. This is done to determine what type of community programme would result in the best behaviour, e.g. specific avoidance or promotion of different types of dental practices to combat the altered environment.

DIFFERENCES BETWEEN ERADICATION, CONTROL AND ELIMINATION OF ENVIRONMENTAL HEALTH HAZARDS

- *Eradication method:* This is a method whereby technology is used to completely remove the cause of a particular disease in the entire world.
- *Control methods:* These are methods whereby technology is used to prevent any further increase of a particular disease but cause of the disease is still present.
- *Elimination methods:* These are techniques to remove the cause of a particular disease in a given area e.g. a region or a country but not in the entire world.

The previously mentioned various methods could involve chemical, biological, physical, behavioural interventions through planned national health programmes involving the environmental factors, e.g. dental fluorosis control programme in areas with high fluorine content of water.

POLLUTION CONTROL

1. AIR POLLUTION

Introduction

Air pollution is a broad term applied to all physical (particulate matter), chemical and biological agents that may modify the natural characteristics of the atmosphere and the environment.

Some definitions also consider physical perturbations such as noise pollution, heat, radiation or light pollution as air pollution. Definitions commonly include the term *harmful* as a requisite to consider a change to the atmosphere as pollution.

Air is the ocean we breathe. Air supplies us with *oxygen,* which is essential for our bodies to live. Air is 99.9% nitrogen, oxygen, water vapour and inert gases. Human activities can release substances into the air, some of which can cause problems for humans, plants and animals.

There are several main *types* of pollution and well-known *effects* of pollution commonly discussed. These include smog, acid rain, the greenhouse effect and "holes" in the ozone layer. Each of these problems has serious implications on our health and wellbeing as well as for the whole environment.

One type of air pollution is the release of **particles** into the air from burning fuel for energy. Diesel smoke is a good example of this *particulate matter.* The exhaust from burning fuels in automobiles, homes and industries is a major source of pollution in the air. Some authorities believe that even the burning of wood and charcoal in fireplaces and barbeques can release significant quantities of soot into the air.

Another type of pollution is release of *noxious gases,* such as sulphur dioxide, carbon monoxide, nitrogen oxides and chemical vapours. These can take part in further chemical reactions once they are in the atmosphere, forming smog and acid rain.

Pollution also needs to be considered *inside* our homes, offices and schools. Some of these pollutants can be created by indoor activities such as smoking and cooking.

Outdoor Air Pollution

Smog is a type of large-scale outdoor pollution. It is caused by chemical reactions between pollutants derived from different sources, primarily automobile exhaust and industrial emissions. Cities are often centres of these types of activities, and many suffer from the effects of smog, especially during the warm months of the year.

Black carbon pollution. Black carbon pollution is release of tiny **particles** into the air from burning fuel for energy. Air pollution caused by such particulate has been a major problem since the beginning of the *industrial revolution* and the development of the *internal combustion engine.* Mankind has become so dependent on the burning of **fossil fuels** (petroleum products, coal and natural gas) that the sum total of all combustion-related emissions now constitutes a serious and widespread problem, not only to human health, but also to the entire global environment.

Temperature inversion occurs when air close to the earth is cooler than the air above it. Under these conditions the pollutants cannot rise and be dispersed. Cities surrounded by mountains also experience trapping of pollutants. Inversion can happen in any season. Winter inversions are likely to cause particulate and carbon monoxide pollution. Summer inversions are more likely to create smog.

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Acid rain. Another consequence of outdoor air pollution is **acid rain**. When a pollutant, such as sulphuric acid combines with droplets of water in the air, the water (or snow) can become *acidified*. The effects of acid rain on the environment can be very serious. It damages plants by destroying their leaves, it poisons the soil and it changes the chemistry of lakes and streams. Damage due to acid rain kills trees and harms animals, fish and other wildlife.

Greenhouse effect. Also referred to as global warming, is generally believed to come from build-up of carbon dioxide gas in the atmosphere. Carbon dioxide is produced when fuels are burned. Plants convert carbon dioxide back to oxygen, but release of carbon dioxide from human activities is higher than the world's plants can process. The situation is made worse since many of the earth's forests are being removed, and plant-life is being damaged by acid rain. Thus, amount of carbon dioxide in the air is continuing to increase. This build-up acts like a blanket and *traps heat* close to the surface of our earth. Changes of even a few degrees affect us all through changes in the climate and even the possibility that the polar ice caps may melt (one of the consequences of polar ice cap melting would be a rise in global sea level, resulting in widespread coastal flooding).

Ozone depletion is another result of pollution. Chemicals released by our activities affect the *stratosphere*, one of the atmospheric layers surrounding earth. The ozone layer in the stratosphere protects the earth from harmful *ultraviolet radiation* from the sun. Release of *chlorofluorocarbons* (CFCs) from aerosol cans, cooling systems and refrigeration equipment removes some of the ozone, causing "holes" to open up in this layer and allowing the radiation to reach the earth. Ultraviolet radiation is known to cause skin cancer and has damaging effects on plants and wildlife.

Indoor Air Pollution

Many people spend large portion of time indoors—as much as 80–90% of their lives. We work, study, eat, drink and sleep in enclosed environments where air circulation may be restricted. For these reasons, some experts feel that more people suffer from the effects of indoor air pollution than outdoor pollution.

There are many sources of indoor air pollution. Tobacco smoke, cooking and heating appliances and vapours from building materials, paints, furniture, etc. cause pollution inside buildings. *Radon* is a natural radioactive gas released from the earth. Pollution exposure at home and work is often greater than outdoors.

Both indoor and outdoor pollution need to be controlled and/or prevented.

Pollution Sources

Anthropogenic sources. Anthropogenic sources are related to burning different kinds of fuel—human activity

- Combustion-fired power plants
- Vehicles with internal combustion engine
- Devices powered by two-stroke cycle engines
- Stoves and incinerators especially coal ones
- Wood fires, which usually burn inefficiently
- Farmers burning their crop waste.

Other anthropogenic sources

- Aerosol sprays and refrigeration, which once depended on freon and other chlorofluorocarbons
- Dust and chemicals from farming, especially of erodable land, saw dust bowl fumes from paint, varnish and other solvents
- Military actions, including use and testing of nuclear bombs, poison gases and germ warfare
- Waste deposition in landfills, which generate methane.

Natural sources

- Dust from natural sources, usually large areas of land with little or no vegetation
- Methane, emitted by the decomposition of animals, usually cattle
- Smoke and carbon monoxide from wildfires
- Volcanic activity, which produces sulphur, chlorine and ash particulates.

Contaminants

Contaminants of air can be divided into **particulates** and **gases**. Important pollutant gases include:

- **Carbon monoxide,** which is primarily emitted from combustion process, particularly from petrol vehicle exhausts due to incomplete combustion; the highest concentrations are generally found at roadside locations. Inhalation of high levels of carbon monoxide can cause headaches, fatigue and respiratory problems.
- **Chlorofluorocarbons**, which destroy the stratospheric ozone layer.
- **Hydrocarbons**
- **Lead and heavy metals**
- **Nitrogen oxides**
- **Sulphur oxide**, which cause acid rain and is caused from the burning of fuel containing sulphur, mostly at power plants, and during metal smelting and other industrial processes.

Effects of Air Pollution on Health

Air pollution can affect our health in many ways with both *short-term* and *long-term* effects. Different groups of individuals are affected by air pollution in different ways. Some individuals are much more sensitive to pollutants than others. Young children and elderly people often suffer more from the effects of air pollution. People with health problems such as asthma, heart and lung disease may also suffer more when the air is polluted. The extent to which an individual is harmed by air pollution usually depends on **total exposure** to the damaging chemicals, i.e. the *duration of exposure* and the *concentration of the chemicals* must be taken into account.

Short-term effects. These include irritation to the eyes, nose and throat and upper respiratory infections such as

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bronchitis and pneumonia. Other symptoms can include headaches, nausea and allergic reactions. Short-term air pollution can aggravate medical conditions of individuals with asthma and emphysema. In the great "smog disaster" in London in 1952, 4,000 people died in a few days due to high concentration of pollution.

Long-term effects. These can include chronic respiratory disease, lung cancer, heart disease and even damage to the brain, nerves, liver or kidneys. Continual exposure to air pollution affects the lungs of growing children and may aggravate or complicate medical conditions in the elderly.

Deaths

It is estimated that 3 million people may die of air pollution each year worldwide. Of the 3 million mortalities, 2.8 million may be due to indoor air pollution. Ninety percent of the 3 million estimated deaths are in developing nations.

The worst short-term civilian event from pollution in India was the 1984 Bhopal disaster. Leaked industrial vapours killed more than 2,000 people outright and injured anywhere from 150,000 to 600,000 others, some 6,000 of whom would later die from their injuries.

The United Kingdom suffered its worst air pollution event when the December 4th Great smog of 1952 formed over London. In 6 days more than 4,000 died, and 8,000 more died within the following months. An accidental leak of anthrax spores from a biological warfare laboratory in the erstwhile USSR in 1979 near Sverdlovsk is believed to have been the cause of hundreds of civilian deaths.

Intentional air pollution in combat is called chemical warfare. Poison gas as a chemical weapon was principally used during World War II and resulted in an estimated 91,198 deaths and 1,205,655 injuries. Various treaties have sought to ban its further use. *Nonlethal* chemical weapons, such as tear gas and pepper spray are widely used.

Prevention of Damaging Effects of Air Pollution

In many countries in the world, steps are being taken to stop the damage to our environment from air pollution. **Scientific groups** study the damaging effects on plant, animal and human life. **Legislative bodies** write laws to control emissions.

The first step in solving air pollution is *assessment*. Once exposure levels have been set, steps can be undertaken to *reduce exposure* to air pollution. These can be accomplished by regulation of man-made pollution through legislation. Many countries have set controls on **pollution emissions for transportation vehicles and industry**.

Adequate ventilation is also a key to controlling exposure to indoor air pollution. Home and work environments should be monitored for adequate airflow and proper exhaust systems be installed.

One of the most dangerous air pollutants is cigarette smoke. ***Restricting smoking*** is an important key to a healthier environment. Legislation to control smoking is in effect in some locations, but personal exposure should be monitored and limited wherever possible. Only through the efforts of scientists, business leaders, legislators and individuals can we reduce the amount of air pollution on the planet. This challenge must be met by all of us in order to assure that a healthy environment will exist for ourselves and our children.

Summary

Air pollution is a broad term applied to all physical (particulate matter), chemical and biological agents that modify the natural characteristics of the atmosphere.

Air pollutants are classified as either **primary or secondary**. A primary air pollutant is one that is emitted directly to the air from a given source. Carbon monoxide is an example of a primary air pollutant because it is produced as a byproduct of combustion.

A secondary air pollutant is formed in the atmosphere through chemical reactions involving primary air pollutants. The formation of ozone in photochemical smog is an example of a secondary air pollutant. The atmosphere is a complex, dynamic and fragile system. Concern is growing about the effects of air pollutant emissions in a global context, and the interlinkage of these emissions with global warming, climate change and stratospheric ozone depletion.

2. NOISE POLLUTION

Noise pollution is unwanted man-made sound that penetrates the environment. Noise pollution can be caused by many sources including highways, vehicles, police cars, ambulances, factories, concerts, music, air-conditioners, engines, machine, aircraft, helicopters, alarms, public address systems, industrial development and construction work. In general, noise pollution refers to any noise irritating to one's ear, which comes from an external source. The word "noise" comes from the Latin word *nausea* meaning seasickness.

Noise pollution can be defined as "unwanted or offensive sounds that unreasonably intrudes into our daily activities." It has many sources, most of which are associated with urban development: road, air and rail transport; industrial noise; neighbourhood and recreational noise. A number of factors contribute to problems of high noise levels including:

- Increasing population, particularly where it leads to urban consolidation; in turn generally it may lead to increased noise levels
- Increasing volumes of road, rail and air traffic
- Productivity losses due to poor concentration, communication difficulties or fatigue due to insufficient rest
- Health care costs to rectify loss of sleep, hearing problems or stress
- Loss of psychological wellbeing.

What is Noise?

Noise magnitude is often measured in decibels (dB), a logarithmic scale in which each turning down the volume

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on stereos and TVs. Avoidance of noisy areas is a priority, as much as possible. Using sound absorbing materials to soundproof office rooms in noisy environment reduce exposure. Move noisy machine away from people, or by building a soundproof structure.

Though we can measure individual sounds that may actually damage human hearing, it is difficult to monitor cumulative exposure to noise or to determine just how much is too much. The definition of noise itself is highly subjective. To some people the roar of an engine is satisfying or thrilling; to others it is an annoyance. Loud music may be enjoyable or a torment, depending on the listener and the circumstances.

Causes of Noise Pollution

Nowadays, noise pollution is identified as one of the leading environmental health problems. There is nothing extraordinary about the source of all this noise; it is merely the sound of everyday life. Some of the chief causes of noise pollution are machines and modern equipment of various types, automobiles, train, aircraft, use of explosives, bursting of firecrackers, dog barking, use of loudspeakers, loud rock and roll concerts, domestic stereo, noisy construction work, noise from rail/roads, industrial noise, noisy amusement parks and noise in building. Even children's toys can produce sounds capable of causing permanent hearing damage.

Different Levels of Noise Decibels

Different levels of noise are depicted in Table 3.1.

Home and office appliances. Much noise in most peoples' lives comes from appliances, machines and gadgets they use in their everyday life. From lawn mowers, mobile phones and microwave ovens that emit noise only when used, to devices like computers and air-conditioners that are always on, noise from home and office machines have serious health repercussions.

A rapid escalation in the use of car stereos nowadays, many outfitted with powerful subwoofers, might contribute to noise pollution when they are driven through the residential neighbourhood at all hours.

Table 3.1 Levels of noise (in decibels)

Level	Noise (in dB)
Library	30
Talking	50–60
Washing machine	61
Television	65–70
Festivals	80–122
Mixie	90–95
Walkman	90–110
Heavy traffic	90–100
Vehicular horns	100–105
Motor cycle	110–115

Effects

Noise pollution can be harmful to animals. High levels of noise pollution may interfere with the natural cycles of animals, which may change their migration paths to avoid the sound. Persistent infrasonic sound, i.e. low frequency sounds can cause physical disturbances to people. For example, diesel generators for refrigerated trucks are a common source for this type of noise pollution.

Following factors tend to establish the human effects of noise pollution:

1. The inherent unpleasantness of the sound
2. The persistence and recurrence of the noise
3. Whether the sound interferes with listener 's activities.

WHO suggests that noise can affect human health and wellbeing in a number of ways, including annoyance reaction, sleep disturbance, interference with communication, performance effects, effects on social behaviour and hearing loss. Noise can cause annoyance and frustration as a result of interference, interruption and distraction. Activity disturbance is regarded as an important indicator of the community impact of noise.

Research into the effects of noise on human health indicates a variety of health effects. People experiencing high noise levels (especially around airports or along road/rail corridors) differ from those with less noise exposure in terms of: increased number of headaches, greater susceptibility to minor accidents, increased reliance on sedatives and sleeping pills and increased mental hospital admission rates.

Exposure to noise is also associated with a range of possible physical effects including: changes in blood pressure, other cardiovascular changes, problems with the digestive system and general fatigue.

There is fairly consistent evidence that prolonged exposure to noise levels at or above 80 dB can cause deafness. The amount of deafness depends upon the degree of exposure.

Noise in our everyday life can permanently damage our hearing. The damage in hearing depends on how loud the noise is and how long you are exposed to it. The damage builds up gradually until there is a permanent damage to hearing. So, preventing excessive exposure to noise is the only way to avoid hearing loss.

Effects of hearing loss due to noise pollution. Hearing loss reduces employability of the hearing impaired. Speech, language and educational delay will result if a child has significant hearing impairment. Other effects of noise are tinnitus, ringing sound in the ear experienced by those exposed to loud noise, which can be reduced by designing equipment that are not as noisy. Increase of public awareness of the dangers of overexposure to noise can lead to the use of ear protectors and the avoidance of dangerous noise exposure.

In addition, loud sounds can cause increased heart rate, blood pressure and respiration; gastrointestinal motility is inhibited; peripheral blood vessels constrict and muscles become tense. Sleep is disturbed; performance is less than optimum; behaviour is altered negatively;

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decreased coordination and concentration; increased stress, which can be usually a long-term process.

It is impossible to know at exactly what point noise becomes loud enough to cause damage to the ears. Seventy decibels can be taken as a safe average for a 24-hour day (this figure is based only on the risk to hearing, and does not take into account other health factors such as loss of sleep).

Since sound intensity doubles with every increase of 3 dB, the time of safe exposure would be cut in half with each such increase.

Prevention of Damage to Hearing Loss

Nowadays however, the risk has spread to children and young adults and has become a common occupational and environmental hazard. The ability to hear is a precious gift. We need to preserve this gift.

- Use of hearing protection such as earplugs or earmuffs should be compulsory for those who are exposed to noise constantly. To be effective, hearing protectors must be snug, airtight and comfortably sealed. Muff-type protectors cover the entire external ear and provide greater protection than do earplugs. If earmuff and earplugs are used together, better will be the protection.
- Protect your children by enclosure around it. Thus a worker should wear ear protection if exposed to a steady 75 dB for 8 hours, 78 dB for 4 hours and so on. Brief exposure to noises of up to 100 dB is not considered risky provided the average remains within the prescribed levels. Noise pollution is not easily defined. Part of the difficulty lies in the fact that in some ways it is different from other forms of pollution.

Law and Noise Pollution

Every citizen has a right of decent environment and they have a right to live peacefully. Right to sleep at night and to have a right to leisure, which are all necessary ingredients of the right of life guaranteed under the Constitution of India. Right to sleep is not only fundamental right; it is to be considered as a basic human right.

Role of the Government

Governments have traditionally viewed noise as a "nuisance" rather than an environmental problem. As a result, most regulation has been left up to local authorities. Where they exist, they may contain a general prohibition against making noise that is a nuisance to other people, or they may set out specific guidelines for the level of noise allowable at certain times of the day and for certain activities. Regardless of how lax or stringent a local law may be, enforcement is difficult.

The police may also act on certain kinds of noise complaints, but generally do not assign them a high priority. Even small values in dB levels mean large differences in terms of sound pressure. It is said that a 65-year-old tribal can hear better than a teenager who subjects himself to a loud music and noise levels which is excess of 85 dB. 60 dB is the normal conversation.

Radiation

Radiation is an important aspect of man's physical environment that has triggered a world wide concern in terms of developing safety standards and protection. There are mainly two types of radiation (see Fig. 3.1): (i) ionizing radiation, and (ii) nonionizing radiation.

Ionizing radiation has the ability to penetrate tissues and deposit energy. It comprises electromagnetic radiations such as X-rays and gamma rays and corpuscular radiations such as alpha particles, beta particles (electrons) and protons.

Nonionizing radiation has a longer wavelength and less energy than the ionizing radiation. It includes ultraviolet radiation, visible light, infrared radiation, microwave radiation and radiation frequency radiation.

Sources of radiation exposure. Man gets exposed to radiation either through natural sources or manmade technologies or activities. Natural radiation may come from cosmic rays, environment and within the body. Environment contributes radiation through the presence of radioactive elements like uranium, radium present in soil and rocks and through radioactive gases like radon and thoron. Internal radiation occurs from radioactive material stored within the body.

Advances in science and technology do contribute to radiation such as X-rays wherein the patients as well providers are involved. Similarly nuclear explosions release tremendous energy.

Biological effects of radiation. Ionizing radiations have profound biological effects such as somatic and genetic effects. Depending on the dose or the exposure, somatic effect may be immediate such as radiation sickness, acute radiation syndrome or delayed like leukaemia, carcinogenesis, fetal developmental abnormalities and shortening of lifespan.

While genetic effects are far reaching, may result from injury to chromosomes—chromosome mutations.

Radiation protection. X-rays constitute a great hazard which needs due consideration. X-ray should be used when indicated and avoided especially in children and pregnant women. Periodic monitoring and surveillance of X-ray machines while giving due attention to safety of the workers has to be carried out. Techniques should improve, dose should be reduced and protective measures such as lead aprons (0.5 of lead) and shields should be used. Workers should wear dosimeter or film

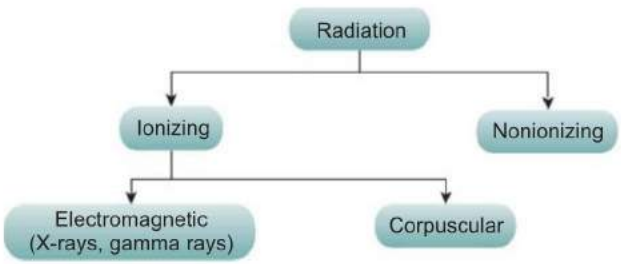


Figure 3.1 Types of radiation.

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badge. Periodic medical examination is mandatory for X-ray workers.

Housing

Housing is much more than the physical structure. It is place where people reside and pursue their goals. WHO expert group (1961) prefers residential environment to housing and is defined as "the physical structure that the man uses and the environs of the structure including all necessary services, facilities, equipment and devices needed or designed for the physical and mental health and the social wellbeing of the family and the individual."

Basically a house should provide a sanitary shelter. There should be sufficient space for family life and related activities. It should be accessible for community service and amenities. There should be scope for family participation in community life. It provides economic stability and overall wellbeing of the family.

Criteria for healthful housing. As per WHO expert committee:

1. Healthful housing provides physical protection and shelter.
2. Provides adequately for cooking, eating, washing and excretory functions.
3. Housing is designed, constructed, maintained and used in a manner such as to prevent the spread of communicable diseases.
4. Provides for protection from hazards of exposure to noise and pollution.
5. Is free from unsafe physical arrangements due to construction or maintenance and from toxic or harmful materials.
6. Encourages personal and community development, promotes social relationships, reflects a regard for ecological principles, and by these means promotes mental health.

Housing standards. There is no universal housing standards. It varies from place to place due to cultural, social and climatic factors. Housing standards are determined by number of factors such as family income, size and composition of the family, standard of living, lifestyle, age and stage, education and cultural factors.

3. WATER POLLUTION

Introduction

Comprising over 70% of the earth's surface, water is undoubtedly the most precious natural resource that exists on our planet. Without the seemingly invaluable compound comprising hydrogen and oxygen, life on earth would be nonexistent: it is essential for everything on our planet to grow and prosper. Although we as humans recognize this fact, we disregard it by polluting our rivers, lakes and oceans. Subsequently, we are slowly but surely harming our planet to the point where organisms are dying at a very alarming rate. In addition to innocent organisms dying off, our drinking water has become greatly affected, as is our ability to use water for recreational purposes. In order to combat water pollution, we must understand the problems and become part of the solution.

When toxic substances enter lakes, streams, rivers, oceans and other water bodies, they get dissolved or lie suspended in water or get deposited on the bed. This results in pollution of water whereby quality of the water deteriorates, affecting aquatic ecosystems. Pollutants can also seep down and affect the groundwater deposits.

Water pollution has many sources. The most polluting of them are the city sewage and industrial waste discharged into the rivers. The facilities to treat wastewater are not adequate in any city in India. Presently, only about 10% of the wastewater generated is treated; the rest is discharged as it is into our water bodies. Due to this, pollutants enter groundwater, rivers and other water bodies. Such water, which ultimately ends up in our households, is often highly contaminated and carries disease-causing microbes. Agricultural run-off, or the water from the fields that drains into rivers, is another major water pollutant as it contains fertilizers and pesticides.

Water pollution occurs when a body of water is adversely affected due to addition of large amounts of materials to the water. The sources of water pollution are categorized as being a point source or a non-source point of pollution. Point sources of pollution occur when the polluting substance is emitted directly into the waterway. A pipe spewing toxic chemicals directly into a river is an example. A non-source point of pollution occurs when there is run-off of pollutants into a waterway, for instance when fertilizer from a field is carried into a stream by surface run-off.

Types of Water Pollution

Toxic substance. For example, herbicides, pesticides and industrial compounds.

Organic substance. For example, manure or sewage.

Thermal pollution. Thermal pollution can occur when water is used as a coolant near a power or industrial plant and then is returned to the aquatic environment at a higher temperature than it was originally before. Thermal pollution can lead to a decrease in the dissolved oxygen level in the water while also increasing the biological demand of aquatic organisms for oxygen.

Ecological pollution. Ecological pollution takes place when chemical pollution, organic pollution or thermal pollution is caused by nature rather than by human activity. An example of ecological pollution would be an increased rate of siltation of a waterway after a landslide which would increase the amount of sediments in run-off water.

Sources of Pollution

- Industrial waste (e.g. various chemical wastes produced as a result of the manufacturing process)
- Domestic waste (e.g. waste food, toilet and sewage, kitchen or sullage water, solid wastes such as paper, plastic, etc.) Agricultural waste (e.g. pesticide residues, fertilizers, animal excreta, etc.)
- Hazardous hospital wastes (e.g. needles and syringes used, gloves, blood and organic material, plastic intravenous tubes, etc.)

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- Hotel wastes (e.g. left-over food, utensil cleaning water, etc.)
- Automobile exhausts (e.g. carbon monoxide, sulphur dioxide, etc.)
- Urban waste (e.g. discarded building material, etc.) Excessive noise due to industry, vehicle, etc.
- Thermal pollution due to radiant heat from asphalted roads, buildings, etc.
- Radiation pollution.

All the previously mentioned wastes pollute the atmosphere chemically, physically, biologically and even psychologically.

Health Impacts of Water Pollution

It is a well-known fact that clean water is absolutely essential for healthy living. Adequate supply of fresh and clean drinking water is a basic need for all human beings on the earth, yet it has been observed that millions of people worldwide are deprived of this.

Freshwater resources all over the world are threatened not only by over exploitation and poor management but also by ecological degradation. The main source of freshwater pollution can be attributed to discharge of untreated waste, dumping of industrial effluent and run-off from agricultural fields. Industrial growth, urbanization and the increasing use of synthetic organic substances have serious and adverse impacts on freshwater bodies. It is a generally accepted fact that the developed countries suffer from problems of chemical discharge into the water sources mainly *groundwater,* while developing countries face problems of agricultural run-off in water sources. Polluted water, like *chemicals in drinking water,* causes problem to health and leads to *waterborne diseases* which can be prevented by taking measures that can be taken even at the household level.

Waterborne Diseases

Waterborne diseases are infectious diseases spread primarily through contaminated water. Though these diseases are spread either directly or through flies or filth, water is the main medium for spread of these diseases, hence they are termed as waterborne diseases.

Most intestinal (enteric) diseases are infectious and are transmitted through faecal waste. Pathogens—which include virus, bacteria, protozoa, and parasitic worms— are disease-producing agents found in the faeces of infected persons (Table 3.2). These diseases are more prevalent in areas with poor sanitary conditions. These pathogens travel through water sources and interfuses directly through persons handling food and water. Since these diseases are highly infectious, extreme care and hygiene should be maintained by people looking after an infected patient. Hepatitis, cholera, dysentery and typhoid are the more common waterborne diseases that affect large populations in the tropical regions (see Fig. 3.2).

Water Purification Methods

Water purification would be an important component of community health care. It must be emphasized that the quantity of water available is as important as the quality of water. Larger quantity of water availability leads to an easier adoption of cleanliness behaviour rather than only higher quality of water.

There are various methods of water purification:

Home-based methods.

i. Boiling for 20 minutes or till "roll boiling" (i.e. appearance of large bubbles arising continuously while boiling). This is the ideal method which also kills spores, but it requires easy and cheap availability of fuel, time, extra vessel, etc.

Table 3.2 Causal organisms and water borne diseases

Cause	Water borne Diseases
Bacterial infections	Typhoid Cholera Paratyphoid fever Bacillary dysentery
Viral infections	Infectious hepatitis (jaundice) Poliomyelitis
Protozoal infections	Amebic dysentery and giardiasis
Helminthic infections	Roundworm, threadworm
Cyclops	Guinea worm, fish tapeworm

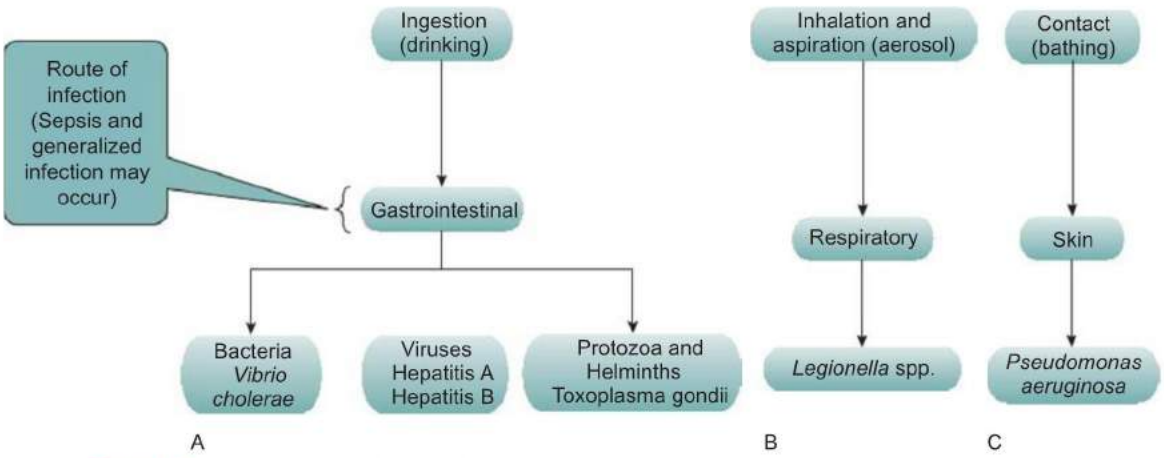


Figure 3.2 Transmission pathways for and examples of common water borne diseases.

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ii. Chlorination of water using chlorine tablets.
iii. Filtration using special clay candles and various types of membranes. This only prevents bacterial contamination but not viral contamination (e.g. viral diarrhoea, hepatitis, polio, etc.).
iv. Defluoridation method for removing excess fluorine (which causes dental fluorosis) by the Nalgonda technique using dried and burnt paddy husk.
v. Sedimentation by storing water, which results in bacteria, etc. settling to the bottom of the vessel.
vi. Use of alum crystals leads to coagulation i.e. clumping of bacteria and settling to the bottom of the vessel.
vii. Clean water to be stored in closed vessels with cheap plastic taps for taking water out by slow decantation (tilting the vessel to pour out required amount of water instead of dipping in glasses to fill the water).

Community-based methods

i. Chlorinating drinking water wells using bleaching powder to achieve a minimum of two parts of chlorine per million parts of water.
ii. Using sand filters followed by large scale chlorination and providing the water through community-based centralised large closed water tanks fitted with multiple taps.
iii. Using deep bore-wells fitted with hand pumps.
iv. Maintaining a separate drinking water dug-well (separate from irrigation water wells). These drinking water wells must have a cover fitted with hand pumps and used only for collecting drinking water. The well should be dug deep enough to cross the first impervious (hard layer such as clay) layer of soil deep in the ground. This is to prevent surface contamination from seeping (sinking) into the bottom of the well.

Monitoring International Standards for Drinking Water

Standards for international requirements take into consideration any specific regional or local requirements for quality control.

1. By measuring the bacterial quality of water through the presumptive coliform count method (laboratory based count for coliform bacteria in drinking water sample). Presence of coliform bacteria (especially *Escherichia coli* bacteria) in the water indicates faecal contamination. The count should be ideally zero.
2. By surveying the drinking water well area for maintenance of sanitary measures.
3. Doing a biological examination to look for microscopic organisms (e.g. algae, protozoa, etc.) in the drinking water sample.

Water Treatment Methods

Screening. A municipal surface water treatment plant must first screen or sieve out large objects such as trash and leaves. The tighter the mesh of the sieve, the smaller the particles must be to pass through. Filtering is not sufficient to completely purify water, but it is often a necessary first step, since such particles can interfere with the more thorough purification methods.

Storage. Water from rivers may also be stored in bank side reservoirs for periods between a few days and many months to allow natural biological purification to take place. By mere storage the quality of water improves and about 90% of the suspended impurities settle down in 24 hours by gravity, and water becomes clearer and it allows penetration of light and reduces the work of the filters. Certain chemical changes also take place during storage. On account of aerobic bacteria oxidizing the organic matter present in the water with the help of dissolved oxygen, the content of free ammonia of nitrates level will rise. From the biological point of view, a significant drop takes place in bacterial count during storage and as much as 90% of bacterial count drops in first 5–7 days. This is one of the greatest benefits of storage.

Filtration. This is second stage in purification of water and it is very important stage because 96–99% of bacteria are removed by filtration. There are two types of filters: (i) biological or slow sand filters (Fig. 3.3) and (ii) mechanical or rapid sand filters (Fig. 3.4).

1. Slow Sand Filters: *Elements of slow sand filters*

- Raw water
- Graded sand belt
- Under drainage system.

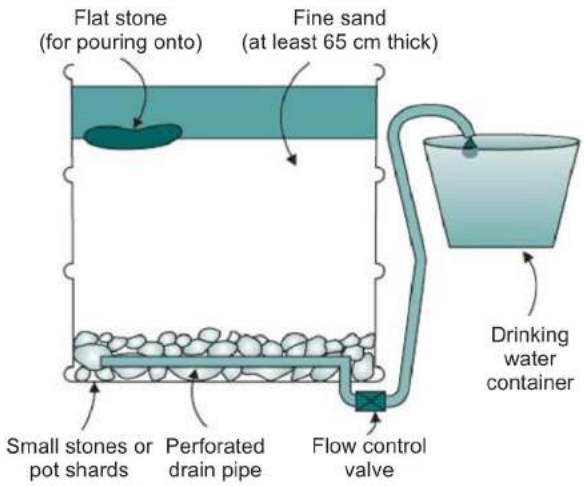


Figure 3.3 Slow sand filters.

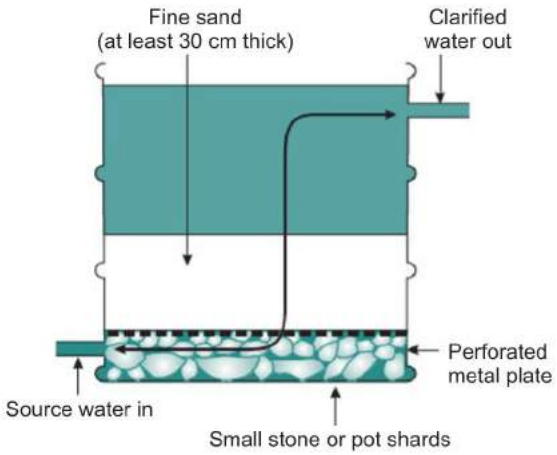


Figure 3.4 Mechanical or rapid sand filters.

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Where land and space are available, water may be treated in slow sand filter beds. These rely on biological treatment processes for their action rather than physical filtration. Slow sand filters are carefully constructed using graded layers of sand with the coarsest at the base and the finest at the top. Drains buried at the base of the filter convey treated water away for disinfection. When a new slow sand filter bed is brought into use, raw water is carefully decanted onto the filter material until a water depth of 1 to 3 m is achieved, dependent on the size of the filter bed. The water passing through the filter for the first few hours is recirculated through the filter and not put into supply. Within a few hours, a biological film comprising of bacteria, protozoa, fungi and algae builds on the surface of the sand. This is the Schmutzdecke layer and it is this layer that removes all the impurities. This is also called "vital layer," "zoogleal" or biological layer. This layer is slimy and gelatinous and consists of thread-like algae and numerous bacteria.

The vital layer is heart of the slow sand filters and removes organic matter, filters bacteria and oxidizes ammoniacal nitrogen into nitrates and helps in yielding bacteria free water. Until the vital layer is fully formed in the first few days the filtrate is usually run to waste.

Normally the filter may run for weeks or months without cleaning. When the bed resistance increases then filter bed has to be cleaned. The supernatant water is drained off and sand bed is cleaned by scraping off the top portion of the sand layer to a depth of 1.5 to 2.5 cm.

Advantages

1. Simple to construct and operate
2. The physical, chemical and biological quality of filter water is very good
3. It is cheaper than the rapid sand filters
4. Slow sand filters have been very effective to reduce total bacterial counts by 99 to 99.99%.

2. Rapid Sand Filters: Rapid sand filters are mainly of two types: (i) the **gravity type** (Paterson's filter) and (ii) **pressure type** (Candy's filter). Following steps are involved by rapid sand filters in purification of water:

1. *Coagulation:* Raw water is first treated with chemical agent, coagulant such as alum, from 5–40 mg per litre.
2. *Rapid mixing:* The treated water is then subjected to vigorous agitation in a mixing chamber for few minutes. This allows a thorough dissemination of alum with water.
3. *Flocculation:* This involves a slow and gentle stirring of such treated water in a flocculated chamber for a period of 30 minutes. The most commonly used flocculator is of mechanical type. The slow *and* gentle stirring results in formation of thick, copious and white precipitate of aluminium hydroxide. The thicker the precipitate, the greater will be the settling velocity.
4. *Sedimentation:* The coagulated water is allowed into sedimentation tank and it is detained for 2 to 6 hours allowing for impurities and bacteria along with flocculant precipitate to settle down in this tank. At least 94% of the flocculant precipitate needs to be removed before water is admitted into rapid sand filters. For proper and better maintenance, tanks should be cleaned regularly from time to time.

Table 3.3 Contents of filter box

Raw (supernatant) water	—	1–1.5 m
Sand bed	—	1.2 m
Gravel support	—	0.35 m
Filter bottom	—	0.2 m

Filter bed. Each unit of filter bed has surface of about 90 to 100 square feet and sand is the filter medium. Size of the particles is between 0.4 and 0.7 mm. The depth of the sand bed is usually about 1 metre and below this bed is a layer of graded gravel between 30 and 40 cm deep. The depth of the water on the top of the sand bed is about 1 to 1.5 m. The rate of filtration is about 6–16 cubic metre/square metre/hour (Table 3.3).

Filtration. The alum floc, which is not removed by sedimentation, is held back on the sand bed. This forms a slimy layer comparable to the zoogleal layer in the slow sand filters. It adsorbs bacteria from the water. As filtration proceeds the suspended impurities and bacteria clog the filters, and in turn the filters will become dirty and will begin to lose their efficiency of filtering. When **loss of the head** reaches about 7 to 8 feet, filtration stops and filters are subjected to washing, thus this process is known as backwashing. Rapid sand filters require frequent washing either daily or weekly depending upon the loss of head. Washing is accomplished by reversing the flow of water through sand bed which is called backwashing. The whole process of washing takes place in about 15 to 20 minutes, and in some rapid sand filters compressed air is used as a part of the backwashing process.

Advantages of Rapid Sand Filters Over the Slow Sand Filters are:

1. Rapid sand filter can deal with raw water directly. No previous storage needed
2. The space required for filter bed is less
3. Filtration is quite rapid, 40 to 50 times that of slow sand filters
4. Washing and cleaning of the filter is easy.

Disinfection. The finished water is then disinfected with chlorine gas, chloramine, perchloron sodium hypochlorite, chlorine dioxide, ozone or ultraviolet light, before it is pumped into the distribution system of water mains and storage tanks on its way to consumers. Some plants also prechlorinate their raw water influent after the screening phase to reduce the incidence of biological films in the treatment cycle. They may also prechlorinate to oxidize and precipitate out dissolved iron and manganese from the water.

A chemical agent to be potentially useful disinfectant has to satisfy the following criteria:

1. It should be capable of destroying the pathogenic organisms present and not unduly influenced by physical and chemical properties of water, pH and mineral constituents.
2. It should not leave products of reaction which might make water toxic or make it unpotable.

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3. It should be dependable and readily available at reasonable cost permitting for most convenient safe and accurate application to water.

Chlorination. Chlorination is one of the best advances in purification of water. It is supplement and not a substitute to sand filtration; chlorine kills all pathogenic bacteria but unfortunately has no effect on spores and certain viruses except in high doses. Apart from its germicidal effects, it has a value in water treatment: it oxidizes iron, manganese and hydrogen sulphide. It also destroys some taste and odour producing constituents.

Action of chlorine: When chlorine is added to water, there is formation of hydrochloric and hypochlorous acids. The hydrochloric acid is neutralized by the alkalinity of the water. The hypochlorous acid ionizes to form hydrogen ions and hypochlorate ions. The disinfecting action of chlorine is mainly due to hypochlorous acid and to a small extent due to hypochlorite ions. The hypochlorous acid is the most effective form of chlorine for water disinfection. Chlorine acts best as a disinfectant when the pH of water is around 7, and when the pH exceeds 8.5 it is unreliable as a disinfectant because most of the hypochlorous acid (90%) gets ionized to hypochlorite ions.

Method of chlorination: Disinfecting the water on large scale, chlorine is applied in the form of:

1. Chlorine gas
2. Chloramine
3. Perchloran.

Chlorine gas is the first preference because it is quick in action, efficient, cheap and easy to apply. It requires a special equipment known as "chlorinating equipment," as chlorine is irritant to the eye and poisonous.

Chloramine is a loose compound of chlorine and ammonia. The greatest drawback of chloramines is that they have a slower action.

Perchloran or highest hypochlorite is a calcium compound which carries 50 to 60% of available chlorine.

Breakpoint chlorination: Addition of chlorine to ammonia in water produces chlorine which does not have same efficiency and effect as that of free chlorine. If the chlorine dose in the water is increased, a reduction in the residual chlorine occurs due to destruction of chloramines by the added chlorine. The end products do not represent any residual chlorine. This fall in residual chlorine will continue with further increase in chlorine dose and after some stage, the residual chlorine will begin to increase in proportion to the added dose of chlorine. This point at which the residual chlorine appears and when all combined fluorines have been completely destroyed is the *breakpoint,* and corresponding dose is the *breakpoint dosage.*

Other water purification techniques. Other popular methods for purifying water, especially for local private supplies are listed in the following. In some countries some of these methods are also used for large scale municipal supply. Particularly important are distillation (desalination of sea water) and reverse osmosis.

1. ***Carbon filtering:*** Charcoal, a form of carbon with a high surface area due to its mode of preparation, adsorbs many compounds, including some toxic compounds. Water is passed through activated charcoal to remove such contaminants. This method is most commonly used in household water filters and fish tanks. Household filters for drinking water sometimes also contain silver, trace amounts of silver ions having a bactericidal effect.
2. ***Distilling (Fig. 3.5):*** Distillation involves boiling the water to produce water vapour. The water vapour then rises to a cooled surface where it can condense back into a liquid and be collected. Because the solutes are not normally vaporized, they remain in the boiling solution. Even distillation does not completely purify water because of contaminants with similar boiling points and droplets of unvapourised liquid carried with the steam. However, 99.9% pure water can be obtained by distillation.
3. ***Reverse osmosis (Fig. 3.6):*** Mechanical pressure is applied to an impure solution to force pure water through a *semipermeable membrane.* The term is *reverse osmosis,* because normal osmosis would result in pure water moving in the other direction to dilute the impurities. Reverse osmosis is theoretically the most thorough method of large scale water purification available, although perfect semipermeable membranes are difficult to create.
4. ***Ion exchange:*** Most common ion exchange systems use a zeolite resin bed and simply replace unwanted Ca^{2+} and Mg^{2+} ions with benign (soap friendly) Na^{+} or K^{+} ions. This is the common water softener. A more rigorous type of ion exchange swaps H^{+} ions for unwanted cations and hydroxide (OH) ions for unwanted anions. The result is $H^{+} + OH^{-} \rightarrow H_2O$ This system is recharged with hydrochloric acid and sodium hydroxide, respectively. The result is essentially *deionized water.*

Portable water purification. Portable drinking water systems or chemical additives are available for hiking, camping and travel in remote areas. Portable pump filters are commercially available with ceramic filters that will filter 5,000 to 50,000 litres per cartridge. Some also utilize activated charcoal filtering.

Chemical additives include chlorine dioxide or iodine solutions.

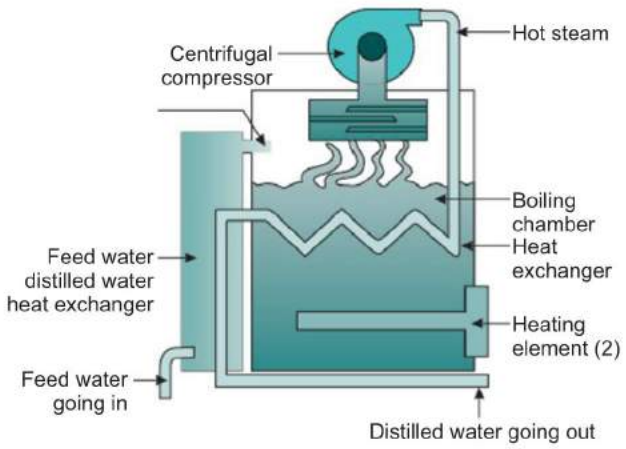


Figure 3.5 Distillation process of water purification.

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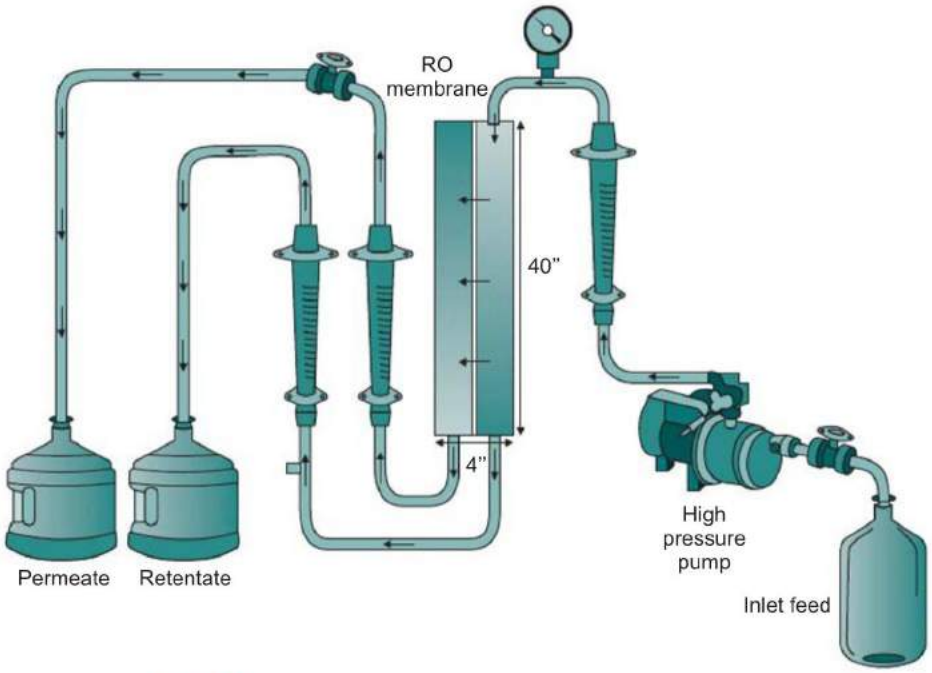


Figure 3.6 Reverse osmosis process of water purification.

Iodine, in solution, crystallized or in tablets, is added to water. Iodine kills off many, but not all of the most common pathogens that may be present in natural freshwater sources such as lakes, rivers and streams. Carrying iodine for water purification is light in weight.

Chlorine bleach can also be used as an emergency measure. The correct amount is dropped into the water, and then it is covered for 30 minutes or 1 hour. After this it may be left open to reduce the chlorine smell and taste.

Neither chlorine (e.g. bleach) nor iodine alone is considered effective against *Cryptosporidium,* and they are limited in effectiveness against *Giardia* (chlorine is slightly better than iodine against *Giardia).*

Solar disinfection. Microbes are destroyed through temperature and UVA radiation, provided by the sun. Water is placed in a transparent plastic bottle, which is oxygenated by shaking, followed by topping-up. It is placed on tile or metal for 6 hours in full sun, which raises the temperature and gives an extended dose of solar radiation, killing any microbes that may be present. The combination of the two provides a simple method of disinfection for tropical developing countries.

Water quality—criteria and standards for potable water. The guidelines for drinking water as per WHO is based on four aspects:

1. Acceptability aspects.
2. Microbiological aspects.
3. Chemical aspects.
4. Radiological aspects.

1. **Acceptability aspects:** The acceptability of drinking water to consumers is subjective and can be influenced by many different constituents:
   a. ***Physical parameters***
      Taste, odour and appearance: Taste and odour can originate from natural inorganic and organic chemical contaminants and biological sources or processes (e.g. aquatic microorganisms), from contamination by synthetic chemicals, from corrosion or as a result of water treatment (e.g. chlorination). Taste and odour may also develop during storage and distribution due to microbial activity. *Colour:* Drinking water should ideally have no visible colour. Colour is also strongly influenced by presence of iron and other metals, either as natural impurities or as corrosion products. *Hardness:* Hardness caused by calcium and magnesium is usually indicated by precipitation of soap scum and the need for excess use of soap to achieve cleaning. Public acceptability of the degree of hardness of water may vary considerably from one community to another, depending on local conditions. *pH and corrosion:* Although pH usually has no direct impact on consumers, it is one of the most important operational water quality parameters. For effective disinfection with chlorine, pH should preferably be less than 8; however, lower pH water is likely to be corrosive. The pH of the water entering the distribution system must be controlled to minimize the corrosion of water mains and pipes in household water systems. *Turbidity:* Turbidity in drinking water is caused by particulate matter that may be present from source water as a consequence of inadequate filtration or from resuspension of sediment in the distribution system. It may also be due to the presence of inorganic particulate matter in some groundwaters or sloughing of biofilm within the distribution system. The appearance of water with a turbidity of less than 5 NTU is usually acceptable to consumers, although this may vary with local circumstances. *Temperature:* Cool water is generally more palatable than warm water, and temperature will impact on the acceptability of a

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Table 3.4 Inorganic constituents in potable water and their recommended guideline values (WHO)

Inorganic Constituent	Main Use	Guideline Value
Aluminium	Aluminium is the most abundant metallic element and constitutes about 8% of the Earth's crust. Aluminium salts are widely used in water treatment as coagulants to reduce organic matter, colour, turbidity and microorganism levels.	0.2 mg/litre or less
Chlorine	Chlorine is produced in large amounts and widely used both industrially and domestically as an important disinfectant and bleach.	5 mg/litre
Copper	Copper is both an essential nutrient and a drinking water contaminant. It has many commercial uses. It is used to make pipes, valves and fittings and is present in alloys and coatings.	2 mg/litre
pH	—	range 6.5– 9.5
Manganese	Manganese is one of the most abundant metals in the Earth's crust, usually occurring with iron. It is used principally in the manufacture of iron and steel alloys, as an oxidant for cleaning, bleaching and disinfection as potassium permanganate and as an ingredient in various products.	0.4 mg/litre
Sodium	Sodium salts (e.g., sodium chloride) are found in virtually all food (the main source of daily exposure) and drinking water.	200 mg/ litre

number of other inorganic constituents and chemical contaminants that may affect taste. High water temperature enhances the growth of microorganisms and may increase taste, odour, colour and corrosion problems.

b. ***Inorganic constituents*** (see Table 3.4).

2. **Microbiological aspects**
   a. ***Biological indicators:*** Ideally, drinking water should be free from pathogenic microbes; the primary bacterial indicator is coliform supplemented by faecal streptococci and sulphite reducing clostridia.
   b. ***Virological aspects:*** Drinking water should be free from any viruses infections for man.
   c. ***Biological aspects:*** Drinking water should not contain any pathogenic intestinal protozoa and helminths and also free living organisms such as algae and fungi.

   Microbial water quality: For microbial water quality, verification is likely to include microbiological testing. In most cases, it will involve the analysis of faecal indicator microorganisms, but in some circumstances it may also include assessment of specific pathogen densities (Table 3.5).
3. **Chemical aspects:** Prolonged periods of exposure of certain chemicals in water cause adverse health effects. These include inorganic chemicals and organic chemicals (Table 3.6).
4. **Radiological aspects:** Radioactivity in drinking water should be maintained within safe limits and kept as low as possible. The proposed guideline values are:
   Gross alpha activity 0.1 Bq/l
   Gross beta activity 1.00 Bq/l
   (Bq Becqueral-unit of activity
   1Bql disintegration per second)

To a large extent, consumers have no means of judging the safety of their drinking water themselves, but their attitude towards their drinking water supply and their drinking water suppliers will be affected to a considerable extent by the aspects of water quality that they are able to perceive with their own senses. It is natural for consumers to regard with suspicion water that appears dirty or discoloured or that has an unpleasant taste or smell, even though these characteristics may not in themselves be of direct consequence to health.

Table 3.5 Microbial constituents in potable water and their recommended guideline values (WHO)

Organisms	Guideline Value
All water directly intended for drinking: *Escherichia coli* or thermotolerant coliform bacteria	Must not be detectable in any 100-ml sample
Treated water entering the distribution system: *E. coli* or thermotolerant coliform bacteria	Must not be detectable in any 100-ml sample
Treated water in the distribution system: *E. coli* or thermotolerant coliform bacteria	Must not be detectable in any 100-ml sample

The appearance, taste, colour and odour of drinking water should be acceptable to the consumer.

Health-based targets: Health-based targets are an essential component of the drinking water safety framework. Health-based targets provide the basis for application of guidelines to all types of drinking water supply. Constituents of drinking water may cause adverse health effects from single exposures (e.g. microbial pathogens) or long-term exposures (e.g. many chemicals).

Preventive Measures

Waterborne epidemics and health hazards in the aquatic environment are mainly due to improper management of water resources. Proper management of water resources has become the need of the hour as this would ultimately lead to a cleaner and healthier environment.

In order to prevent the spread of waterborne infectious diseases, people should take adequate precautions. City water supply should be properly checked and necessary steps taken to disinfect it. Water pipes should be regularly checked for leaks and cracks. At home, water should be boiled, filtered or other methods, and necessary steps taken to ensure that it is free from infection.

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Table 3.6 Chemical contaminants in potable water and their maximum permissible recommended guideline values (WHO)

Constituent	Main Use	Guideline Value
Acrylamide	Residual acrylamide monomer occurs in polyacrylamide coagulants used in the treatment of drinking water.	0.0005 mg/litre (0.5 mg/litre)
Alachlor	Alachlor (CAS No. 15972-60-8) is a pre-and post-emergence herbicide used to control annual grasses and many broad-leaved weeds in maize and a number of other crops.	0.02 mg/litre
Aldicarb	Aldicarb (CAS No. 116-06-3) is a systemic pesticide used to control nematodes in soil and insects and mites on a variety of crops. It is very soluble in water and highly mobile in soil.	0.01 mg/litre
Arsenic	Arsenic is widely distributed throughout the Earth's crust, most often as arsenic sulphide or as metal arsenates and arsenides.	0.01 mg/litre
Barium	Barium is present as a trace element in both igneous and sedimentary rocks, and barium compounds are used in a variety of industrial applications.	0.7 mg/litre
Benzene	Benzene is used principally in the production of other organic chemicals. It is present in petrol, and vehicular emissions constitute the main source of benzene in the environment.	0.01 mg/litre

The Environment (Protection) Act 1986

The act is a general measure for the protection of the environment. It extends over 26 sections and gives exclusive powers to the government and various other public authorities to take various measures for protecting the environment (water, air and land).

CONCLUSION

Clearly, problems associated with water pollution have the capabilities to disrupt life on our planet to a great extent. The government has passed laws to try to combat water pollution thus acknowledging the fact that water pollution is, indeed, a serious issue. But government alone cannot solve the entire problem. It is ultimately up to us, to be informed, responsible and involved when it comes to the problems we face with our water. We must become familiar with our local water resources and learn about ways for disposing harmful household wastes so they do not end up in sewage treatment plants that cannot handle them or landfills not designed to receive hazardous materials.

In our yards, we must determine whether additional nutrients are needed before fertilizers are applied, and look for alternatives where fertilizers might run off into surface waters. We have to preserve existing trees and plant new trees and shrubs to help prevent soil erosion and promote infiltration of water into the soil. Around our houses, we must keep litter, pet waste, leaves and grass clippings out of gutters and storm drains. These are just a few of the many ways in which we, as humans, have the ability to combat water pollution.

Awareness and education will most assuredly continue to be the two most important ways to prevent water pollution. If these measures are not taken and water pollution continues, life on earth will suffer severely.

Global environmental collapse is not inevitable. But the developed world must work with the developing world to ensure that new industrialized economies do not add to the world's environmental problems. Conservation strategies have to become more widely accepted, and people must learn that energy use can be dramatically diminished without sacrificing comfort. In short, with the technology that currently exists, the years of global environmental maltreatment can be reversed.

SOLID WASTE MANAGEMENT

INTRODUCTION

As the cities are growing in size and in problems, such as the generation of refuse including plastic waste, various municipal waste treatment and disposal methods are now being used to try and resolve these problems. One common sight in all cities is the rag picker who plays an important role in the segregation of this waste.

Garbage generated in households can be recycled and reused to prevent creation of waste at source and reducing amount of waste thrown into the community dustbins.

Solid waste can be classified into different types depending on their source: (a) household waste is generally classified as municipal waste, (b) industrial waste as hazardous waste and (c) biomedical waste or hospital waste as infectious waste.

(a) Household waste: The domestic waste consists of garbage like food wastes, cooking wastes and rubbish which consists of paper, cloths, metal, old batteries, old medicines, etc. Domestic waste can be hazardous.

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(b) Hazardous waste: Industrial and hospital waste is considered hazardous as they may contain toxic substances. Certain types of household wastes are also hazardous. Hazardous wastes could be highly toxic to humans, animals and plants; are corrosive, highly inflammable or explosive and react when exposed to certain things, e.g. gases. India generates around 7 million tonnes of hazardous wastes every year, most of which is concentrated in four states: Andhra Pradesh, Bihar, Uttar Pradesh and Tamil Nadu.

(c) Biomedical waste: It means any waste which is generated during the diagnosis, treatment or immunization of human being or animals or in research activities pertaining thereto or in the production or testing of biological materials.

General Waste Disposal Methods

The methods of disposal depend on the type of waste (e.g. solid wastes, liquid wastes, vapours and gases, sullage, sewage, etc.). These methods could be as follows:

a. Incineration is burning waste at high temperature using fuel or electrical incinerators. However incineration itself may produce fumes and smoke and suspended dust particles in the atmosphere.

b. Burial (i.e. digging large pits into which the waste is placed and covered over with soil): Very often urban buildings are built over these covered sites. This could lead to contamination of underground water, which may later be wrongly used for drinking (e.g. digging drinking water wells).

c. Dumping on land. This method is very common in rural areas where agricultural waste is merely dumped in a vacant spot and these often become breeding grounds for disease carrying flies etc.

d. Dumping in the sea. Very often toxic industrial wastes and radioactive substances are taken to the seas and oceans and dumped into the seawater. This often kills marine life. Petroleum products being carried by ships can also sink or be damaged leading to pollution by chemicals such as lead, mercury, benzene, etc. which often reaches the sea shore or fishes get contaminated. In this way, the toxic materials ultimately reach the land and affect the health of the human beings.

e. Dumping in the river. Factories are very often built near the river and their polluted industrial liquid waste is let off into the river. The river water is often used for drinking, bathing, etc. and thus humans get affected.

DISPOSAL OF WASTES

Disposal of wastes is now largely the domain of sanitarians and public health engineers. However, health professionals need to have a basic knowledge of the subject since improper disposal of wastes constitutes a health hazard. Further, the health professional may be called upon to give advice in some special situations, such as camp sanitation or coping with waste disposal problems when there is a disruption or breakdown of community health services in natural disasters. These aspects are considered in this chapter.

SOLID WASTES

The term "solid wastes" includes garbage (food wastes), rubbish (paper, plastics, wood, metal, throwaway containers, glass), demolition products (bricks, masonry, pipes), sewage treatment residue (sludge and solids from the coarse screening of domestic sewage), dead animals, manure and other discarded materials. Strictly speaking, it should not contain night soil. In India and similar other countries, it is not uncommon to find night soil in collection of refuse. The output of daily waste depends upon the dietary habits, lifestyles, living standards and the degree of urbanization and industrialization. The per capita daily solid waste produced ranges between 0.25 and 2.5 kg in different countries.

Solid waste, if allowed to accumulate, is a health hazard because:

a. It decomposes and favours fly breeding
b. It attracts rodents and vermin
c. The pathogens which may be present in the solid waste may be conveyed back to man's food through flies and dust. And also there is a possibility of water and soil pollution
d. Heaps of refuse present an unsightly appearance and nuisance from bad odours.

Usually there is a correlation between improper disposal of solid wastes and incidence of vector-borne diseases. Therefore, in all developed countries, there is an efficient system for collection, removal and final disposal without any risk to health.

Sources of Refuse

Street refuse. Refuse that is collected by the street cleansing service or venging is called street *refuse*. It consists of leaves, straw, paper, animal droppings and litter of all kinds.

Market rufuse. Refuse that is collected from markets is called *market refuse*. It contains a large proportion of putrid vegetable and animal matter.

Stable litter. Refuse that is collected from stables is called *stable litter*. It contains mainly animal droppings and leftover animal feeds.

Industrial refuse. This comprises a wide variety of wastes ranging from completely inert materials such as calcium carbonate to highly toxic and explosive compounds.

Domestic refuse. The domestic *refuse* consists of ash, *rubbish* and *garbage*. Ash is the residue from fire used for cooking and heating. Rubbish comprises paper, clothing, bits of wood, metal, glass, dust and dirt. Garbage is waste matter arising from the preparation, cooking and

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consumption of food. It consists of waste food, vegetable peelings and other organic matter. Garbage needs quick removal and disposal because it ferments on storage.

Storage

The first consideration should be given to the proper storage of refuse while awaiting collection. The galvanized steel dustbin with close fitting cover is a suitable receptacle for storing refuse. The capacity of a bin depends upon the number of users and frequency of collection. Nowadays, in the western countries the "paper sack" is used. Refuse is stored in the paper sack, and the sack itself is removed with the contents for disposal, and a new sack is substituted subsequently.

Public bins. Public bins cater for storage of garbage from household. They are usually without cover in India because people do not like to touch them. They are kept on a concrete platform raised 2 to 3 inches above ground level to prevent flood water entering the bins. In bigger municipalities, the bins are handled and emptied mechanically by lorries fitted with cranes.

Collection

The method of collection depends upon the resources. House-to-house collection is by far the best and effective method of collecting refuse. Unfortunately in India, this type of collection system is not there. People are expected to dump the refuse in the nearest public bin, which is usually not done. Refuse is generally dispersed all along the street, and some is thrown out in front and around the house and on the street. As a result, an army of sweepers is required for sweeping the streets in addition to the gang for collecting the refuse from public bins. The refuse is then transported in refuse collection vehicles to the place of ultimate disposal. Dead animals are directly transported to the place of disposal.

The collection methods normally practised in India need drastic revision and improvement in the interest of better hygiene. Environmental Hygiene Committee (1949) recommended that municipalities and other local bodies should arrange for collection of refuse not only from the public bins but also from individual houses. A house-to-house collection results in a simultaneous reduction in the number of public bins. The open refuse cart should be abandoned and replaced by enclosed vans. Mechanical transport should be used wherever possible, as it is more practical and economical than the 19th century methods. There is a wide variety of refuse collection vehicles of all shapes and sizes. The latest arrival in the western countries is the "dustless refuse collector" which has a totally enclosed body, and this is one of the best methods.

Methods of Disposal

There is no single method of refuse disposal, which is equally suitable in all circumstances. The choice of a particular method is governed by local factors such as cost and availability of land and labour. The principal methods of refuse disposal are:

a. Dumping
b. Controlled tipping or sanitary landfill
c. Incineration
d. Composting
e. Manure pits
f. Burial.

a. Dumping. Refuse is dumped in low lying areas partly as a method of reclamation of land but mainly as an easy method of disposal of dry refuse. As a result of bacterial action, refuse decreases considerably in volume and is converted gradually into humus. Kolkata disposes of its refuse by dumping, and the reclaimed land is leased out for cultivation. Drawbacks of open dumping are:

i. The refuse is exposed to flies and rodents
ii. It is a source of nuisance from the smell and unsightly appearance
iii. The loose refuse is dispersed by the action of the wind
iv. Drainage from dumps contributes to the pollution of surface and groundwater.

A WHO Expert Committee (1967) condemned dumping as "the most insanitary method that creates public health hazards, a nuisance and severe pollution of the environment." Dumping should be outlawed and replaced by sound procedures.

b. Controlled tipping. Controlled tipping or sanitary landfill is the most satisfactory method of refuse disposal where suitable land is available. It differs from ordinary dumping in that the material is placed in a trench or other prepared area, adequately compacted and covered with earth at the end of the working day. The term "modified sanitary landfill" has been applied to those operations where compaction and covering are accomplished once or twice a week.

Three methods are used in this operation: the trench method, the ramp method and the area method.

(i) *The trench method:* Where level ground is available, the trench method is usually chosen. A long trench is dug out—2 to 3 m (6–10 ft) deep and 4 to 12 m, (12–36 ft) wide, depending upon local conditions. The refuse is compacted and covered with excavated earth. Where compacted refuse is placed in the fill to a depth of 2 m (6 ft), it is estimated that 1 acre of land per year will be required for 10,000 population.

(ii) *The ramp method:* This method is well suited where the terrain is moderately sloping. Some excavation is done to secure the covering material.

(iii) *The area method:* This method is used for filling land depressions, disused quarries and clay pits. The refuse is deposited, packed and consolidated in uniform layers up to 2 to 2.5 m (6–8 ft) deep. Each layer is sealed on its exposed surface with a mud cover at least 30 cm (12 inches) thick. Such sealing prevents infestation by flies and rodents and suppresses the nuisance of smell and dust. This method often has the disadvantage of requiring supplemental earth from outside sources.

Chemical, bacteriological and physical changes occur in buried refuse. The temperature rises to over 60° C within 7 days and kills all the pathogens and hastens the

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decomposition process. Then, it takes 2 to 3 weeks to cool down. Normally, it takes 4 to 6 months for complete decomposition of organic matter into an innocuous mass. The tipping of refuse in water should not be done as it creates a nuisance from odours given off by the decomposition of organic matter. The method of controlled tipping has been revolutionized by mechanization. The bulldozer achieves the tasks of spreading trimming and spreading top soil.

c. Incineration. Refuse can be disposed of hygienically by burning or incineration. It is the method of choice where suitable land is not available. Hospital refuse which is particularly dangerous is best disposed of by incineration. Incineration is practised in several of the industrialized countries, particularly in large cities due to lack of suitable land. Incineration is not a popular method in India because the refuse contains a fair proportion of fine ash, which makes the burning difficult. A preliminary separation of dust or ash is needed. All this involves heavy outlay and expenditure, besides manipulative difficulties in the incinerator. Further, disposal of refuse by burning is a loss to the community in terms of the much-needed manure. Burning, therefore, has a limited application in refuse disposal in India.

d. Composting. Composting is a method of combined disposal of refuse and night soil or sludge. It is a process of nature whereby organic matter breaks down under bacterial action resulting in the formation of relatively stable humus-like material, called the compost which has considerable manurial value for the soil. The principal by products are carbon dioxide, water and heat. The heat produced during composting—60°C or higher, over a period of several days—destroys eggs and larvae of flies, weed seeds and pathogenic agents. The end-product compost—contains few or no disease-producing organisms, and is a good soil builder containing small amounts of the major plant nutrients such as nitrates and phosphates. The following methods of composting are now used: (i) Bangalore method (anaerobic method) and (ii) mechanical composting (aerobic method).

- Bangalore method *(Hot fermentation process):* As a result of investigations carried out under the auspices of the Indian Council of Agricultural Research at the Indian Institute of Science, Bangalore, a system of anaerobic composting, known as *Bangalore method* (hot fermentation process) has been developed. It has been recommended as a satisfactory method of disposal of town wastes and night soil.

Trenches are dug 90 cm (3 ft) deep, 1.5 to 2.5 m (5–8 ft) broad and 4.5 to 10 m (15–30 ft) long, depending upon the amount of refuse and night soil to be disposed of. Depths greater than 90 cm (3 ft) are not recommended because of slow decomposition. The pits should be located not less than 800 m (half mile) from city limits. The composting procedure is as follows: First, a layer of refuse about 15 cm (6 in) thick is spread at the bottom of the trench. Over this, night soil is added corresponding to a thickness of 5 cm (2 in). Then, alternate layers of refuse and night soil are added in the proportion of 15 cm (6 in) and 5 cm (2 in) respectively, till the heap rises to 30 cm (1 ft) above the ground level. Top layer should be of refuse, at least 25 cm (9 in) thickness. Then, the heap is covered with excavated earth. If properly laid, a man's legs will not sink when walking over the compost mass.

Within 7 days as a result of bacterial action considerable heat (over 60°C) is generated in the compost mass. This intense heat which persists over 2 or 3 weeks, serves to decompose the refuse and night soil, and to destroy all pathogenic and parasitic organisms. At the end of 4 to 6 months, decomposition is complete and the resulting manure is a well-decomposed, odourless, innocuous material of high manure value ready for application to the land. The Environmental Hygiene Committee (1949) did not recommend composting by municipalities with a population of over 100,000. Bigger municipalities should install underground sewers to transport human excreta.

Mechanical composting: Another method of composting known as "mechanical composting" is becoming popular. In this, compost is literally manufactured on a large scale by processing raw materials and grinding out a finished product. The refuse is first cleared of salvageable materials such as rags, bones, metal, glass and items which are likely to interfere with the grinding operation. It is then pulverized in pulverizing equipment in order to reduce the size of particles to less than 2 inches. The pulverized fuse is then mixed with sewage, sludge or night soil in a rotating machine and incubated. The factors, which are controlled in the operation are a certain carbon–nitrogen ratio, temperature, moisture, pH and aeration. The entire process of composting is complete in 4 to 6 weeks. This method of composting is in vogue in some of the developed countries, e.g. Holland, Germany, Switzerland, Israel. Government of India is considering the installation of mechanical composting plants in selected cities. Cities such as Delhi, Nagpur, Mumbai, Chennai, Pune, Allahabad, Hyderabad, Lucknow and Kanpur have offered to join the Government for setting up pilot plants for mechanical composting.

e. Manure pits. In rural areas of India, there is no system for collection and disposal of refuse. Refuse is thrown around the houses indiscriminately resulting in gross pollution of the soil. The problem of refuse disposal in rural areas can be solved by digging "manure pits" by the individual householders. The garbage, cattle dung, straw and leaves should be dumped into the manure pits and covered with earth after each day's dumping. Two such pits will be needed, when one is closed, other will be in use. In 5 to 6 month's time, the refuse is converted into manure, which can be returned to the field. This method of refuse disposal is effective and relatively simple in rural communities.

f. Burial. This method is suitable for small camps. A trench 1.5 m wide and 2 m deep is excavated, and at the end of each day the refuse is covered with 20 to 30 cm of earth. When the level in the trench is 40 cm from ground level, the trench is filled with earth and compacted, and a new trench is dug out. The contents may be taken out after 4 to 6 months and used on the fields. If the trench is 1 m in length for every 200 persons, it will be filled in about 1 week.

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Impacts of Solid Waste on Health

A tremendous progress on account of improvement in the science and technology has led to the modernization and change in the lifestyle. At the same time, it has disadvantages of causing air and water pollution. As there has been a rise in the population globally, the demand for food and other essentials is steadily increasing. This in turn has resulted in generation of waste, daily by each household. This type of household or other nondomestic waste is collected by concerned municipalities or waste collecting agencies. If this is not organized and carried out properly it can cause environmental pollution, thus affecting the health of the population at large. Unfortunately, this happens both in the rural and the urban areas of the developing countries.

Waste disposal of excreta and other liquid or solid wastes from the household or a community can pose a serious health hazard if they are not managed properly. This is one of the main sources and a cause for several infectious diseases. Also, the uncollected waste, which is thrown in the open environment can attract flies, rodents, etc. and in turn play a major role in transmission of diseases from place to place, putting the safe environment at risk. Of late the plastic waste is another major concern and cause for ill health.

The unscientific disposal of solid waste can put the group or population at risk, especially preschool children and workers connected with the waste disposal. When there is no proper waste disposal method it can produce toxic and infectious material and this can become health hazard for the population living close to waste dump. Another major concern is contamination of water supply due to leakage from landfill or waste dumping which is a major risk factor for ill health. Direct handling of solid wastes by the waste workers and the rag pickers can result in various types of infectious and chronic diseases.

Thus exposure to unscientific disposal of solid waste can be hazardous to human health, especially affecting the disadvantaged population.

Hospital Waste Management

Hospitals have existed in one form or the other since time immemorial. But there never has been so much concern about the waste generated by them (Table 3.8). With the increase in number of hospitals there has been increase in quantum of waste generated. It is ironical that the every hospital that brings relief to the sick can create health hazard due to improper management of waste generated by it. Its implications are on public, health care personnel and environment at large.

Discovery of hospital-acquired infection or nosocomical infection, rising incidence of hepatitis B and HIV, increasing land and water pollution has lead to increase in possibility of many diseases. Air pollution due to emission of hazardous gases by incinerator such as furans, dioxins etc. has compelled the authorities to think seriously about hospital waste. The thrust area has now become a threat to the public health.

Ultimately, Ministry of Environment and Forests, Government of India passed an Act on biomedical waste (management and handling) rule, 1998 which came into force on 27 July 1998. This rule applies to all those who generate, collect, receive, store, dispose, treat or handle biomedical waste in any manner. Table 3.7 shows the categories of biomedical waste, types of waste, and treatment and disposal options under this rule. As per this rule any person who generates waste needs to apply for consent to respective state pollution control boards for generating and appropriate management. Failing to do so, he or she will be liable for penalty which amounts to Rs 100,000/ and/or 5 years of imprisonment. The rule has been amended on 6 March 2000, 2 June 2000, 17 September 2003. As per the rules, all health care waste management system by December 2002 will be implemented.

A dental hospital is a complex multidisciplinary system which consumes lots of items for delivery of dental care. Since last few years there has been a rapid mushrooming of dental hospitals to meet the demand for care which has increased the quantity of dental health care waste. Though the quantity from each establishment may not be as much as in the general hospital, the collective quantity and quality is certainly significant.

The advent and acceptance of "disposables" has contributed to this issue and made hospital waste a significant factor in today's health care establishments.

Terminology

Hospital waste. It refers to all the wastes generated, discarded and not intended for further use in the hospital.

Biomedical waste. Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals or in research activities pertaining there to or in the production or testing of biological and including categories as mentioned in schedule 1 in Table 3.7.

CBWTF. Common biomedical waste treatment facility (CBWTF). An establishment which has MOU with waste generators to collect waste on daily basis and can charge nominal amount for its services.

General Waste

Dry. Paper, plastic, wrappers, etc.

Wet. Food remains or any decomposable matter.

Infectious waste. Any material which has come into contact with blood or body fluids, specimen materials, culture plates, etc., which could cause infection, e.g. dressings, cotton used for treatment and soiled instruments.

Sharps. Which could causes cut or punctures. For example, needle, scalpel saw, glass, blade, broken ampoules, lancet, etc.

Pharmacological waste. Unused or discarded drugs, chemicals, etc.

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Table 3.7 Different categories of waste disposal

Waste Category	Contents	Treatment and Disposal Options	Colour Code	Type of Container
Cat 1 Human anatomical	Human tissues, organs, body parts	Incineration/deep burial	Yellow	Plastic bag
Cat 2 Animal waste	Animals tissues, organs body parts, carcasses bleeding parts, fluid blood and experimental animals used in research, waste generated by veterinary hospital colleges, discharges from hospitals and animals houses	Incineration/deep burial	Yellow	Plastic bag
Cat 3 Microbiology and biotechnology waste	Laboratory cultures stocks, specimen of microorganism live or attenuated vaccines, human and animal cell culture used in research and industrial laboratories, wastes from production of biological toxins dishes and devices used for transfer of cultures	Local autoclaving microwaving incineration	Yellow/red	Plastic bag, disinfected container
Cat 4 Waste sharps	Needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts; this includes both used and unused sharps	Disinfection/chemical treatment[3]/ autoclaving/microwaving and mutilation shredding[4]	Blue/white translucent	Plastic bag, puncture proof container
Cat 5 Discarded medicines and cytotoxic drugs	Waste comprising of outdated, contaminated and discarded medicines	Incineration/destruction and disposal in secured landfills	Black	Plastic bag
Cat 6 Soiled waste	Items contaminated with blood and body fluids including cotton dressing, soiled plaster casts, linen bedding other material contaminated with blood	Incineration/autoclaving/ microwaving	Yellow/red	Disinfected container, plastic bag
Cat 7 Soiled waste	Waste generated from disposable items other than the waste sharps such as tubing catheters, intravenous sets, etc.	Disinfection/chemical treatment[3]/ autoclaving/microwaving and mutilation shredding[4]	Blue/white translucent	Disinfected container, plastic bag
Cat 8 Liquid waste	Waste generated from laboratory washing, cleaning, housekeeping and disinfecting activities	Disinfection/chemical treatment[3]	Not applicable	Not applicable
Cat 9 Incineration ash	Ash from incineration of any biomedical waste	Disposal in municipal landfill	Black	Plastic bag
Cat 10 Chemical waste	Waste generated from chemicals used in the production of disinfection materials and insecticides, etc.	Chemical treatment and discharge into drains for liquid and secured landfill for solids	Black	Plastic bag

Table 3.7 Schedule I and II (Under Rule 5 and 6)
1 = There will be no chemical pretreatment before incineration. Chlorinated plastics shall not be incinerated.
2 = Deep burial shall not be an option available only in towns with population less than 500,000 and in rural areas.
3 = Using at least 1% hypochlorite or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection.
4 = Must be such so as to prevent unauthorized reuse.
5 = Liquid wastes do not require containers/bags.
6 = If disinfected locally need be put into containers/bags.
Note: Colour coding of waste categories with multiple treatment options to depend on treatment option.

Table 3.8 Categories of waste generated in a dental hospital and their final disposal

Waste Categories	Contents	Colour Coding	Final Disposal
General waste	Stationary waste, cartons, boxes	Green	Corporation bin
Infected waste	Used cotton, gauze, biopsy tissue, granulation tissue, excised tissue, extracted teeth, dressing materials	Yellow	Incineration (CBWTF)
Cyclables	Plastics, metals, intact glass, lead foil, plaster casts	Red	Identify buyer (CBWTF)
Waste sharps	Needles, scalpels, blades, lancet, broken glass, etc.	White transparent	Sanitary land fill (CBWTF)

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Recyclables. Containers/items of plastic intact glass wares, metals, etc.

Chemical waste. Cleaning, disinfecting products used in cleaning and housekeeping.

Radioactive waste. Solid, liquid and gaseous waste that is contaminated with radio nuclides.

Composition of Hospital Waste

a. Nonhazardous – 85%
b. Hazardous – 15%
   Hazardous but not infective – 5%
   Hazardous but infective – 10%

Rationale for Waste Disposal

a. To prevent nosocomial infections or hospital acquired infections.
b. To protect health care providers.
c. To prevent risk to general population.
d. To protect our environment.

Steps in Waste Management

1. Segregation
2. Decontamination
3. Deformation/destruction
4. Containment/label/transportation
5. Disposal

1. Segregation. To segregate the waste into different categories at point of generation to reduce chances of injury and the quantity of hazardous waste.

2. Decontamination. Disinfection reduces chances of infection. Disinfectant solution can be prepared by dissolving one full scoop of bleaching powder in 1 L of water. Commercially available disinfectants can also be used.

3. Deformation. Prevents reuse and remarketing of the syringes, needles and gloves. Use of needle cutter or burner is recommended.

4. Containment. Some of the health care waste cannot be disposed off on a daily basis. Hence they need to be contained safely until disposal. Syringes, plaster of pairs casts, condemned instruments, mercury, lead foil, fixer solution needs to be contained in appropriate containers.

Label. Label the container properly.

Transportation. Use of heavy duty gloves, trolley is recommended.

5. Final disposal. MOU with CBWTF facility is recommended.

Personal protective equipments for staff handling waste
Protective eye wear
Double strength gloves (rubber)
Boots
Aprons
Masks
Immunization

OCCUPATIONAL HAZARDS ASSOCIATED WITH WASTE HANDLING

Infections

- Skin and blood infections resulting from direct contact with waste and from infected wounds.
- Eye and respiratory infections resulting from exposure to infected dust, especially during landfill operations.
- Various diseases that result from the bites of animals feeding on the waste.
- Intestinal infections that are transmitted by flies feeding on the waste.

Chronic Diseases

- Incineration operators are at risk of chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous compounds.

Accidents

- Bone and muscle disorders resulting from the handling of heavy containers.
- Infecting wounds resulting from contact with sharp objects.
- Poisoning and chemical burns resulting from contact with small amounts of hazardous chemical waste mixed with general waste.
- Burns and other injuries resulting from occupational accidents at waste disposal sites or from methane gas explosion at landfill sites.

PUBLIC EDUCATION

Refuse disposal cannot be solved without public education. People have very little interest in cleanliness outside their homes. Many municipalities and corporations usually look for the cheapest solution, especially in regard to refuse disposal. What is needed is public education on these matters, by all known methods of health education, viz. pamphlets, newspapers, broadcasting, films, etc. Police enforcement may also be needed at times.

Prevention of Environmental Pollution

Pollution can be prevented by:

1. *Substitution of industrial manufacturing materials* with harmless chemicals etc.
2. *Biodegradable (i.e. breakdown by bacteria, sunlight, etc.) materials* can be used such as paper, natural fibres, etc. instead of nonbiodegradable substances such as plastic.
3. *Segregation of waste:* This can be done by separating materials at home, or farm or industry in such a manner that each type of waste material can be destroyed

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using different control measures. This is particularly important for hospital waste which can be contaminated with disease causing organisms.

4. *Enforcing the rules of waste disposal by legislative (*i.e. *legal) methods* whereby people can be fined or punished for improper waste disposal or use of hazardous materials.
5. *Modifying people's behaviour towards discarding waste materials, through health education:* Examples of these behavioural methods could be through implementation of community health education whereby the importance of waste as a source of disease can be emphasized. People could be taught to use waste disposal methods provided by the Government or they could construct their own small waste disposal units (e.g. soakage pits, septic tanks, etc.). The people can also destroy mosquito and fly breeding areas, maintain cleanliness of home and animal sheds, promote use of biodegradable materials, etc.

Ultimately, mere provision or availability of pollution controlling measures are of no use until the behaviour of the people is changed through education so that they may actually use these methods and maintain environmental hygiene.

Four Rs (Refuse, Reuse, Recycle, Reduce) to be followed for waste management

1. *Refuse:* Instead of buying new containers from the market, use the ones that are in the house. Refuse to buy new items though you may think they are prettier than the ones you already have.
2. *Reuse:* Do not throw away the soft drink cans or the bottles; cover them with home-made paper or paint on them, and use them as pencil stands or small vases.
3. *Recycle:* Use shopping bags made of cloth or jute, which can be used over and over again. Segregate your waste to make sure that it is collected and taken for recycling.
4. *Reduce:* Reduce the generation of unnecessary waste, e.g. carry your own shopping bag when you go to the market and put all your purchases directly into it.

Climate Change and Health: Key Factors

- Climate change affects the social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter.
- Between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year, from malnutrition, malaria, diarrhoea and heat stress.
- The direct damage costs to health (i.e. excluding costs in health-determining sectors such as agriculture and water and sanitation), is estimated to be between US$ 2–4 billion/year by 2030.
- Areas with weak health infrastructure – mostly in developing countries – will be the least able to cope without assistance to prepare and respond.
- Reducing emissions of greenhouse gases through better transport, food and energy-use choices can result in improved health, particularly through reduced air pollution.

Climate change

- Over the last 50 years, human activities – particularly the burning of fossil fuels – have released sufficient quantities of carbon dioxide and other greenhouse gases to trap additional heat in the lower atmosphere and affect the global climate.
- In the last 130 years, the world has warmed by approximately 0.85°C. Each of the last 3 decades has been successively warmer than any preceding decade since 1850[1].
- Sea levels are rising, glaciers are melting and precipitation patterns are changing. Extreme weather events are becoming more intense and frequent.

What is the impact of climate change on health?

Although global warming may bring some localized benefits, such as fewer winter deaths in temperate climates and increased food production in certain areas, the overall health effects of a changing climate are likely to be overwhelmingly negative. Climate change affects social and environmental determinants of health – clean air, safe drinking water, sufficient food and secure shelter.

Extreme heat

- Extreme high air temperatures contribute directly to deaths from cardiovascular and respiratory disease, particularly among elderly people. In the heat wave of summer 2003 in Europe for example more than 70,000 excess deaths were recorded[2].
- High temperatures also raise the levels of ozone and other pollutants in the air that exacerbate cardiovascular and respiratory disease.
- Pollen and other aeroallergen levels are also higher in extreme heat. These can trigger asthma, which affects around 300 million people. Ongoing temperature increases are expected to increase this burden.

Natural disasters and variable rainfall patterns

- Globally, the number of reported weather-related natural disasters has more than tripled since the 1960s. Every year, these disasters result in over 60,000 deaths, mainly in developing countries.
- Rising sea levels and increasingly extreme weather events will destroy homes, medical facilities and other essential services. More than half of the world's population lives within 60 km of the sea. People may be forced to move, which in turn heightens the risk of a range of health effects, from mental disorders to communicable diseases.
- Increasingly variable rainfall patterns are likely to affect the supply of freshwater. A lack of safe water can compromise hygiene and increase the risk of diarrhoeal disease, which kills approximately 760,000 children aged under 5, every year. In extreme cases, water scarcity leads to drought and famine. By the late 21st century, climate change is likely to increase the frequency and intensity of drought at regional and global scale[1].
- Floods are also increasing in frequency and intensity, and the frequency and intensity of extreme precipitation is expected to continue to increase throughout the current century[1]. Floods contaminate freshwater supplies, heighten the risk of waterborne diseases and

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create breeding grounds for disease-carrying insects such as mosquitoes. They also cause drownings and physical injuries, damage homes and disrupt the supply of medical and health services.
- Rising temperatures and variable precipitation are likely to decrease the production of staple foods in many of the poorest regions. This will increase the prevalence of malnutrition and undernutrition, which currently cause 3.1 million deaths every year.

Patterns of infection

- Climatic conditions strongly affect waterborne diseases and diseases transmitted through insects, snails or other cold blooded animals.
- Changes in climate are likely to lengthen the transmission seasons of important vector-borne diseases and to alter their geographic range. For example, climate change is projected to widen significantly the area of China where the snail-borne disease schistosomiasis occurs[3].
- Malaria is strongly influenced by climate. Transmitted by Anopheles mosquitoes, malaria kills almost 600,000 people every year – mainly African children under 5 years old. The Aedes mosquito vector of dengue is also highly sensitive to climate conditions, and studies suggest that climate change is likely to continue to increase exposure to dengue.

Measuring the health effects

- Measuring the health effects from climate change can only be very approximate. Nevertheless, a WHO assessment, taking into account only a subset of the possible health impacts, and assuming continued economic growth and health progress, concluded that climate change is expected to cause approximately 250,000 additional deaths per year between 2030 and 2050; 38,000 due to heat exposure in elderly people, 48,000 due to diarrhoea, 60,000 due to malaria and 95,000 due to childhood undernutrition[4].

Who is at risk?

- All populations will be affected by climate change, but some are more vulnerable than others. People living in small island developing states and other coastal regions, megacities and mountainous and polar regions are particularly vulnerable.
- Children – in particular, children living in poor countries – are among the most vulnerable to the resulting health risks and will be exposed longer to the health consequences. The health effects are also expected to be more severe for elderly people and people with infirmities or preexisting medical conditions.
- Areas with weak health infrastructure – mostly in developing countries – will be the least able to cope without assistance to prepare and respond.

WHO response

- Many policies and individual choices have the potential to reduce greenhouse gas emissions and produce major health co-benefits. For example, cleaner energy systems, and promoting the safe use of public transportation and active movement – such as cycling or walking as alternatives to using private vehicles – could reduce carbon emissions, and cut the burden of household air pollution, which causes some 4.3 million deaths per year, and ambient air pollution, which causes about 3.7 million deaths every year.

In 2015, the WHO Executive Board endorsed a new work plan on climate change and health. This includes:

- **Partnerships:** to coordinate with partner agencies within the UN system, and ensure that health is properly represented in the climate change agenda.
- **Awareness raising:** to provide and disseminate information on the threats that climate change presents to human health, and opportunities to promote health while cutting carbon emissions.
- **Science and evidence**: to coordinate reviews of the scientific evidence on the links between climate change and health, and develop a global research agenda.
- **Support for implementation** of the public health response to climate change: to assist countries to build capacity to reduce health vulnerability to climate change, and promote health while reducing carbon emissions.

REVIEW QUESTIONS

1. Difference between eradication, control and elimination.
2. What are the impacts of environment on health?
3. Define greenhouse effect.
4. What is indoor air pollution and its effect on health.
5. Discuss effects of air pollution on health.
6. Describe effects of noise pollution on health.
7. What are the biological effects of radiation on health?
8. Describe the steps involved in water purification.
9. What are the differences between rapid sand and slow sand filters?
10. Define breakpoint in chlorination.
11. What are the WHO standards for quality, criteria and standards of potable water?
12. Describe water borne diseases.
13. Describe the Bangalore method of waste disposal.
14. Define manure pits.
15. How do you prevent environmental pollution?

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4 Health Education

Dara S Amar and Anitha R Sagarkar

CHAPTER OUTLINE

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INTRODUCTION

Health is a shared responsibility and requires both treatment and preventive approach for its maintenance. Although, the treatment has its popularity share, the focus on disease prevention has many long-term implications to public health like, reduction in health expenditures that individuals, employers, families, insurance companies, medical facilities, communities, the state and the nation would spend on medical treatment. The health education, as a part of the integrated approach is perceived to impact fundamentally every aspect of health and wellbeing that includes disease prevention, health promotion and quality of life. Hence, the individual or the community needs to be empowered.

DEFINITION

As per National Conference on Preventive Medicine (1977) USA, "Health education is a process that informs, motivates and helps people to adopt and maintain healthy practices and lifestyles, advocates environmental changes as needed to facilitate this goal, and conducts professional training and research to the same end."

PRINCIPLES OF HEALTH EDUCATION

Health education empowers individuals or family or community in gaining better control over their health matters. Health education to be effective should be designed based on the tenets of social science. Some of the principles of health education are detailed in (Fig. 4.1 and Table 4.1):

1. Interest
2. Participation
3. Motivation
4. Known to unknown
5. Comprehension
6. Soil, seed and sower
7. Learning by doing
8. Reinforcement
9. Good human relationship
10. Leader



Figure 4.1 Principles of health education.

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Table 4.1 Importance of various principles of health education

Health Principle	Why It's Important
Interest **Health education should be directed to the felt needs of a person**	Once the interest is addressed, the information is usually liked and followed
Participation is a key to success of health education programs	Active participation leads to active learning that enables an individual to find solutions to better health and living
Known to unknown	• Assessment of the known information like beliefs, concepts, misconceptions and then to the unknown or to expected way • This varies population-wise and hence has to be planned accordingly
Comprehension **Health education should be based on the level of the target group's understanding and should consider spoken language preferably**	To avoid the technical terms with simple explanation
Motivation **Motivation precedes change**	• Is especially true in changing behaviour conducive to health • The positive or negative incentive or motives used by the health educator, such as praise or punishments to bring about the desired change
Reinforcement **To remember and to understand its importance**	• To make it a part of their internal value system
Learning by doing **The participant's gains confidence of performing such tasks even without supervision**	• The health education programs fail if they do not provide the opportunity to do what one has learnt • This principle has dual advantages such as the participant will do what he or she has learnt or understood, thereby providing and instant feedback to the educator to correct wherever required
Soil, seed, sower **Soil–Mind** **Seed–Health education** **Sower–Health educator**	• The health educator has the time to see the right information in the people so as to reap desired change in behaviour
Good human relations **Also a key to success of health education**	The relationships between the health educator and the participants should be trustworthy, only then information gains importance
Leaders **Act as agents of change**	• Health educator should identify leaders in a community because they act as agents of change. If they're convinced they in turn convince their group to follow • Leaders are involved in all the stages of planning and evaluation of health education programs

APPROACHES TO PUBLIC HEALTH EDUCATION

The comprehensive approach to enhance health of the public should be an ongoing process, both at individual and community level.

Various approaches to public health are:

Acronym- SHaRP approach.

1. Regulatory approach
2. Service approach
3. Health education approach
4. Primary health care approach.

Public health can be achieved in combination of approaches according to the prevailing public health problem (Fig. 4.2).

Regulatory approach:

- From – The ruling Government
- Through – Administrative set-up
- Expected outcome – change of unhealthy behaviour.
- Eg. – In situations like threat to health system such as infectious or communicable diseases or social evils such as child marriage etc.

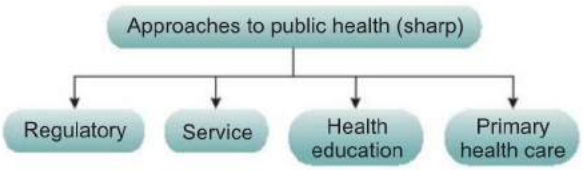


Figure 4.2 Approaches to public health.

Service approach: While service approach aims at providing all the required health services with the hope that these services are utilized. The services based on felt needs are utilized while the rest becomes a failure.

Health education approach: While health education approach believes in informing and motivating people and later guiding them into action for the practice of healthy behaviour and utilization of health services, it acts at cognitive, affective and psychomotor levels to change one's behaviour. It takes considerable time but the results are long lasting.

Primary health care approach: Primary health care approach is a holistic concept involving the community at all the stages of planning and evaluation. It helps people to be self-reliant in the matters of health, guides them in identifying their health problems and finding practical solutions.

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CONCEPTS OF HEALTH EDUCATION

To promote the health of the individual it is necessary to teach the health concepts and self-care skills in the ways they understand. Learning includes measurable change in behaviour that persists over time, needs practice, and reinforcement to be permanent.

The health educator needs to know how people learn, based on learning situations one should apply appropriate educational theory either singly or in combination (see Fig. 4.3).

NATURE OF LEARNING

Learning occurs in three domains, namely cognitive, affective and psychomotor. Each domain has specific behavioural components that form hierarchy of steps or levels. Effective health education is based on understanding these levels (Table 4.2).

Change expected by the health educators depends on:

1. Meet the felt need of the individual/the community.
2. Be very simple and realistic with the utilization of the existing knowledge and practices of the community/individual.
3. Amend into the existing lifestyle.
4. Be nonconflictory to the culture, customs and beliefs.
5. Use the locally available resources, i.e. money, manpower and materials.

In addition to these principles, information given should have credibility that is based on facts and conforms to social system. Health should set an example to the community observing healthy practices and lifestyle. Feedback is crucial to success of any program wherein health educator modifies as and when required to suit to their needs.

METHODS OF HEALTH EDUCATION

Health education not only provides the opportunity for an individual or a group of people or a community to learn about healthy practices and lifestyles and in turn to attain optimum level of health. There are various methods available to provide effective health education to the people. The health educator should choose the proper method and the proper media to be used to help the people in adopting healthy practices. The main purpose of health education is to provide and help learning process in the individuals to acquire knowledge that may result in the change of behaviour and attitudes.

The methods employed for each of the mentioned group varies (Fig. 4.4).

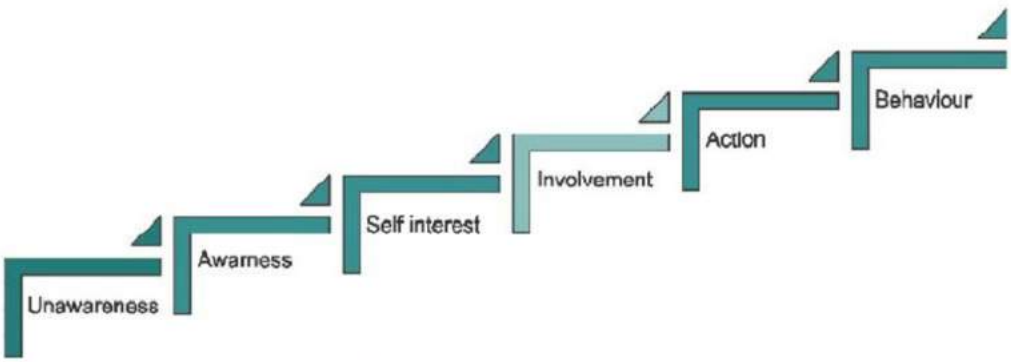


Figure 4.3 Learning steps.

Table 4.2 Education theories

Education Theories	Aim	Salient Features
Behavioural theory	To change behaviour by means of reinforcement or punishment	• Useful when the learner has cognitive limitation • The educator has full control of feedback system
Social learning theory	Changing beliefs and expectations by providing information	• When the subjects believe that the outcome is desirable, they are more likely to change their behaviour
Cognitive theory	At thought patterns and providing information	• Changing learner's behaviour
Humanist theory	At self-determination of learners	• Emphasizes the influence of feelings, emotions and personal relationships on behaviour
Developmental theory	At the learning that occurs differently in each stage of development	• Learning opportunities should match with the readiness to learn which, in turn, depends on the individual's developmental stage
Critical theory	At changes thinking and behaviour	• This theory facilitates ongoing dialogue and open enquiry leading to increase in depth of knowledge

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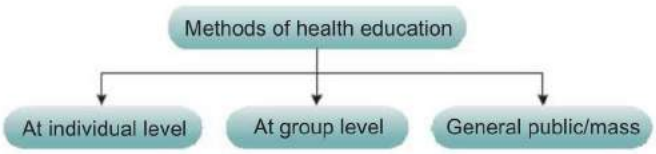


Figure 4.4 Methods of health education.

1. Health Education at Individual Level

This is one of the best methods of education. It is the most reliable method and has the long lasting effect. Health education by the direct and indirect individual approach had undoubtedly resulted in changing behaviour of the people for better healthy practices.

The most important advantage of this type of health education is that, it facilitates a "two-way" communication and also that the health educator can discuss with the individual and persuade to change his or her behaviour.

The individual also gets an opportunity for asking doubts and clarifying them. Through this type of health education all aspects of health can be imparted to the family members also. The main disadvantage of this method is that health education is given to only those who come in contact with a doctor or dentist or the health educator. Thus the number of people receiving health education is small. The village health workers and multipurpose workers in India are the best examples of health educator for individual and family health education.

2. Health Education at Group Level

a. Lectures. A lecture is a discourse on one particular subject delivered by one person. It is usually used extensively in colleges and high schools. It is also a most accepted and popular method.

The main value of a lecture is that a number of facts and concepts can be presented in a short time to a large number of people. There is no individual participation and very little opportunity for creative thinking, except perhaps in the discussion following a lecture. Usually there is no interaction between the lecturers and the learners.

The following points should be kept in mind in preparing for this type of health education.

- Prepare the oral presentation in detail on the basis of definite purpose and expected outcome.
- Limit the number of facts presented and illustrate with examples and visual aids.
- Adapt the lecture to the understanding as well as the interest of the group.
- Give only specific and constructive details and express them clearly.
- Be accurate in presenting the health facts.
- Hold the audience's attention by using a pleasant voice and a good sentence structure.

A lecture can be made more attractive and acceptable by using educational aids like (a) chalkboard, (b) charts and diagrams, (c) overhead projections, (d) flannel graphs, (e) posters, (f) slide presentations, (g) flash cards and (h) exhibits; e.g. recent updated slide preparation methods like Prezi, etc.

The main disadvantage of a lecture is that it is a "one way" communication. The topic selected for the lecture for a particular subject if it is not in relation to the interest of the audience, it would not be effective.

b. Symposium. This is one of the modern methods used for group health education. The symposium consists of a number of experts who are invited to speak on a particular topic. Each speaker is given an opportunity to present various some aspects pertaining to selected topic. The symposium is conducted under leadership of a chairman or a modulator who has to initiate the symposium with an introduction to the topic and by introducing different speakers to the audience. Symposium should consist of the following:

- Topics selected should be of interest to the audience.
- The speakers should be selected in such a way that's they are experts in a particular topic selected.
- The topic of symposium should be selected beforehand.
- The speaker should be informed in advance about the topic, the time and place the symposium to be held.
- Chairman of the symposium conducts the proceedings of the program in a systematic manner.

Advantage: The audience understands the topic better if it is presented in an easy and a simple way by various speakers.

Disadvantage: Lack of participation from the audience, so no scope for either participation or feedback.

Symposia are useful and effective in delivering health education to group of adults who have an attitude for listening and the ability to appreciate the different aspects of the topic presented.

c. Group discussions. Usually group discussions are the most commonly employed methods for group health education. It is of utmost importance in health education because the participants get a chance to express and exchange their views and ideas during the proceedings. It is a type of "two way" communication.

Ideally the topics for discussion are taken up and shared by all the members of the group. It is a process wherein the problem is identified collectively and the solution is formed from combining the member's ideas, opinions and experiences. Group discussions can be formal or informal.

The group discussions will be led by group leader who has the responsibilities of initiating the discussions, conducting the discussion in the proper manner and giving each of the audience a chance to actively participate in the discussion.

The member should be prepared to change his or her attitudes and action or decisions if needed, even though opinion is expressed.

d. Small group discussions. The most informal form of communication is the small group discussions or buzz sessions. It provides considerable interaction by students and allows free expression of ideas and opinions. A good buzz session depends on a background of information. Normally this type of communication is used in high school teaching.

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Buzz sessions are most successful when students are motivated to continue their interest into an activity beyond the buzz session, for example they may try to do something about the dental health problems of the community.

e. Large group discussions. A discussion following the presentation of new ideas and practices helps in bringing out the important decisions and in reinforcing the thinking of the group. The learner should be given opportunities to express his or her ideas and opinions. The whole group should be made to involve. However, everyone may not participate in the expression of ideas. If the discussions involve only few individuals, others become disinterested and bored. The class discussions are valuable instruments of learning when they are conducted on a background of information. All discussions should have one person as the group leader.

f. Panel discussions. Panel discussions are another widely employed popular method for group health education. There will be a panel comprising three to five members out of which one person is chosen as the leader. Usually the size of the panel is determined by the time allotted for the discussion. The panel selects a topic of interest of the audience. The panel might consist of an expert on the particular topic selected.

Panel discussions are carried out in a methodical manner as follows:

- Each panel member is allotted five to ten minutes to present his view on the topic chosen.
- Each member is given an additional time of five minutes to present his or her expertise if any, against other points of view of other members.
- The audience should be asked to participate in the discussions by asking pertinent questions to the panel members.
- The leader of the panel sums up the different views presented and makes recommendations for solving the problem.
- Decisions of the panel may be presented to those concerned for consideration, acceptance or rejection and for proper action.

In panel discussion the chances for audience participation are less as in the case of a symposium. Whenever the audience is given chances for asking questions and clarifying their doubts, it becomes a panel discussion forum.

g. Workshops. This is another popular method for continuing education for group of people. Experts from a particular discipline discuss specific topics and problems, and outline the proceedings for action. Workshops usually last for few days where people get together and work in different groups and discuss problems of concern. Hence it can be called as a problem solving method.

Each group within the workshop will be headed by a chairman and will have a recorder for recording the proceedings. The chairman has the responsibility of conducting the workshop in a systematic manner.

Workshops are mainly advantageous for people with previous experience on particular topics, and for institutions and departments.

h. Seminars. These are methods usually employed by educational institutions. Education can be given to a large number of people among the presence of persons qualified in topics of interest or disciplines. The seminars may incorporate workshops, if required.

This method provides the opportunity for large number of professional people to come together and exchange their ideas and views on the topics of interest.

i. Role-playing or socio-dramas. Socio-dramas or role-playing are forms of expressing dramatic experiences during health education programs. These are methods that have gained wide popularity among school children. It can also be called as "psychodrama" and it is a form of demonstration where real life situations are enacted out without any artificial ingredients. This makes it very appealing to the audience.

Many health promotion agencies around the world have adopted this technique for educating the people on communicable and noncommunicable diseases. For example, wide varieties of socio-dramas are staged to educate the public about HIV and AIDS and its prevention.

The main advantage of this method is that people can understand better when they visualize the situations, and it produces a lasting impression in their minds.

Role-playing can be used to allow children express freely. The therapeutic value of emotional release through self-expression is well known. There are many instances where children can release tensions built up by dental ill health or fear of dental treatment.

Role-playing will frequently bring out the timid child and stimulates him or her to participate in the group activities. While role-playing is unrehearsed and to a degree spontaneous, it is necessary for the teacher to have some control of the situation in order to have the positive attitudes, which are formed by the group.

j. Demonstrations. This is mainly based on the principle of learning by doing. Hence demonstrations are meaningful and successful in many situations. The advantage of demonstration is that it is more effective than spoken words as it leaves a visual impression in the minds of the audience. Practical demonstrations are made use of in health education programs.

k. Institute. It is a popular method of group health education in the western countries. The institutes comprise a number of meetings, which are scheduled over a period of time usually scheduled for few days or weeks. The purpose of institute is to convey specific information and instructions in selected areas of work. Health education methods like lectures, symposia, group discussions and panel discussions can be made use of in an institute.

The main advantage of institute is that it provides inspiration for the people to action and also creates awareness and interest in them towards practicing good healthy practices.

Responsibilities of the members of the group discussion:

- To identify the leader and moderators of the group
- To provide information to each member of the group
- To ensure equal participation from all members
- To be part of the decisions and actions to be taken

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- Have knowledge about different aspects of the problems
- Think objectively, without any bias or personal influence

3. Health Education for General Public or Mass

Health education for a large community or the general public can be given using the mass media of communication. Mass communication literally means communication that is given to a community by using mass media communication methods. The main advantages of using mass media are:

- Large number of people can be reached at one time in one place
- People of all socioeconomic status have an access to health education.

The various media used for mass communication include:

a. Televisions
b. Radio
c. Newspapers/press
d. Posters
e. Health museums
f. Health exhibitions
g. Health magazines
h. Health information booklets

The disadvantage of all the previously mentioned mass media is that they are all "one-way" method of communication. Hence it is not possible for the audience who receive health education to clarify their doubts or express their views.

a. Television. Televisions are one of the most popular and widely used media in mass communication.

The **advantages** include:

- Entertainment based plus serves the purpose of conveying the message clearly
- Enmass coverage of public, either as groups/communities
- Comprehensive coverage of topics with timely delivery
- Caters to all classes of people

The **disadvantages** are:

- Mode of communication is "one-way," so no feedback/reciprocation from the target group
- High cost of television sets

- Accessibility by all people is questionable

Examples: Central Government of India advertisements on vaccination and Swachh Bharat Abhiyan.

b. Radio. Radios play an important role in every man's day-to-day life. Health education talks can reach the masses very easily through radios. Before selecting particular topic on health education, the local language has to be considered and chosen appropriately through radios. The advantages of using radio are that they are cheaper media for mass communications and they are accessible to people of all socioeconomic status.

c. Newspapers/press. Among the different media available for mass communication, newspapers play an important role. The advantages are that newspapers are easily accessible by the community and are available in languages they can follow. But, this method of communication may not be useful in rural areas wherein large percentage of illiterate people are residing.

d. Posters. Generally posters have a limited value in health education. The public quickly reaches "saturation" point with posters because of their universal use for advertising purposes. Posters can only be used to present "slogans" which have little educational value for health purposes.

The posters are generally used for mass education by displaying it in public places like railway stations, bus stations, public transports etc.

Requirements for ideal poster:

1. The message to be conveyed through a poster should stimulate thinking of the individual.
2. Only one single idea should be conveyed in a poster at one time.
3. The message to be conveyed should be brief but at the same time should draw the attention of the people.
4. The letters and graphics should be large enough to be visible clearly by the people from a long distance.

e. Health exhibitions. Health exhibition is another popular method for educating the masses. These exhibitions can be conducted during some fairs and festivals in one particular area or geographic region. In the health exhibition, appropriate models or exhibits can be used to demonstrate various parts of the body, their importance and function. If they are properly organized, health exhibitions are the best method to attract large number of people.

The advantage of exhibitions is that the people can come across new ideas in health matters, which they have not heard otherwise.

f. Health magazines. A wide variety of health magazines are available in the market. Many weekly and monthly magazines published in India have a column on health, which is dealt by experts in different fields of medicine and dentistry. However, they are useful only for literate people. The health topics presented should not confuse the public with the usage of too many scientific terms; at the same time, they should be as accurate as possible.

g. Health information booklets. Various government departments issue health information booklets for the usage of the general public and also many nongovernmental agencies bring out health information booklets for the benefit of the population.

The Ministry of Health from time-to-time is bringing out a number of booklets on various both communicable and noncommunicable diseases and methods of prevention for the education of the public.

The initiating point for the health education is based on the situation analysis in terms of:

- The target population,
- Location/place,
- Health workers/professionals involved,
- Topic to be covered,
- Cultural background,
- Language of delivery

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- Duration
- Need of the individual/community
- Total number covered

CHARACTERISTICS OF AN EFFECTIVE HEALTH EDUCATION

- Be directed to the influencial people in the community
- Have periodic reinforcement using appropriate methods
- Use adaptable channels of communication like role-playing, songs, drama or story telling
- Use simple language with local context
- Emphasize on short-term benefits rather than the long-term benefits
- Use demonstrations for identification of the adoptable methods
- Provide opportunities for dialogue, participation, discussion, feedback at the varied levels of planning, implementation and evaluation

COMMUNICATION

The main purpose of empowerment is to ensure change in behavior that is conducive to health.

Types of Communication

1. One way (Didactic method): providing a lecture full of information about the public health problems and methods to prevent or control in the community and
2. Two-way discussion (Socratic method): which provides ample opportunity to raise queries, add new ideas and directions

BARRIERS TO COMMUNICATION

The barriers to **communication** are precise matters that can alter or inhibit **communication** with the target groups or individuals.

Barriers in Process of Communication

Researchers have identified many barriers in communication that can be classified as follows:

1. **Physiological barriers in communication.**
   - The physiological barriers include difficulties in hearing or seeing, in understanding and self-expression, etc.
   - These should be utilized in overcoming such barriers for effective communication.
2. **Environmental barriers in communication.**
   - The environmental barriers are due to excessive noise, difficulties in vision, congested areas and crowding.
3. **Psychological barriers in communication.**
   - Emotional disturbances, depression, neurosis or any other psychosomatic disorder
4. **Cultural barriers in communication.**
   - Generally the cultural barriers include more or less persistent patterns of behaviour like habits, beliefs, customs, attitudes, religion, etc.

However there are some barriers while communicating to the people of rural background with low literacy rate as follows:

a. Differences in meaning assigned to scientific terms by the layman and the professional.
b. Ethnic and cultural conflicts.
c. Habits contrary to those desired.
d. Lack of faith in treatment.
e. Fear of pain or injury.
f. Poverty.
g. Difficulty to travel to keep up the appointments.
h. Attitudes towards charity.

HEALTH EDUCATION AND PROPAGANDA

Health education is behaviour-centred process, aims at developing favourable attitudes, habits and skills. It appeals to reason, makes people think for themselves, disciplines primitive desires. In this process, knowledge and skills are actively acquired through self-reliant activity. It develops reflective behaviours, trains people to use judgment before acting, thereby resulting in individuality, personality and self-expression.

Propaganda is information-centred process, makes no attempt to change attitude or behaviour, it appeals to emotion, prevents or discourages thinking by ready-made slogans and stimulates primitive desires (Table 4.3). Knowledge is instilled in the minds of the people as it is passively received. It aims at impulsive action and develops a standard pattern of attitudes and behaviour.

Table 4.3 Difference between health education and propaganda

Health Education	Propaganda or Publicity
1. Knowledge and skills are actively acquired	1. Knowledge instilled in the minds of the people
2. It makes people think for themselves	2. Prevents or discourages thinking by ready-made slogans
3. It disciplines primitive desires	3. Arouses and stimulates primitive desires
4. It develops reflective behaviour; trains people to use judgment before acting	4. Develops reflexive behaviour; aims an impulsive actions
5. It appeals to reason	5. Appeals to emotion
6. Helps to develop individuality, personality and self-expression	6. Develops a standard pattern of attitudes and behaviours according to the mould used
7. Knowledge is thus acquired through self-reliant activity	7. Knowledge is spoon-fed and passively received
8. The process is behaviour centred; aims at developing favourable attitudes, habits and skills	8. The process is information centred, no change of attitude or behaviour

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CONCLUSION

Health education is a complex activity in which different individuals, groups and organizations play a part. Parents, teachers, medical professionals, health workers, government and nongovernmental agencies are active partners in the health education team. Health education is a major and important component in any preventive or promotive public health programs. Health education is also an important, integral part of the social sciences. Hence the scope of health education exceeds beyond the conventional health sector. It covers every aspect of family and community health.

REVIEW QUESTIONS

1. Define health education. Discuss principles of health education.
2. Describe levels of health education.
3. Discuss models of health education.
4. Write notes on:
   a. AV aids
   b. Barriers for communication
   c. Types of communication
   d. Methods of health education
   e. Health education and propaganda

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Primary Health Care

5

Shivram and Anitha R Sagarkar

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INTRODUCTION

During early 1970s, the health sector was criticized for its vertical approaches, which presented many letdowns on implementation. There was a need on divergent approaches to meet the health requirements of the community, especially with rural population. This inspired novel approaches to health care in different parts of the world for better outcome. In accordance with this numerous inspirations were highlighted, of which the China's entrance into the United Nations (UN) system as the "barefoot doctors," is worth a mention. These were the people who were present in the community they served who gave importance on rural health care sector rather than the urban health care and importance on preventive care rather than curative care and combination of western and traditional cultures. Therefore, all these situations were befitted with a landmark event for primary health care that took place at Alma-Ata in 1978.

ALMA-ATA DECLARATION 1978

It was declared at the International Conference at Alma-Ata in 1978, to accommodate the urgent need to protect and promote the health of all the people of the world, as follows:

1. The Conference strongly endorsed that health, which as defined by WHO is a fundamental human right, and the attainment of the highest level of it is a social goal and necessitates action from many sectors.
2. The health inequality present across the globe is a common concern expressed by all the countries.
3. Health promotion and protection of the population are required for a consistent economic and social development which will lead to better quality of life and peace globally.
4. People across the globe have the right and duty to participate at the individual and community level in planning and implementing the health care services.
5. Primary health care as essential health care has been defined by Alma-Ata conference in the year in 1978 is based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination. It forms an integral part of both: (i) health care system at the country level which is very important and (ii) the overall social and economic development of the community. It constitutes the first element of health care process in which primary health care is first contact level for the individuals, family and community with the national health system.
6. Primary health care:
   - Depends and originates from the socio-economic profile of the country and must be evidence-based research.
   - Addresses the community's health problems in terms of providing promotive, preventive, curative and rehabilitative services.
   - Includes at least: education concerning prevailing health problems and the methods of preventing and controlling them; promotion of food supply and proper nutrition; an adequate supply of safe water and basic sanitation; maternal and child health care, including family planning; immunization against the major infectious diseases; prevention and control of locally endemic diseases; appropriate treatment of common diseases and injuries and provision of essential drugs.

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- Comprises coordinated intersectoral participation, predominantly agriculture, animal husbandry, food, industry, education, housing, public works, communications and other sectors.
- Requires and promotes maximum community and individual self-reliance and participation in the planning, organization, operation and control of primary health care, making fullest use of local, national and other available resources; and to this end develops through appropriate education the ability of communities to participate.
- Should be sustained by interlinked referral systems for comprehensive health care of all.
- The felt health needs of the community should be addressed with the functional united referral approach of all the health workers, including the traditional practitioners.
- The necessity of all the governments' political will to devise national policies, strategies and plan of action to launch and sustain primary health care as part of a comprehensive national health system.
- All countries should collaborate with the spirit of partnership and service to ensure primary health care to all with joint WHO/UNICEF report as a concrete basis.
- Better and complete use of the world's resources helps in achieving an acceptable level of health for all the people of the world by the year 2000. Primary health care in particular should be allotted its proper share to accelerate the social and economic development for which the genuine policy of independence, peace, détente and disarmament could and should release additional resources.
- It calls for urgent need to develop and implement primary health care globally with emphasis in developing countries considering new international economic order. It also urges for national and international commitment through various agencies such as governmental, nongovernment organizations, funding agencies, all health workers and the whole world community.

PRIMARY HEALTH CARE

Alma-Ata conference (1978 by WHO and UNICEF) defined primary health care as follows:

The approach has also been called as "health by the people" and "placing people's health in people's hands." Primary health care was accepted by the member countries of WHO as key to achieving the goal of "Health for All."

Definition

"Essential health care based on practical scientifically sound and socially acceptable methods and technology made universally accessible methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and the country can afford to maintain at every stage of their development in the spirit of self-determination."

PRINCIPLES OF PRIMARY HEALTH CARE

The Government of India launched a Rural Health Scheme based on the principle of "placing people's health in people's hands." This was introduced resulting from the background work of Shrivastav Committee in 1975. During this time Alma-Ata declaration also materialized in 1978 with the theme of "health for all by 2000" through PHC (primary health care). Based on this the National Health policy was approved by Parliament in 1983 (Fig. 5.1 and Table 5.1).

Village Level

To implement this policy at the village level, the following schemes are in operation (Table 5.2):

a. Village health guides scheme
b. Training of local *dais*
c. ICDS Scheme.

Subcentre Level (Fig. 5.2)

- The subcentre is the peripheral outpost of the existing health delivery system in rural areas.

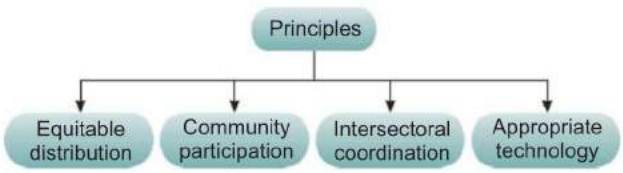


Figure 5.1 Principles of primary health care.

Table 5.1 Description for principles of primary health care

Sl. No.	Principles of Primary Health Care	Description
1.	Equitable distributions	Health services must be uniformly accessible to all people, despite their background (geographic area, socio-economic status)
2.	Community participation	With respect to planning, implementation and evaluation of health services, with effective utilization of resources (3M-manpower, money and materials)
3.	Intersectoral coordination	Involvement of the sectors that contribute to health sector like agriculture, animal husbandry, food, industry, education, housing, public works, communication and other sectors
4.	Appropriate technology	Scientifically sound technology Should contribute to solve the health problem.

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Table 5.2 Methods of training and guidelines for selection of various type of health care workers

Type of Health Worker	Details of Launching	Guidelines for Selection	Training Process	Services Provided
Village health guides	1977 **Launched** in all states except Kerala, Karnataka, Tamil Nadu, Arunachal Pradesh and Jammu and Kashmir	• Should have an aptitude for social service • Mostly women • Permanent local residents, preferably women • Formal education at least up to the VI standard • Able to spare at least 2 to 3 hours everyday	• Training at the primary health centre, sub-centre or any other suitable place • 200 hours for 3 months • ₹200/month	• Treatment of simple ailments • Activities in first aid, mother and child health including family planning, health education and sanitation
Local *dais* or traditional birth attendants	Comes under the Rural health Scheme	• *One Anganwadi* worker for a population of 1000	• 30 days • Stipend of ₹300 • At the PHC, subcentre or MCH centre for 2 days in a week. • On the remaining 4 days of the week, they accompany female health workers • Emphasis during training should be on asepsis to reduce maternal and infant mortality rate	• Play vital role in propagating small family norm • Elementary care of maternal and child health and sterilization, besides obstetric skills
Anganwadi worker ***Angan* means "a courtyard"**		• Selected from the community she is expected to serve • She is a part-time worker • The beneficiaries are especially nursing mothers, other women (15–45 years) and children below the age of 6 years	• Includes health and nutrition, and child development for 4 months. • Paid ₹200– 250 per month	• Health checkup, • Immunization, • Supplementary nutrition, • Health education, • Nonformal preschool education and • Referral services

- Established for every 5000 (general), and one for every 3000 (hilly, tribal and backward areas).
- As on 31st March 2003, 138,368 subcentres were established in the country
- One male and one female multipurpose health workers
- Functions include mother and child health care, family planning and immunization.
- Future proposal –
  - Extension of the facilities at all subcentres for intrauterine device (IUD) insertion, and simple laboratory investigations like routine examination of urine for albumin and sugar.
- One female HA will supervise the work of 6 female HWs.
- The job descriptions of these workers have been published as manuals by the Rural Health Division of the Ministry of Health and Family Welfare.

Primary Health Centre Level (Fig. 5.2)

- Central Council of Health in 1953 recommended the establishment of primary health centres in community development blocks to provide comprehensive health care for the rural population.
- The primary health centres have increased from 725 during the First to 5,484 by the Fifth Plan (1975–1980).
- Each PHC covering a population of 100,000 or more spread over some 100 villages in each community development block.
- Mudaliar Committee in 1962 had recommended that existing primary health centres should be strengthened and the population to be served by them to be scaled down to 40,000.
- The National Health Plan (1983) proposed reorganization of primary health centres which said, for every

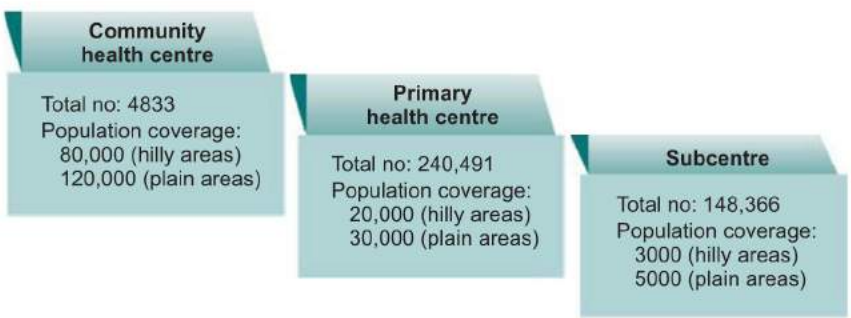


Figure 5.2 Rural health care system in India. (Source: National Health Portal, Rural Health Care system in India, as per March, 2012.)

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30,000 rural population one PHC is required and for every 20,000 population in hilly, tribal and backward areas one PHC is required for more effective coverage.
- As per2012, a ***total of*** 24,049 PHCs are present covering 30,000 at plain areas and 20,000 at hilly areas.

STAFFING PATTERN

At present in each community development block, there are one or more PHCs each of which covers 30,000 rural populations.

In the new set-up each PHC will have the following staff.

At the PHC Level	
Medical officer	1
Pharmacist	1
Nurse/midwife	1
Health worker (female)/annum	1
Block extension educator	1
Health assistant male	1
Health assistant female/LHV	1
UDC	1
LDC	1
Lab technician	1
Driver (subject to availability of vehicle)	1
Class IV	4
Total	**15**
At the Subcentre Level	
Health worker (female)/ANM	1
Health worker (male)	1
Voluntary worker (paid Re 100/month as honorarium)	1
Total	**3**

The establishment of the primary health centre is the valuable national asset especially to cater to the unreached population.

Community Health Centres (Fig. 5.2)

- ***As per 2012 a total*** **of** 4833 with the ***Population coverage of*** 80,000 at hilly areas and 120,000 at plain areas(one in each community development block) with 30 beds and specialists in surgery, medicine, obstetrics and gynaecology, and paediatrics with X-ray and laboratory facilities.
- Community health officer, a new nonmedical post has been created at each community health centre for strengthening preventive and promotive aspects of health care.
- The community health officer is selected from amongst the supervisory category of staff at the PHC and district level with minimum of 7 years experience in rural health programmes. Some states have not accepted this scheme and have opted for a second medical officer.
- The specialists at the community health centre may refer a patient directly to nearest medical college/hospital, based on the requisites.

FUNCTIONS OF PHC

In India it covers all the "10 essential elements" of primary health care as outlined in the Alma-Ata Declaration and they are (Fig. 5.3):

It is proposed to equip the primary health centres with facilities for selected surgical procedures (e.g. vasectomy, tubectomy, MTP and minor surgical procedures) and for

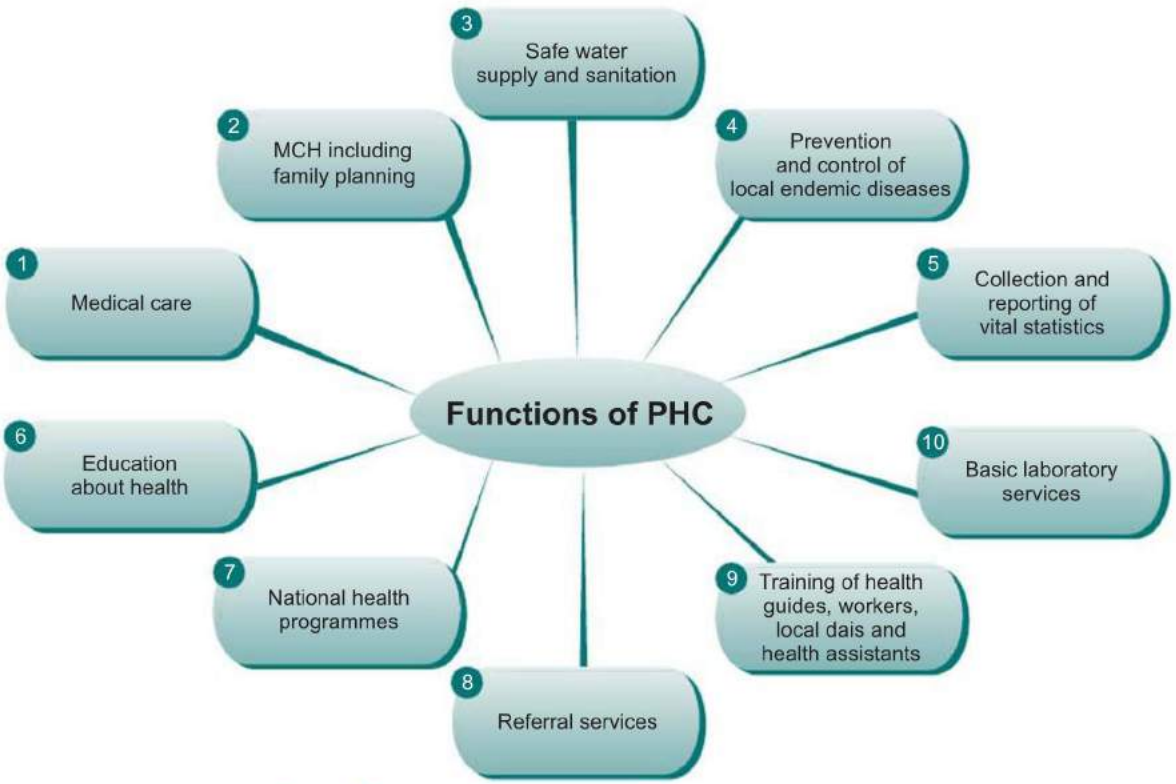


Figure 5.3 Functions of primary health centre (PHC).

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paediatric care. In order to reorient medical education (ROME programme) towards the needs of the country and community care, three primary health centres have been attached to each of the 148 medical colleges.

REASONS FOR LACK OF PRIMARY DENTAL CARE

- Nonexistence of oral health policy.
- Nonexistence of separate oral health budgetary allocation for oral health.
- Lack of commitment and awareness on part of general public, politicians and planning commission towards oral health.
- Virtual nonexistence of oral health insurance schemes.
- Lack of research in social and behavioural aspects regarding oral health (one of the mainstay in planning implementation and sustainability of any oral health care programme).
- Lack of orientation of currently operating oral health care programmes towards preventive and promotive concepts, which are required for long-term and sustainable gains in oral health.
- Nonavailability of uniform baseline data for prevalence and impact of oral diseases in our country which forms grassroots of policy making and planning for oral health care programmes.
- Lack of monitoring of already existing programmes.
- Lack of research in indigenously developed or existing systems—preventive and curative therapies (alternative medicine) in our country.
- Lack of equipment and workforce levels at peripheries and *taluka* level.
- Lack of use of full potential of mass media and other existent systems of public address for oral health education.
- Lack of practical training and know-how of public health to oral health care professionals.
- Decentralization or people-centred rather than government-centred approach in policy making and planning of oral health care programmes to tackle burden of oral disease has to be used.
- Very little research regarding testing of foreign oral health care brands and strategies adopted in the western world for oral health care in our scenario.

CONCLUSION

It's been more than three decades after the Alma-Ata declaration, which has valid principles providing the essential health care services to the unreached. Despite this the health inequities in health status and access to the health care remain an area of concern. Hence, the primary health care sector requires further strengthening to ensure equitable, affordable and comprehensive quality health care services.

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6 National Health Programmes

Hiremath SS

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INTRODUCTION

The value of health is not realized till it is lost. It is not only true at individual level but even at the community and government level. The understanding of the health was articulated by WHO in 1948 as a "state of complete physical, mental and social wellbeing and not merely absence of disease or infirmity." The significance of this concept is to lead a "socially and economically productive life." In a developing country like India, unfortunately health has not been given any priority or importance, in fact, it has been completely neglected. The scene was worse before independence. It is only after India became free, the government has undertaken various measures to improve the health of the people, and prominent among them are the National Health Programmes. These programmes were launched by the Central Government with material and technical assistance from various international agencies for covering a broad range of programmes from providing good environmental sanitation to control and eradication of diseases. The 1983 national health policy recorrected the aim of the Constitution of India for the "elimination of poverty, ignorance and ill health." However, gaps remain larger between the rural and urban in the health set-up. Much momentum was gained during 1999, when there was a vigorous implementation of many programmes and also policy initiatives to improve health facilities. The Sixth Conference of Central Council of Health held in April 1999 proved to be a landmark in finalizing and suggesting innovative strategies to tackle health problems in different areas.

These programmes can be grouped under

I. Preventive and promotive health care
II. Programme for communicable diseases
III. Programme for noncommunicable diseases
IV. National nutritional programmes
V. Programme for system strengthening/ welfare
VI. Miscellaneous

NATIONAL HEALTH PROGRAMMES IN INDIA (Tables 6.1, 6.2 and 6.3)

National Water Supply and Sanitation Programme—1954

- Launched to ensure safe water and drainage to the entire population.
- It identifies the problem of villages, where no source of safe water is available.
- The programme targets at achieving 100% coverage for water, both urban and rural and sanitation—80% for urban and 25% for rural.

Vector Borne Disease Control Programme—1955

Programme was launched in 1955 for control of major vector borne diseases of public health importance like:

- Malaria
- Filaria
- Kala azar
- Japanese encehpalitis
- Dengue/hemorrhagic fever

National Malaria Control Programme (NMCP)—April, 1953

Initiated to introduce residual spraying of DDT (1 gram per square metre of surface area) twice a year in endemic areas where enlargement of spleen rates were over 10%. Results were highly successful, encouraged by which strategy of control was changed to malaria eradication in 1958. But the incidence increased at a rapid rate. Hence, a modified plan of action evolved.

The modified plan of operation included the following:

- Reclassification of endemic areas
- Establishment of drug distribution centres and fever treatment depots

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Table 6.1 National health programmes

1.	National water supply and sanitation programme—1954
2.	Vector borne disease control programme—1955
3.	National leprosy eradication programme—1955
4.	National smallpox eradication programme— 1960
5.	Iodine deficiency disorders programme—1962
6.	National tuberculosis programme—1962
7.	National family welfare programme—1974
8.	Minimum needs programme—1974
9.	National cancer control programme—1975
10.	20-Point programme—1975
11.	National programmes for control of blindness—1976
12.	National mental health programme—1982
13.	National guinea worm eradication programme—1984
14.	National diabetes control programme—1984
15.	Universal immunization programme—1985
16.	National AIDS control programme—1987
17.	Drug de-addiction programme—1987
18.	Diarrhoeal disease control programme—1990
19.	Reproductive and child health programme—1992
20.	Yaws eradication programme—1996
21.	National programme for control and treatment of occupational diseases—1998
22.	National surveillance programme for communicable diseases—1998
23.	National SARS control programme—2003
24.	Antitobacco programme—2003
25.	Nation Rural Health Mission—2005–12

- Urban malaria scheme
- *Plasmodium falciparum* containment
- Research
- Health education
- Reorganization.

The 10th Five-Year Plan targets at reducing morbidity by 25% by 2007 and 50% by 2010.

National filaria control programme (NFCP). It has been in operation since 1955. Recent estimates show that 420 million are exposed to risk of infection, 19 million manifest disease and 25 million have filarial parasite in their blood. Strategy to control includes:

- Vector control through antilarval operation
- Source reduction
- Detection and treatment of microfilaria carriers
- Morbidity management.

Kala azar control programme. Kala azar is endemic in 33 districts of Bihar, Jharkand, UP. Programme was launched in 1990 with support from Central Government. Incidence and death rate have come down by 75% by 2002.

Strategies include:

- Interruption of transmission—indoor residual insecticidal spray twice annually

Table 6.2 Types of groups of various national health programmes

Sl No.	Health Programmes	Programmes
1.	**Preventive and promotive health care**	• Mission Indradhanush
2.	**Programmes for communicable diseases**	• Revised National Tuberculosis Control Programme (RNTCP) • National Leprosy Eradication Programme • National Vector Borne Disease Control Programme • National AIDS Control Programme (NACP) • Pulse Polio Programme
3.	**Programmes for noncommunicable diseases**	• National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) • National Programme for Control of Occupational Diseases • National Programme for Prevention and Control of Deafness (NPPCD) • National Mental Health Programme • National Programme for Control of Blindness
4.	**National nutritional programmes**	• Integrated Child Development Services • National Iodine Deficiency Disorders Control Programme • Midday Meal Programme
5.	**Programmes for system strengthening/ welfare**	• National Programme for Health Care for Elderly (NPHCE) • RMNCH+A • National Health Mission (NHM) • National Urban Health Mission (NUHM)
6.	**Miscellaneous**	• Voluntary Blood Donation Programme • Universal Immunization Programme (UIP) • Integrated Disease Surveillance Programme (IDSP) • National Tobacco Control Programme (NTCP) • Pradhan Mantri Swasthya Suraksha Yojana (PMSSY) • Janani Shishu Suraksha Karyakram (JSSK) • Rashtriya Kishore Swasthya Karyakram (RKSK) • National Health Scheme

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Table 6.3 Features of various national health programmes

Sl No.	Programme	Features

1.	Mission Indradhanush	• On 25th December 2014, the Ministry of Health and Family Welfare (MOHFW), Government of India launched this programme.
		• Objective – to provide full immunity with seven vaccine preventable diseases to all children under the age of 2 years as well as pregnant women.
		• The Mission Indradhanush, acts against seven vaccine preventable diseases, namely:
		  • Diphtheria
		  • Pertussis *(Whooping Cough)*
		  • Tetanus
		  • Tuberculosis
		  • Polio
		  • Hepatitis B
		  • Measles.

2.	National programme for Health care for Elderly (NPHCE)	• The programme has been introduced to provide promotional, preventive, curative and rehabilitative services for the elderly at government health facilities. • The services provided would include day care services, health promotion, preventive services, diagnosis and management of geriatric medical problems (out- and inpatient), and rehabilitative services including home based care as needed. • To strengthen the referral system, the districts will be associated with regional geriatric centres with the development of specialized manpower and research in the same field.
3.	National programme for prevention and control of Cancer, Diabetes, Cardiovascular Diseases & Stroke (NPCDCS)	• This programme aims to prevent and control common NCDs by bringing about behavior and lifestyle changes. • Provides prompt diagnosis and management, capacity building at various levels for prevention, diagnosis and treatment, with emphasis on palliative and rehabilitative care. • Training for both medical and paramedics to cope with the uptrending burden.
4.	Pradhan Mantri Swasthya Suraksha Yojana (PMSSY)	• The scheme was approved in March 2006. • It aims at correcting the inequities in the accessible and affordable health care facilities in the diverse parts of the country. • The first phase in the PMSSY has two components – establishing six institutions similar to AIIMS; and upgradation of 13 Government medical college institutions that are currently existing.
5.	Janani Shishu Suraksha Karyakram(JSSK)	• Was launched in June 2011. • Have free entitlements for pregnant women, newborns and infants as well.
6.	Rashtriya Kishore Swasthya Karyakram(RKSK)	• Also called National Adolescent Health Programme • Launched in January 2014. • Covers adolescents, in the age group of 10–19 years targeting nutrition, reproductive health and substance abuse.

- Early diagnosis and complete treatment
- Health education for community awareness.

The 10th Five-Year Plan aims at elimination of kala azar by 2010.

Japanese encephalitis control. It has high mortality rate and survivors suffer from neurological complications. Strategies include:

- Care of patient
- Development of safe vaccine
- Sentinel surveillance
- Epidemiological monitoring.

Dengue fever control. Following outbreak in Delhi in 1996, guidelines in case of outbreak was sent to all states which included:

- Identification of outbreak
- Delineation of affected area
- Containment of outbreak
- Case management.

National Leprosy Eradication Programme—1955

Programme was launched in 1955 with central aid to achieve control through early detection of cases. In 1983

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the programme was redesignated as eradication programme with the aim of reducing the incidence to 1 per 10,000.

Strategies include:

- Early detection—population survey, school survey contact examination and voluntary referral
- Short-term multidrug therapy
- Ulcer and deformity care
- Rehabilitation activities.

The 10th Five-Year Plan aims at complete integration of the programme into general health care by 2007.

National Smallpox Eradication Programme—1960

Pilot projects for eradication of smallpox were initiated in 1960. The programme was launched in 1962. On 5th July 1975, India became smallpox free. On 8th May 1980, smallpox was officially declared eradicated from the entire world by World Health Assembly (WHO).

National Goitre Control Programme—1962

Launched in India in 1962 through iodized salt with the aim of bringing down iodine deficiency disorder (IDD) to less than 10% by 2000.

A national policy was brought in at the end of eighth plan to fortify all edible salt nationwide. Twenty-six states have completely banned use of uniodized salt.

IDD control cells have been established to ensure effective implementation of this programme.

National Tuberculosis Programme—1962

This has been in operation since 1962 with the following objectives:

***Long-Term Objectives* Include:**

- To reduce to a level where it ceases to be a public health problem (when one case infects less than one new person annually) and prevalence below 14 years to be brought down from 30% to 1%.

***Short-Term Objectives* Include:**

- To detect maximum number of TB cases among outpatients attending any health institution.
- To vaccinate newborn and infants with BCG.
- To undertake objectives in an integrated manner.

District tuberculosis centres have been established. All patients are provided with free short course therapy. All drugs are administered under supervision called Direct Observed Therapy Short-course—DOTS.

The drugs used in DOTS are listed in Table 6.4.

Table 6.4 Drugs for tuberculosis

Drug	Daily dose mg/kg	For 60 kg
Isoniazid	5 (4–6)	300
Rifampicin	10 (8–12)	600
Pyrazinamide	25 (20–30)	1500
Ethambutol	15 (15–20)	1000
Streptomycin	15 (12–18)	1000

National Family Welfare Programme—1974

In April 1976, the first national population policy was framed legalizing age of marriage as 15–18 years for girls and 18–21 for boys.

This policy was modified in 1977 to stress the importance of small family. Since then, it is called Family Welfare Programme. National population policy 2000 is the latest in the series.

Minimum Needs Programme—1974

Introduced during the fifth Five-Year Plan (1974–1978) with the aim to provide basic requirements to improve the standard of living. It is the expression of the commitment towards the development namely, social and economic of the deprived population. The components of the programme are:

- Rural health
- Rural water supply, rural electrification
- Elementary education
- Adult education
- Nutrition
- Environmental improvement of urban slums
- House for landless labourers.

In the field of rural health, objectives to be achieved include establishment of one PHC for 30,000 populations in plain areas and 20,000 populations in tribal areas. In the field of nutrition, to extend nutrition support to 11 million eligible persons, to expand special nutrition programme to all integrated child development service (ICDS) projects and consolidate midday meal programme.

National Cancer Control Programme—1975

In India, it is estimated that there are about 2 million cancer cases at any given point of time with about 0.7 million new cases adding up every year. The programme was started during 1975–76 with central assistance for purchase of cobalt therapy units for treatment of cancer patients. The programme continued during sixth and seventh plans when regional cancer centres were established. During eighth Five-Year Plan, emphasis was on prevention and early detection. From 1990 onwards the following schemes have been initiated:

- Scheme for district projects for preventive health education, early detection and pain relief measure.
- Development of oncology wings in medical colleges and hospitals.
- Scheme for financial assistance to voluntary organizations.

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Table 6.5 Health related points in 20 point programme

Point 1	Attack on rural poverty
Point 7	Clean drinking water
Point 8	Health for all
Point 9	Two-child norm
Point 10	Expansion of education
Point 14	Housing for people
Point 15	Improvement of slums
Point 17	Protection of environment

20 Point Programme—1975

This was initiated in 1975 as a special activity. It was developed with the objective of promotion of social justice and economic growth. It was restructured with the following objectives:

- Eradication of poverty
- Raising productivity
- Reducing inequalities
- Removing social and economic disparities
- Improving the quality of life.

Out of the 20 points, eight points are important towards health (Table 6.5). This programme constitutes country's charter on socioeconomic development, and it has been described as "the cutting edge of the plan for the poor."

National Programme for Control of Blindness—1976

This programme was launched in 1976 with central support.

Strategies include:

- Strengthening service delivery
- Developing human resources for eye care
- Promoting out reach activities and public awareness
- Establishing facilities for every 500,000 people.

Programmes covered under this include:

- Community health education
- Conducting eye camps especially in rural areas
- Cataract surgeries and implantation of intraocular lenses
- School eye screening programmes
- Collection and utilization of donated eyes (20,000 eyes are collected every year from donation).

Vision 2020: The right to sight. It is a global initiative to reduce avoidable blindness by 2020, which has been taken up by WHO. The target diseases are cataract, refractive errors, childhood blindness, glaucoma and diabetic retinopathy.

Universal Immunization Programme—1978

Immunization gained more importance after the eradication of smallpox. WHO launched its expanded programme on immunization (EPI) against six common preventable childhood diseases: diphtheria, pertussis, tetanus, polio, tuberculosis and measles.

Programme is being supported by UNICEF which renamed it as universal child immunization in 1985. Objective was to reduce the mortality and morbidity resulting from vaccine preventable diseases of childhood. Two components are:

- Immunization of pregnant women against tetanus
- Immunization of children in their first year against six diseases.

In India it was launched in 1978. Significant achievements have been made including the pulse polio immunization programme which was launched in 1995, under which all children under 5 years are given additional oral polio drops in December and January every year on fixed days.

National Guinea Worm Eradication Programme—1984

This programme was launched in 1984 with assistance from WHO. It was integrated into the national health system at village level. With well-defined strategies, efficient evaluation and coordination, India has been able to control this disease to a great extent. Majority of these cases were from states of Rajasthan, Madhya Pradesh and Karnataka. Zero cases have been reported since 1996. But the disease has not been completely eradicated from India.

National Mental Health Programme—1984

This was launched during 1982 with technical assistance from WHO. With the objective of ensuring availability of mental health services to all, the district mental health programme was launched in 1996–97. Based on the community oriented approach, this programme includes:

- Training of mental health team at the identified nodal institutes
- Increasing the awareness about mental health problems
- Providing OPD, indoor treatment and follow-up
- Provide valuable data for future planning, improvement in service and research.

National Diabetes Control Programme—1984

This was started during seventh Five-Year Plan, but could not be extended due to lack of funds. Objectives include:

- Identification of high-risk individuals at early stage
- Early diagnosis and management
- Prevention/arresting of complications.

National AIDS Control Programme—1987

This programme was launched in India in 1987 to reduce the HIV spread in India and to strengthen India's capacity to respond to HIV/AIDS on a long-term basis.

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National AIDS prevention and control policy was approved in 2002.

Objectives include reduction of the impact of epidemic and to bring about a zero transmission by 2007.

Some of the programmes undertaken include:

- Blood safety programmes
- Counselling and HIV testing
- Voluntary counselling and testing centre
- STD control programme
- School AIDS education programme
- Prevention of HIV from mother to child.

Drug De-addiction Programme—1987

This programme was started in 1987-88 with the establishment of five de-addiction centres. The Ministry of Health and Family Welfare has an important role to play in the treatment process of drug addicts by way of preventive health, detoxification and aftercare.

Diarrhoeal Disease Control Programme—1990

Diarrhoea is one of the leading causes of deaths in children especially in developing countries. This programme was started during the sixth plan to bring down diarrhoea and cholera related mortality and intensified in 1990 to decrease mortality by 50%. PHCs and district hospitals are involved. Village health guide is supplied with 100 packets of ORS per year. The composition of the ORS is as follows:

Sodium chloride	2.6 g
Trisodium citrate dihydrate	2.9 g
Potassium chloride	1.5 g
Anhydrous glucose	13.5 g

The contents of each packet should be dissolved in one litre of water.

Reproductive and Child Health Programme—1992

The programme is concerned with child survival and safe motherhood. Main highlights:

- Integrates all interventions of fertility regulation, reproductive health, maternal and child health
- Service provided is demand driven
- Upgradation of level of facilities
- Facilities to improve obstetric care
- Outreach services to vulnerable group.

Yaws Eradication Programme—1996

Yaws is a non-venereal tribal treponemal infection causing deformity and destruction leading to economic loss to the already underprivileged community. It can be cured and prevented by a single injection of penicillin. It is amenable to eradication and in the process of doing so, will bring collateral benefits in terms of expanding the outreach of health care delivery to the remote areas. National Institute of Communicable diseases is the nodal point for the programme.

National Programme on Control and Treatment of Occupational Diseases—1996

The National Health Policy of 1983 and also 2002 had occupational health as one of their components. But steps to control and prevent occupational diseases have been neglected. Hence in the year 1998-99, the Ministry of Health and Family Welfare, Government of India has launched a scheme entitled "National Programme for Control and Treatment of Occupational Diseases." The National Institute of Occupational Health, Ahmedabad (ICMR) has been made the nodal agency for the implementation of the same. Following research projects have been proposed to be initiated by the government:

- Prevention, control and treatment of silicosis and silicotuberculosis in agate industry.
- Occupational health problems of tobacco harvesters and their prevention.
- Hazardous process and chemicals, database generation, documentation and information dissemination.
- Capacity building to promote research, education, training at National Institute of Occupational Disease.
- Health risk assessment and development of interventional programme in cottage industries with high risk of silicosis.
- Prevention and control of occupational health hazards among salt workers in the remote desert areas of Gujarat and western Rajasthan.

National Surveillance Programme for Communicable Diseases—1998

Outbreak of plague, malaria and dengue highlighted the urgency of surveillance.

The Ministry of Health launched this programme in 1998 for detection of early warning signals of outbreaks. This includes training of medical and paramedical personnel.

NUTRITIONAL PROGRAMME

1. Integrated Child Development Service (ICDS) Scheme
2. Midday Meal Programme
3. Special Nutrition Programme (SNP)
4. Balwadi Nutrition Programme
5. Wheat Based Supplementary Nutrition Programme
6. Applied Nutrition Programme
7. Tamil Nadu Integrated Nutrition Programme
8. National Nutrition Anaemia Prophylaxis Programme
9. World Food Programme (WFP)

Integrated Child Development Service (ICDS) Scheme

- Integrated Child Development Service (ICDS) scheme was introduced on 2nd October, 1975 as a part of fifth Five Year Plan in continuation of the National Policy for Children in 33 experimental blocks. After successful implementation in these blocks, the scheme was expanded in 1994 to 1996. Currently, the goal of the

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scheme is to have an universal coverage to the entire country.

- **while** the Department of Women and Child Development has the primary responsibility for the programme, the activities shoud also be carried out by the Ministry of Human Resources Development at the centre and the nodal departments at the state which may be Social Welfare, Rural Development, Tribal Welfare, Health and Family Welfare or Women and Child Development.

Beneficiaries of the scheme

1. Children below 6 years
2. Pregnant and lactating women
3. Women in the age group of 15–44 years
4. Adolescent girls in selected blocks

Objectives

1. Improve the nutrition and health status of children in the age group of 0–6 years;
2. Lay strong foundation for the psychological, physical and social development of the child;
3. Effective coordination and implementation of policy among the various departments and
4. Enhance the capability of the mother to look after the normal health and nutrition needs through proper nutrition and health education.

ICDS scheme provide the following services:

1. Supplementary nutrition, Vitamin A, iron and folic acid,
2. Immunization,
3. Health checkups,
4. Referral services,
5. Treatment of minor illnesses,
6. Nutrition and health education to women,
7. Preschool education of children in the age group of 3–6 years and
8. Convergence of other supportive services like water supply, sanitation, etc.

Scheme for Adolescent Girls *(Kishori Shakti Yojna)* Adolescence is an age group which was neither covered by schemes for women or for children. Moreover, adolescent girls are a crucial age group which needs special attention in terms of appropriate nutrition, education, health education, training for adulthood, training for acquiring skills as the base for earning an independent livelihood, training for motherhood, etc. and also their potential as future community leaders should also be exploited. Hence, a scheme for adolescent girls of 11–18 years of age in ICDS was added by the Department of Women and Child Development, Ministry of Human Resource Development in 1991.

The services included are:

1. Watch over menarche,
2. Immunization,
3. General health checkups once in every 6 months,
4. Training for minor ailments,
5. Deworming,
6. Prophylactic measures against anaemia, goiter, vitamin deficiency, etc. and
7. Referal to PHC, District hospital in case of acute need.

Mid-day Meal Programme

This scheme was first introduced in Tamil Nadu. Neither a child that is hungry, nor a child that is ill can be expected to learn. Based on this, the midday meal (MDM) scheme was launched in primary schools in 1962–63. The three areas midday meal caters to are school attendance, reduced dropouts and a beneficial impact on children's nutrition. The programme aimed to cover 21.1 million schoolchildren by 1989–90 through government, local body and private-aided primary schools. Minimum 3 kgs of food grains/ month / per child is provided (300 kcal and 8–12 g of protein per day) by the Central government free of cost. For rural areas, panchayats and nagarpalikas are also involved for setting up of necessary infrastructure for preparing cooked food with the help of NGOs, women's group and parent–teacher councils. The Poverty Alleviation Programme bears the expenditure of cooking, supervision and kitchen. International agencies like Cooperation for American Relief Everywhere (CARE) and World Food Programme (WFP) also assist in supplementary feeding in several states. However, problems in administration and quality of food are a setback for the success of this programme.

Special Nutrition Programme (SNP)

Launched in 1970–71, this programme aims to provide supplementary feeding of preschoolers with 300 cal and 10 g of protein and expecting and nursing mothers about 500 cal and 25 g of protein for 6 days a week. This programme was operated under Minimum Need Programme. The programme targets rural areas inhibited predominantly by lower socioeconomic groups in tribal and urban slums and also funds the nutrition component of ICDS programme.

Balwadi Nutrition Programme

The Central Government launched this program in 1970–71. Funded by voluntary organizations, it provides 300 cal and 10 g of protein per child (3–5 years) per day for 270 days a year.

Wheat Based Supplementary Nutrition Programme

Initially sponsored by Central government, currently this programme is run by state sector. This programme follows the norms of SNP or of the nutrition component of the ICDS and consists of supply of free wheat and bears supportive costs for other ingredients, cooking, transport, etc.

Applied Nutrition Programme

Started as a pilot scheme in Orissa in 1963 and later extended to Tamil Nadu and Uttar Pradesh, the Applied Nutrition Programme (ANP) has the following objectives: (a) promoting production of protective food such as vegetables and fruits and (b) ensuring their consumption by pregnant and nursing mothers and children. During 1973, it was extended to all the states in the country. The

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attention is focused on teaching rural communities through demonstration how to produce food on their own for their consumption with the target populations being children between 2–6 years and pregnant and lactating mothers. Without specifying the nutrient content, nutrition worth of 25 paise per child per day and 50 paise per woman per day are provided for 52 days in 1 year. It encourages kitchen gardens, poultry farming, beehive keeping, etc. Unfortunately, this programme has limited impact due to lack of suitable land, irrigation facilities and low financial investment.

Tamil Nadu Integrated Nutrition Programme (TINP)

The Tamil Nadu Integrated Nutrition Project of 1980 targets children of 6–36 months age and pregnant and lactating women. TINP aimed:

1. To reduced malnutrition upto 50% among children under 4 years of age;
2. To reduce infant mortality by 25%;
3. To reduce vitamin A deficiency in the under 5-year group from about 27% to 5% and
4. To reduce anaemia in pregnant and nursing women from about 55% to about 20%.

This project has four major components:

1. Nutrition services,
2. Health services,
3. Communication and
4. Monitoring and evaluation.

The goals of the programme were:

1. To increase th proportion of children classified as "nutritionally normal" by 50% in new and 35% in TINP-II areas;
2. To reduce the infant mortality to 55% per 1000 live births and
3. To 50% reduction in incidence of low birth weight.

The project is funded by World Bank.

National Nutrition Anaemia Prophylaxis Programme

Available studies on prevalence of nutritional anaemia in India show that 65% infant and toddlers, 60% children in 1–6 years of age, 88% adolescent girls (3.3% has haemoglobin < 7 g/dL; severe anaemia) and 85% pregnant women (9.9% having severe anaemia) are suffering from nutritional anaemia. Lactating women have marginally higher prevalence of anaemia as compared to pregnant women and iron deficiency anaemia is the commonest form.

Launched in 1970, this programme provides the expected and nursing mothers as well as acceptors of family planning with one tablet of iron and folic acid containing 60 mg elementary iron which was raised to 100 mg elementary iron without change in folic acid content (0.5 mg of folic acid) and children in the age group of 1–5 years are providd with one tablet of iron containing 20 mg elementary iron (60 mg of ferrous sulphate) and 0.1 mg of folic acid daily for a period of 100 days. This programme is governed by Maternal and Child Health (MCH) Division of Ministry of Health and Family Welfare and is now a part of RCH programme.

To make the programme successful, long term measures like fortification of food items like milk, cereal, sugar, salt with iron are to be adopted. Nutrition education through school health and ICDS infrastructure to improve dietary intakes in family and promotion of regular intake of iron/folic acid rich foods can be incorporated.

World Food Programme (WFP)

World Food Programme with the goal "A world in which every man, woman and child has access at all times to the food needed for an active and healthy life. Without food, there can be no sustainable peace, no democracy and no development." is actively involved in 84 countries. It was formed as a food aid arm of the United Nation in 1963, WFP is committed to achieve the goal of halving the number who are without adequate access to food by 2015.

Anti-tobacco Programme

The consumption of tobacco has been equivocally established as a major health hazard. Tobacco is responsible for many of the preventable illnesses including cancer. Recognizing this fact, Cigarettes Act was passed in 1975. This included displaying by manufacturers on all cartons/packets of cigarettes, advertisements and the like, a statutory warning "Cigarette smoking is injurious to health." But unfortunately this has not made much impact on smoking habits. Hence the need for a more comprehensive programme was felt. An antitobacco legislation is under consideration in consultation with Ministry of Law, Justice and Company affairs.

PILOT PROJECT ON CONTROL OF CARDIOVASCULAR DISEASES AND STROKE

Cardiovascular diseases (CVD) are the leading contributors of mortality and morbidity globally. This rising incidence especially in developing countries has been attributed mainly to changing lifestyle. Most of these diseases can be controlled by simple measures like lifestyle management, early detection and prompt treatment. A pilot project was initiated in India during 1995–96. The main objectives of the project are:

- To enhance community awareness regarding CVD
- Increasing the awareness of health care workers regarding CVD
- Augmenting the ability of the health care system at all levels for CVD control
- Primary prevention by way of reduction of risk factors
- Cost-effective management of established CVD.

NATIONAL PROGRAMME FOR PREVENTION AND CONTROL OF DIABETES, CARDIOVASCULAR DISEASE AND STROKE (NPDCS)

Non-communicable diseases (NCD), include chronic diseases such as cardiovascular diseases, diabetes, stroke,

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most forms of cancers and injuries. The main etiology of such diseases may be from lifestyle related factors, such as unhealthy diet, lack of physical activity and tobacco use. Changes in living conditions, behavioural habits, increased lifespan (aging population), sociocultural and technological advancements are leading to sharp increases in the prevalence of NCD. These diseases can be prevented by making simple changes in lifestyle.

Objectives of NPDCS

- Prevention and control of NCDs
- Awareness generation on lifestyle changes
- Early detection of NCDs
- Capacity building of health systems to tackle NCDs

The programme was pilot tested in 10 districts of 10 states (January 2008) focusing on health promotion and health education advocacy at various settings. The following interventions are planned in the programme:

i. Health promotion and health education for community
ii. Early detection of persons with high levels of risk factors (at the risk of developing disease) through screening
iii. Strengthening health systems at all levels to tackle NCDs and improvement of quality of care including treatment of sleep disorders and augmenting facilities of dialysis.

National SARS Control Programme (2003)

The year 2003 witnessed two new dreadful international outbreaks of SARS and bird flu.

Severe acute respiratory syndrome (SARS) affected 8422 cases in 29 countries resulting in 916 deaths across all the continents. With a view to prevent its outbreak and spread in India, the Ministry of Health and Family Welfare along with the Ministries of Civil Aviation, Home Affairs and shipping and immigration officials and health professionals posted at international airports/ports conducted screening of all incoming passengers at international airports. Similarly, state governments were also asked to identify nodal officers and hospitals for treatment of SARS cases, should any be noticed. At the central level, National Institute of Virology (NIV), Pune, and National Institute of Communicable Diseases (NICD), Delhi were identified as nodal laboratories for investigations. As a result of such drastic measures only three cases of SARS were reported in the entire country. Similar preventive measures were undertaken by the ministry when the outbreak of bird flu was reported in other countries and resulted in no case ever being reported.

National Rural Health Mission (2005–12)

Based on the fact that health is an integral and important part of country's economic and social development, the Government of India has launched the National Rural Health Mission to carry out necessary architectural correction in the basic health care delivery system. It adopts a synergistic and comprehensive approach by relating health to the determinants of good health viz. segments of nutrition, sanitation, hygiene and safe drinking water.

Another goal of the mission is to mainstream the Indian systems of medicine to facilitate health care. The plan of action includes increasing public expenditure on health, reducing regional imbalance in health infrastructure, pooling resources, integration of organizational structures, optimization of health manpower, decentralization and district management of health programmes, community participation and ownership of assets, induction of management and financial personnel into district health system and operationalizing community health centres into functional hospitals meeting Indian Public Health Standards in each block of the country.

Integrated disease surveillance project (IDSP). IDSP was launched by Hon'ble Union Minister of Health and Family Welfare in November 2004 which is a decentralized, state based surveillance programme in the country. It is designed to detect early warning signs of impending outbreaks and help plan and start an effective response to mitigate the situation. Major components of the project are: (1) integrating and decentralization of surveillance activities; (2) strengthening of public health laboratories; (3) human resource development—training of state surveillance officers, district surveillance officers, rapid response team, other medical and paramedical staff and (4) use of information technology for collection, collation, compilation, analysis and dissemination of data.

Surveillance committees at national, state and district levels are monitoring the project after implementation. Currently networks are established with all state capitals, district head quarters and all government medical colleges on a satellite broadband hybrid network. The network on completion will enable 800 sites on a broadband network. This network enables enhanced speedy data transfer, video conferencing, discussions, training, communication and in future e-learning for outbreaks and programme monitoring under IDSP. A 24 × 7 call centre with toll free telephone to receive disease alerts from anywhere in the country and diverges the information to the respective state/district surveillance units for verification and initiating appropriate actions wherever required.

CONCLUSION

Even though more than 25 programmes were launched, only few have been very successful, like the malaria control programme, tuberculosis control programme, immunization programme and blindness control programme. The main reasons for failure of most of the programmes are lack of funds and monitoring from government and poor participation from the people. Hence educating public to utilize the health services provided to them, and a more serious commitment on the part of government is necessary to carry out all programmes successfully.

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CONCLUSION—cont'd

Some areas like oral health have been completely kept outside the picture. Unfortunately there are no national programmes for prevention of oral and dental diseases, even though most oral diseases are considered of public health concern and problem, and also some of the presently emerging conditions due to change in lifestyle like the noncommunicable diseases such as the oral cancer have not been given importance. Hence there is an urgent need to frame the national oral health policy, in turn, a separate budget allocation for oral health and initiating national oral health programmes.

REVIEW QUESTIONS

1. Write short notes on:
   a. Objectives of the National Health Programme
   b. 20 Point Programme
   c. Minimum Needs Programme
   d. DOTS
   e. Vision 2020—the right to sight
   f. ORS
   g. RCH Programme

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7 International and National Health Agencies

Hiremath SS and Anitha R Sagarkar

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INTRODUCTION

Throughout the history disease and ill health have remained as a burden and liability to the society, nation, and world at large. Nothing on the earth is more important than good health. Societal, technological and environmental factors continue to have a dramatic effect on overall health of the population worldwide. At the same time, they have been facilitating the emergence of new diseases and the re-emergence of old ones. Modern demographic and ecologic conditions favour the spread of both infectious and noninfectious diseases. This could be due to overpopulated growth along with increased prevalence of poverty. And also there is a drastic change in the environmental health on account of behavioural pattern of migrants, travellers and refugees. At the same time there is an increased international tourism across the globe. Altogether this has resulted in unhealthy situation at all levels.

OBJECTIVES

The importance of the international health has come a long way to compromise those problems in the field of health sector including the consideration and the action, which require the participation of more than one country. The health problems of any country have to be dealt officially by government, national and international voluntary organizations. The main objectives of the international health organizations are:

1. The control and management of epidemics and communicable diseases, affecting more than one country including the exchange of useful information on the incidence of epidemic diseases and existing for uniformity in quarantine regulations, procedures and documents.
2. The exchange of health information and experience at international level including a central medical intelligence bureau, fellowship programmes and publications.
3. The international standardization of biological preparation, vital statistics and banned drugs, etc.
4. Coordinated combined research and assistance to research programmes on specific problems, which are common to many nations.
5. Helping and assisting underdeveloped countries in training the health staff, medical planning so as to manage and control the epidemics.
6. International health in case of disasters and also consideration for control of drug addiction.

QUARANTINE

Quarantine is defined as the "limitation of freedom of movement of such well persons or domestic animals exposed to communicable disease for a period of time not longer than the longest usual incubation period of the disease in such manner so as to prevent effective contact with those not so exposed." To keep the spread of disease under control from one region to another region or country, a thorough scrutiny of health status was carried out from time to time. If any person, passenger or a traveller is found to be a suspected carrier of any transmissible disease, he or she will be isolated and detained for a specific period of time. This is called as "Quarantine." This protocol was followed even for animals while transporting from one country to another country. Over a period of time it became a standard established protocol in many countries.

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Types of Quarantine

1. Absolute quarantine
2. Modified quarantine
3. Segregation

A selective partial limitation of freedom of movement such as exclusion of children from school is also practised.

In contrast to isolation, quarantine applies to restrictions on the healthy contacts of an infectious disease. Quarantine, which was once popular method of disease control, has now declined in its popularity on account of poor evidence of spread of disease and lack of knowledge about the causation and the way disease spreads.

INTERNATIONAL HEALTH AGENCIES

There are various international health agencies which are active and serving in different parts of the world as following (Table 7.1):

Table 7.1 International health agencies

Sl. No.	Programme	Features
1.	First International Sanitary Conference	• Was convened in Paris in the year 1851. • Objective: To introduce order and uniformity into quarantine measures, which varied from country to country. • An International Sanitary Code comprising of 137 articles was prepared, but never came into force making the conference a failure.
2.	Pan American Sanitary Bureau (PASB)	• Established in 1902 in America. • Objective: To coordinate quarantine procedures in the American states. • World's 1st International health agency. • In 1947, the bureau was reorganized and was called Pan American Sanitary Organization (PASO). • From 1949, PASO served as WHO regional office for America. • 1958: Name changed to Pan American Health Organisation.
3.	Office International D'Hygiene Publique	• Convened in the year 1907, generally known as Paris office. • Objective: To disseminate information on communicable diseases and to supervise international quarantine measures. • The OIHP continued until 1959 after which it was taken over by WHO.
4.	The Health Organization of The League of Nations	• Objective: To take steps in matters of international concern for the prevention and control of disease. • Due to nonconfinement to quarantine regulations or problems of epidemic diseases, the League branched out into matters such as housing and rural hygiene, training of public health workers and standardization of certain biological preparations. • The League's efforts to amalgamate the OIHP, PASB and the Health Organization proved to be a failure and all three were coexisting during the years between the two World Wars. • 1939: The League of Nations was dissolved, however, its Health Organization in Geneva continues to deal with requests for information and publication of weekly epidemiological records.
5.	The United Nations Relief and Rehabilitation Administration (UNRRA)	• UNRRA was set up in the year 1943 with the purpose of organizing recovery from the effects of WWII. • It had a health division to care for the health of millions of displaced persons, to restore and help services and to retrieve machinery for international interchange of information on epidemic diseases. • It did outstanding work in preventing the spread of typhus and other diseases and was also renowned for its campaign on eradication of malaria from Sardinia, which began as a joint effort including the Rockefeller Foundation and Italian Government. • 1946: UNRRA's official existence was terminated and all its activities and assets were taken by the interim commission of WHO and UNICEF.
6.	World Health Organization	• Established in 7th April 1948. • Objective: Attainment of highest level of health by all people. • Governed by 192 member states through World Health Assembly. • WHO member states are grouped into six regions. Each region has a regional office.

Continued

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Table 7.1 International health agencies—cont'd

Sl. No.	Programme	Features

7.	Cooperative for American Relief Everywhere (CARE)	• CARE works to reduce poverty.
		• Designs and manages community-based projects in areas such as education, health care and economic development.
		• Together, CARE and communities build a foundation for self-sufficiency and lasting solutions to problems caused by poverty.
		• Activities:
		  ◦ Agriculture and natural resources
		  ◦ Education
		  ◦ Emergency relief
		  ◦ Health
		  ◦ Nutrition
		  ◦ Small economic activity development
		  ◦ Water sanitation and environmental health

8.	US Agency for International Development	• Established on 3rd November 1961 by President John F. Kennedy.
		• First US foreign assistance organization whose primary emphasis was on long range economic and social development assistance efforts.
		• Objective: Better future for all.
		• It supports long-term and equitable economic growth and advances US foreign policy objectives.
		• USAID's cross-cutting programmes, for helping other countries in crisis, are:
		  ◦ Transition initiatives
		  ◦ Private and voluntary cooperation
		  ◦ Conflict management
		  ◦ Urban programmes
		  ◦ Water
		  ◦ Women in development
		• USAID operates in 26 countries and territories in Asia, Middle East and North Africa.

9.	Asia and Near East (ANE)	

10.	United Nations International Children's Emergency Fund (UNICEF)/United Nations Children's Fund	• Areas of Work:
		  ◦ Communities and families
		  ◦ Countries in crisis
		  ◦ Girls' education
		  ◦ Health
		  ◦ HIV/AIDS
		  ◦ Immunization plus
		  ◦ Nutrition

11.	Swedish Agency for International Development and Cooperation (SIDA)	• SIDA is a government agency under the Ministry for Foreign Affairs. • Goal: To contribute to the possibility of poor people in improving their living conditions. • SIDA works independently within the framework laid down by Swedish Parliament and Government. • It is a global organization with its head office in Sweden and field offices in some 50 countries.

12.	SIDA in India	• Towards the end of 2003, work is being done with Indian organizations in civil society (NGOs) and with multilaterals such as UNICEF and the International Bank for Reconstruction and Development.
		• The tasks being carried out include in sectors of
		  ◦ Health
		  ◦ Human rights and democracy, etc.

13.	Red Cross	• The International Red Cross and Red Crescent Movement are the world's largest humanitarian network, with a presence and activities in almost every country. • The movement incorporates the Geneva-based International Committee of the Red Cross (ICRC) and the International Federation of Red Cross and Red Crescent Societies, as well as national societies in 178 countries. • Founded by Henry Dunant and four other men in the aftermath of battle in 1859.
14.	Indian Red Cross Society	• Incorporated under Parliament Act XV of 1920. • The IRCS has state/UT branches in 32 of them with 650 district and subdistrict branches. • The President of India is the President of the Society. • The National Managing Body consists of 19 members. • The President nominates the Chairman and 6 members and the remaining 12 are elected by the state and UT branches through an electoral college.

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Table 7.1 International health agencies—cont'd

Sl. No.	Programme	Features
15.	Social Welfare policy	• Social welfare is a state of human wellbeing that exists when social problems are managed, when human needs are met and when social opportunities are maximized. • Scope: It establishes the basis of Red Cross and Red Crescent action both in emergency response operations and implementation of long-term developmental social programmes as well as with respect to advocacy issues in the social development and social action field.
16.	Strategy 2010	• Strategy 2010 will guide the federation action from 2000 to 2010. • Mission: To improve the lives of vulnerable people by mobilizing the power of humanity. • It defines three strategies for the Federation and its member national societies to follow.

17.	International Labour Organization	• Created in 1919, at the end of World War I, by two industrialists, Robert Owen of Wales and Daniel Legrand of France.
		• Set up in Geneva in the year 1920.
		• It is the UN specialized agency (first specialized agency of UN in 1946), which seeks the promotion of social justice and internationally recognized for human and labour rights.
		• Objectives behind which the organization was created:
		  ◦ Humanitarian
		  ◦ Political
		  ◦ Economic
		  ◦ Social justice
		• The ILO constitution was written between January and April 1919, by the Labor Commission set up by the Peace Conference, which composed of representatives from nine countries under the chairmanship of Samuel Gompers, Head of the American Federation of Labor.
		• The ILO constitution became Part XIII of the Treaty of Versailles.
		• It formulates international labour standards in the form of:
		  ◦ Conventions and recommendations
		  ◦ Setting minimum standards of basic labour rights: Freedom of association, the right to organize, collective bargaining, abolition of forced labour, equality of opportunity and treatment, and other standards regulating conditions across the entire spectrum of work-related issues.

18.	Rockefeller Foundation	• It is an US-based global philanthropy committed to enriching and sustaining the lives and livelihoods of poor and excluded people throughout the world.
		• Accomplishments:
		  ◦ Established first schools of public health.
		  ◦ Providing early support in the United States for education.
		  ◦ Developing vaccine to prevent yellow fever.
		  ◦ Established important international cultural institutions.
		  ◦ Modernizing agriculture in the developing world – "Green Revolution."
		• Offices:
		  ◦ Headquarters–New York City (US).
		  ◦ Regional offices–Bangkok, Nairobi, San Francisco.
		  ◦ Conference and study centre in Bellagio (Italy).
		• Programmes:
		  ◦ Health equity.
		  ◦ Food security.
		  ◦ Working communities.
		  ◦ Creativity and culture.
		  ◦ Global inclusion.

19.	Food and Agriculture Organization (FAO)	• Important chronological events:
		  ◦ 1943: Forty-four governments meeting in Hot Springs, Virginia, US, commit themselves to founding a permanent organization for food and agriculture.
		  ◦ 1975: First session of FAO conference, Quebec City, Canada. Established FAO as a specialized United Nations agency.
		  ◦ 1981: First World Food Day observed on 16th October by more than 150 countries.
		• Objectives:
		  ◦ Putting information within reach.
		  ◦ Sharing policy expertise.
		  ◦ Providing a meeting place for nations.
		  ◦ Bringing knowledge to the field.
		  ◦ Achieving food security for all.

20.	World Bank	• Incepted in the year 1944. • It is a vital source of financial and technical assistance to developing countries around the world. • Made up of two unique development institutions owned by 184 member countries – The International Bank for Reconstruction and Development (IBRD) and the International Development Association. • Mission: Poverty reduction.

Continued

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Table 7.1 International health agencies—cont'd

Sl. No.	Programme	Features

21.	Colombo Plan	• January 1950 at the Commonwealth Conference on Foreign Affairs, Colombo.
		• Primary focus: Human resources development in the Asia-Pacific region:
		  • To promote interest in and support for the economic and social development.
		  • To promote technical cooperation among member countries.
		  • To keep under review relevant information on technical cooperation between member governments, multilateral and other agencies.
		  • To facilitate transfer and sharing of developmental experiences among member countries.
		  • To assist LDC's of Colombo plan region through dissemination of technical and industrial knowledge.

22.	Ford Foundation	• Founded in 1936 with grants from Henry Ford and his son Edsel Ford of the Ford Motor Company, headed by McGeorge Bundy from 1966–1979.
		• Currently headed by Kathryn S. Fuller.
		• It is a major donor to fairness and accuracy in reporting, a left wing media watchdog group.
		• Functions:
		  • Establishment of orientation/ training centres.
		  • Establishment of research and action project.
		  • Establishment of rural health services.
		  • Supporting research in the field of family planning.

WHO Regional Offices

WHO Member states are grouped into six regions. Each region has a regional office. The map (Fig. 7.1) shows WHO regions and the location of the regional offices and also the description of world health days of importance (see Tables 7.2–7.4).

INDIAN VOLUNTARY HEALTH AGENCIES

Various voluntary health agencies are actively serving the Indian population from time to time. The functions and role of some of the Indian voluntary health agencies are hereby briefed as follows (Table 7.5):

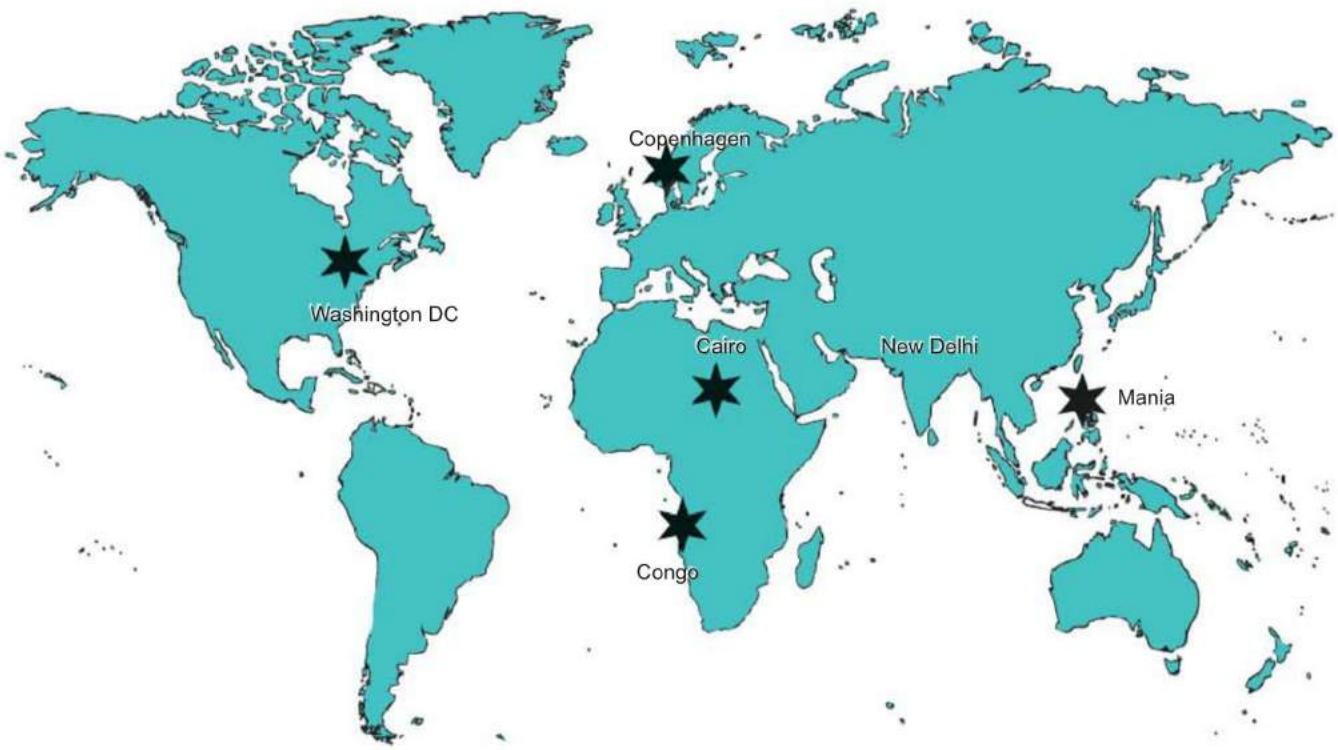


Figure 7.1 WHO regions and regional office locations.

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Table 7.2 Regional offices of WHO

Sl. no.	Name	Head Quarters
1.	Regional Office for the Africa	Congo
2.	Regional Office for the Americas	Washington DC
3.	Regional Office for the South-East Asia	New Delhi
4.	Regional Office for the Europe	Copenhagen
5.	Regional Office for the Eastern Mediterranean	Cairo
6.	Regional Office for the West Pacific	Manila

Table 7.3 World health day themes

Year	World Health Day Theme
1950	Know your own health services
1951	Health for your child and the World's children
1952	Healthy surroundings make healthy people
1953	Health is wealth
1954	The nurse: pioneer of health
1955	Clean water means better health
1956	Destroy disease-carrying insects
1957	Food and health
1958	Ten years of health progress
1959	Mental illness and mental health in the world today
1960	Malaria eradication—a world challenge
1961	Accidents need not happen
1962	Preserve sight—prevent blindness
1963	Hunger: disease of millions
1964	No trace of tuberculosis
1965	Smallpox—constant alert
1966	Man and his cities
1967	Partners in health
1968	Health in the world of tomorrow
1969	Health, labour and productivity
1970	Early detection of cancer saves lives
1971	A full life despite diabetes
1972	Your heart is your health
1973	Health begins at home
1974	Better food for a healthier world
1975	Small pox—point of no return
1976	Foresight prevents blindness
1977	Immunize and protect your child
1978	Down with high blood pressure
1979	A healthy child—a sure future
1980	Smoking or health: the choice is yours
1981	Health for all by the year 2000
1982	Add life to years
1983	Health for all by 2000: the countdown has begun
1984	Children's health: tomorrow's wealth
1985	Healthy youth: our best resource
1986	Healthy living—everyone a winner
1987	Immunization—a chance for every child
1988	Health for all—all for health
1989	Let's talk health
1990	Our planet—our health: think globally, act locally
1991	Should disaster strike—be prepared
1992	Heart beat: the rhythm of life
1993	Handle life with care—prevent violence and negligence
1994	Oral health for a healthy life
1995	Target 2000—a world without polio
1996	Healthy cities for better life—a challenge
1997	Emerging infectious diseases—global alert and global response
1998	Safe motherhood: pregnancy is precious—let's make it special
1999	Healthy ageing, healthy living, start now
2000	Safe blood starts with me—blood saves lives
2001	Mental health: stop exclusion—dare to care
2002	Move for health
2003	Healthy environment for children
2004	Road safety
2005	Make every mother and child count
2006	Working together for health
2007	Investing in health to build a safer future
2008	Protecting health from adverse effect of climate change
2009	Save lives, make hospital safe in emergencies
2010	Urbanisation and health
2011	Antimicrobial resistance
2012	Good health adds life to years
2013	Healthy heart beat, healthy blood pressure
2014	Vector-borne diseases: small bite, big threats
2015	Food safety
2016	Diabetes

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Table 7.4 World health: days of importance

Day	Importance
30 January	Anti-leprosy day
7 April	World health day
22 April	World habitat day
31 May	World no-tobacco day
1 July	Doctor's day
11 July	World population day
2 October	Anti-drug addiction day
13 October	Anti-natural disaster day
1 December	Anti-AIDS day
11 December	UNICEF day

Table 7.5 Indian voluntary health agencies

	Indian Voluntary	Health Agencies
1.	Occupational Health and Safety Center	• A voluntary organization dedicated to ensure a healthier work place for workers and also provide medical checkup.
2.	Nirmaya Health Foundation	• A nonprofit, community-based NGO, a group of health workers which serves the under-privileged communities in the urban slums of Mumbai city.
3.	Push Trust	• A charitable organization, which helps the destitute, orphans, neglected, needy and abandoned children by providing their basic needs.
4.	Prayas Social Welfare Society	• An NGO working for the promotion of education and health for street/poor children and their families.
5.	Theosophical Society	• A worldwide body promoting universal brotherhood.
6.	Shroff's Foundation Trust	• An NGO providing supportive services in implementation of interventions in diverse areas such as rural development, health, agriculture, livestock, etc.
7.	Sarvodaya International Trust	• Promotes Gandhian ideals of truth, nonviolence, peace, universal brotherhood and humanitarian service.
8.	Kasturba Seva Samithi	• A voluntary organization for empowering rural youth aimed at sustainable rural development.
9.	Deepak Foundation	• A nonprofit organization working for overall development of women with information dissemination on reproductive health and economic empowerment programmes in Gujarat.
10.	Give Foundation	• A nonprofit organization helping NGOs in raising funds and promotes efficient and effective giving that provides greater opportunities to the poor in India.
11.	Child Welfare and Holistic Organization	• A nonprofit organization working for child welfare and rural development.
12.	Brahma Kumaris	• A spiritual organization providing educational courses in human, moral and spiritual values.
13.	Food Relief Charity	• A nonprofitable charitable organization working for the betterment of children and general people in rural and urban areas.
14.	Anandalok: Welfare Centre for Mentally Handicapped	• A welfare centre for mentally handicapped people through their development programmes.
15.	Agape Bible Fellowship	• A Christian charitable trust working with a vision to reach the unreached masses of Indians who are living in darkness to make them self-confident and self-dependent through their teaching programmes.
16.	Action for Autism	• A nonprofit organization for autism providing support and services for clinical assessment, counseling, referral, etc.
17.	Deep Griha Society	• An independent charitable organization that has been working to better the lives of people living in slums in Pune.
18.	Sankara Nethralaya	• A charitable, not for profit eye hospital, offering various programmes for ophthalmologists.
19.	Seva Bharati	• A voluntary organization providing rural development programmes, education to the needy, health to the underprivileged, etc.
20.	Blue Cross of Hyderabad	• An NGO working towards the welfare of animals and preservation of animal rights.

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Table 7.5 Indian voluntary health agencies—cont'd

	Indian Voluntary	Health Agencies
21.	Child in Need Institute	• An NGO working to achieve sustainable development among poor communities living in the city of Kolkata, South 24 Parganas, and surrounding areas.
22.	Ashwini Kumar Medical Relief Society	• An NGO offering treatment for tuberculosis patients and working for the upliftment of downtrodden people for their health care and education.
23.	Sai Prem	• A children and old age home and trust with a global mission for holistic development and care of human being.
24.	Tamil Nadu Corporation for Development of Women Ltd.	• A government undertaking with a mission to build the capacity of poor and disadvantaged women.
25.	Cause An Effect Foundation	• Human welfare organization for the victims of Orissa super cyclone working for children, women and families of tsunami victims to enable them regain their lost livelihood.
26.	Central Institute on Mental Retardation	• An institute established for education, training, development and rehabilitation of the mentally challenged.
27.	Alternative for India Development	• A national level NGO working for the development of the poor by providing education, health provision and an adequate livelihood.
28.	Bombay Leprosy Project	• A regional nonprofit organization working towards the goal of a "world without leprosy".
29.	Rehabilitation Council of India	• An organization working for bringing up a standardized training course for the persons with disability.

CONCLUSION

Gradually international health collaboration came into existence, to counteract emergence of new dimension of disease and health related problems. This process went through various stages like quarantine regulations to safeguard public health, studying of the scientific data to understand the causes of infectious diseases and their modes of transmission. In the 20th century the main aim was to fight infectious diseases and to eradicate them. This phase is the rise of international institutions aiming at favouring better health organization in individual countries. The WHO was founded mainly to fight existing epidemics while little importance was given to emerging diseases. WHO did not invent "global health," other larger forces were responsible for transition from international to global health. WHO certainly did help promoting interest in global health and contributed significantly to the dissemination of new concepts and new ideas, in turn, to serve and re-establishing as the unquestioned steward of health of the world's population. However a series of new infectious diseases and the emergence of old diseases that were thought to be eradicated eventually revealed the need for continuous surveillance.

REVIEW QUESTIONS

1. What are the objectives of International and National health agencies?
2. Define quarantine and mention the different types of quarantine.
3. What are the objectives and functions of WHO?
4. Mention the international and national health agencies around the world.
5. Discuss Colombo plan and its importance in the field of health.
6. What is WHO theme for oral health?
7. Write note on Red Cross.

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8 Hospital Administration

Narendranath V

CHAPTER OUTLINE

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INTRODUCTION

Hospital, being the essence of entire health care delivery system demands an effective professional team of hospital administrators and clinicians.

Administrator of the hospital might be good clinicians but it is absolutely essential that their managerial abilities are developed to achieve their personal as well as organizational goals. It has been realized that the training in managerial concepts and skills is lacking at all levels of medical curriculum in India. This situation may sometimes drive them consciously to compromise the quality of health services delivered in hospitals. Hence this chapter gives a light in some of the aspects of hospital administration.

CHANGE OF ROLE AS HEALTH ADMINISTRATOR

When a health care professional wants to pursue his or her career as administrator, there are challenges to be faced. The primary need is to recognize that the technical knowledge may not help much in the new administrative role. Why? Because as an alternative of just self-focusing, the health care professional has to extend in the successes of his or her team associates as well. The health care professional has to play a key role that necessitates integration both at vertical and horizontal dimensions.

IMPORTANCE OF HOSPITAL ADMINISTRATION

Hospitals are the most complex organizations in our contemporary society. Unlike a factory, it does not produce any material goods but produces an intangible product called medical care. In a hospital, the inputs are human being, the inputs are largely processed by human resource of the organisation and the outputs are also humans. This human element imposes an additional dimension in hospital management.

Management functions are, by and large transferable from one situation to the other with some variation in emphasis in certain areas. Hospitals are becoming complex organizations in areas of technological explosion, runaway cost, rising clientele expectations, governmental and social regulations and complex competitiveness to deal with such situation, some preparation on the part of hospital manager is essential.

IMPORTANCE OF HOSPITAL MANAGEMENT

Often the students get confused about the terminology as what is management and what is administration. The administration is pronounced at higher level of management, while management is pronounced at lower level. Thus administration and management may be distinct activities but both pertain to the dual aspect of the same device.

Administration is the sum total of all activities, manual, clerical, managerial, technical and the like undertaken in pursuit of an objective. Management is the art of getting things done through and with people in informally organized groups.

Role of an Administrator

Towards patient. Create patient-friendly environment, understand clinical requirements, patient's physical and emotional needs, ensure patient satisfaction and education.

Towards organizations. Primary duty is to manage the hospital effectively and efficiently with available resources:

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staff, equipments, materials, finance, legal aspects, marketing and quality management.

Towards community. Obtain community participation, integrate hospital with other health care institutions, supporting primary care, providing extramural services (arranging camps).

Skills Required for Hospital Administrator

1. Technical skills
2. Analytical skills
3. Decision making skills
4. Computer skills
5. Human resource skills
6. Communication skills
7. Conceptual skills

Management Essentials for Hospital Administration

1. Material
2. Financial
3. HR

Material management. Material management is effectively used by hospital administrators as it costs about 30–40% of hospital budget. The quality of service in a hospital also significantly depends in management of materials/stores/purchase department (Fig. 8.1).
The purchase of the materials in

- right quantity, of the
- right quality, at the right price, from the
- right source and
- maintenance of appropriate stores helps the materials flow and thus ensures efficiency without "stock outs" and "excessive stocking." Pilferage control is also an important activity of store manager.

Inventory analysis is a systematic analysis of all items in stores for achieving the objectives if inventory control. Many methods can be adopted based on the requirement of the organisation. ABC analysis is based on the annual consumption and cost criteria. It is thus seen that a large number of items consume only a small percentage of resources and vice versa. XYZ analysis is one of the basic supply chain techniques, often used to determine the inventory valuation inside stores. An effective inventory control system balances the two objectives that is material cost and stock outs to optimum advantage.

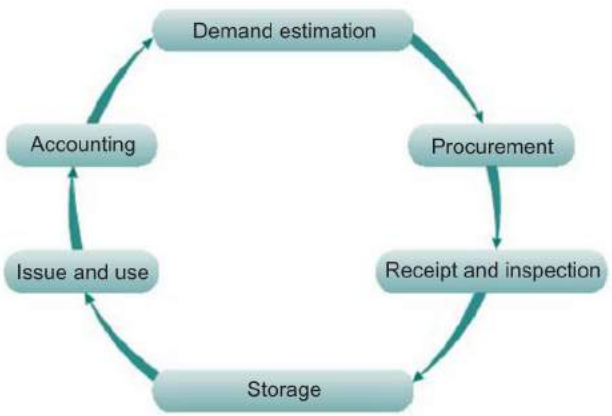


Figure 8.1 Materials management cycle.

Human resource (HR) management. Human relation is the integration of the people into the work situation that motivates them to work together to maximize the productivity, and to create better social and psychological satisfaction.

Hospital human resource refers to those people who are trained for specific functions which pertain to promotion, restoration and maintenance of health of the people.

The hospital HR Department has a vital role in determining the productivity and the quality of services rendered. Hospital HR planning ensures that the right number of people are available at the right place, at the right time and with the right skills and enables the motivation of the staff to deliver the care services to the patients.

Functions of HR Department:

1. Recruitment of personnel
2. Interviewing
3. Promotion and transfer
4. Termination of employment
5. In-service training
6. Safety
7. Health programmes
8. Recreation
9. Remuneration and incentives

Financial management. An understanding of basic financial management, concepts and techniques has become a necessity for hospital administrators. Financial management is that managerial activity which is concerned with the planning and controlling of the hospital's resources.

Various tools and techniques are available for assistance of the hospital's administrators. Some of the common tools/techniques available are:

1. Budget: capital budget, cash budget, zero-based budget, etc.
2. Cost–benefit and cost-effective analysis
3. Breakeven analysis

The hospital administrator has to be well versed with cost accounting techniques, balance sheet, profit and loss account and various statistical techniques.

HOSPITAL AS A SYSTEM

Planning and Designing of a Hospital

Every step of establishing a hospital or clinic is the idea born in the mind of an individual and hence the first step should be aptly appealing to the end users. To have a hospital without exceptions, it has to be built on a triad of good planning, good design and construction and good administration; if any one of the factor is missing then the outcome building will be a mediocre hospital or one that is doomed to fail.

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Table 8.1 Services rendered by hospital organization

Clinical and nursing services	Supportive services	General administration including business and utility services
• Outpatient services	• Radiological services	• Personnel management
• Inpatient services	• Laboratory services	• Financial management
• Emergency and casualty services	• Central sterile supply services	• Housekeeping services
• Operation theatre services	• Laundry services	• Material management
	• Blood bank services	• Dietary services
	• Mortuary services	• Hospital engineering services
	• Rehabilitation services (physical medicine)	• Transport
	• Medical records	• Public relations
	• Social worker	• Communications
	• Pharmacy services	• Fire and security

Elements of Detailed Project Report (DPR) for Building Hospital

- Background of the project
- Constraints/limitations
- Financial statements (cash flows)
- Labour requirement
- Material management
- Local regulations/laws pertaining to hospital
- All details drawing, e.g. architectural work drawing, plumbing, etc.
- Detailed estimate of the project
- PERT chart
- List of medical equipments and specifications of each department
- Man power requirements
- Running, maintenance and operational cost
- Budgetary projection

LEGAL ASPECTS OF PRIVATE PRACTICE

The society has laid down the laws of land prescribing normative prescriptive behaviour of individuals and group with a provision of deterrent and corrective punishment for any contravention. However, in general there is no specific law relating to hospitals or their staff and equipment. In such a situation it is of paramount importance that the hospital administrator must identify and understand the laws that have a bearing to working of the hospital. Application of laws, specially so with regard to consent of the patient, evidence, maintenance of secrecy, medical negligence and law of torts need special attention.

Private practice is governed by a few regulations, the knowledge of which safeguards us against any potential lawsuits. Medical Malpractice law is emerging as a very important area of law. Doctors being sued for negligence are increasing.

Various Laws and Regulations Applicable to Dental Practice

- Professional Registration with Dental Council of India –State Dental Council
- Shops and Establishment Act
- Karnataka Private Medical Establishments (KPME) Act–Clinical Establishment Act (CEA)
- Biomedical waste (BMW) management rules–MOU with CTF
- Ethical documentation and consent
- Vicarious responsibility–Respondent superior
- Medical negligence
- Consumer Protection Act (CPA)
- AERB approval

Negligence

Unintentional action that occurs when a person performs or fails to perform an action that a reasonable person would or would not have committed in a similar situation:

I. Act of Omission
II. Act of Commission

Vicarious Responsibility

- Vicarious liability is a form of secondary or indirect liability that is imposed when parties have a particular relationship, usually an agency relationship. When it is applicable to a particular situation, a principal is required to answer for an agent's negligent or otherwise wrongful actions.
- Vicarious liability is often applicable to employer–employee relationships, but it is also applicable to other situations where a superior is held responsible for the acts of a subordinate.
- *Respondent superior* embodies the general rule that an employer is responsible for the negligent acts or omissions of its employees.
- "Let the master answer."
- Under *respondent superior* an employer is liable for the negligent act or omission of any employee acting within the course and scope of his or her employment.
- A hospital or a nursing home, as an institution, is vicariously liable for the performance and efficiency of its employees.

QUALITY IN DENTAL PRACTICE AND ACCREDITATION

In India, health system currently operates within an environment of rapid social, economic and technical changes.

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It is important to improve the quality of dental facility. At the same time there must be an incentive not only to improve the capacity of national dental facility but also to provide quality care from time to time. This is possible through accreditation and it can be a part of national health system. NABH accredits dental facility with accreditation for Dental Health Care Service Providers (DHSP; Fig. 8.2).

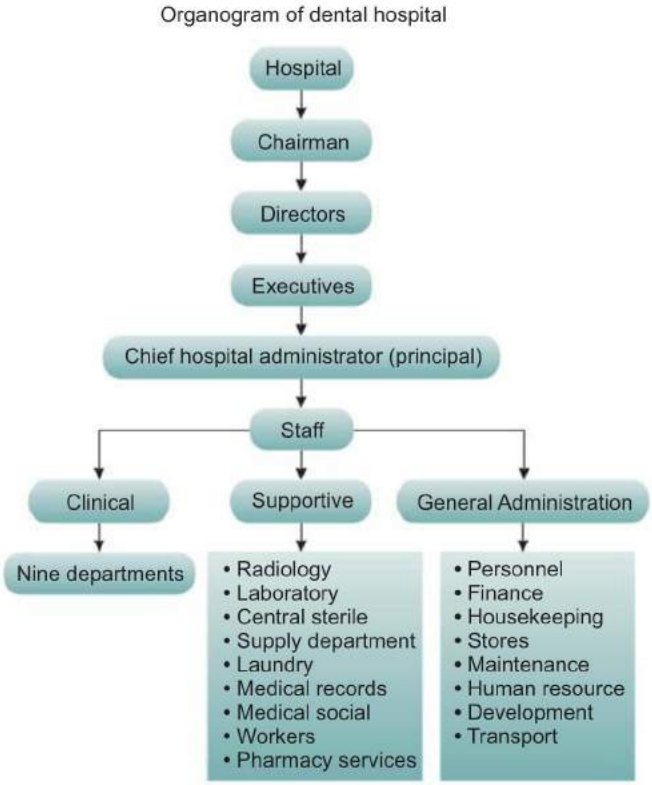


Figure 8.2 Organizational structure of a dental hospital.

Technical committee of NABH formulates complete set of standards for evaluation of dental facility for grant of accreditation. The standards provide framework for quality assurance and quality improvement for dental facility. The standards focus on patient safety and quality of care. The standards are equally applicable to dental facility in the government as well as in the private sector.

Section A: Accreditation Standards for Dental Hospitals and Educational Institutions

Category 1: DHSPs associated with hospitals without inpatient facility
Category 2: DHSPs associated with hospitals/educational institutes and standalone DHSPs with inpatient facility

Section B: Accreditation Standards for Dental Clinics

NABH STANDARDS FOR DENTAL FACILITY

Patient-centred Standards

1. Access, assessment and continuity of care (AAC)
2. Care of the patient (COP)
3. Patient rights and education (PRE)
4. Management of dental material and equipments
5. Inflection control (IC)

Organisation-centred Standards

6. Continuous quality improvement (CQI)
7. Responsibilities of the management (ROM)
8. Facility management and safety (FMS)
9. Human resource management (HRM)
10. Information management system (IMS)

CONCLUSION

There is a vast scope of building up of positive image of the government hospitals as the hospital and basically service institution, and service itself is the positive base. An organized effort should be made towards the attitudinal changes of the functionaries in the hospital and towards good public relations within and outside the hospital.

Hospital being recognized as an industry is mostly under the state control. With the existing problem created by the simultaneous presence of internal and external person, hospital needs application of the human relationship to smoothen the differences, and to motivate the worker for better patient care.

The present day practice of the medicine has attained a highly complex status, efficiency of the medical care depends on a complexity of factors therefore, and there is no simple measure to evaluate the quality of medical care services, provided by the hospital. However, in this chapter an attempt has been made to outline various methods of evaluation of quality and quality of the services, the operational cost of service and extent of consumer satisfaction.

Establishment of hospital planning and evaluation cell at the highest level is essential to develop and maintain baseline for the use of planning and effective control of medical services.

Dentistry as a profession offers a gratitude with various career options like private practice, attached to a large health care set-up and academies. What so is the profession we have to work in an organisation? This chapter covers few of the managerial issues, which are likely to be encountered by the graduate.

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9 Behavioural Sciences

Dara S Amar and Sushi Kadanakuppe

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INTRODUCTION

Medicine and social sciences are interlinked in their own special way with human behaviour. Health cannot be separated from its social context. Recently it has been observed that social and economic factors have as much influence on health status as medical interventions. These factors have a direct bearing and influence on the course and outcome of the various communicable and noncommunicable diseases. The term social sciences are concerned with those disciplines which are committed to the study of human behaviour in a more scientific way. They include sociology, social psychology, social anthropology, political science and economics. The term behavioural sciences is applied and concerned especially to sociology, social psychology and social anthropology, as they deal directly with human behaviour. These disciplines share the major goals of social sciences including human behaviour and also the understanding of specific aspects of public health in the study of man and his or her surroundings.

DEFINITION

Behavioural science is the science of the study of human behaviour at the level of their own self, other individuals, family and community members and the resulting reaction on the dental health programme.

COMPONENTS

Since human behaviour is complex in nature, components of behavioural science include many areas of sociology, human physiology, psychology, psychobiology, criminology, cognitive science and anthropology.

CATEGORIES OF BEHAVIOURAL SCIENCES

I. Information processing sciences
   1. Psychology
   2. Cognitive science
   3. Psychobiology
   4. Neural networks
   5. Social cognition
   6. Social psychology
   7. Semantic networks
   8. Ethology
   9. Social neuroscience

II. Relational sciences
   1. Sociological social psychology
   2. Social networks
   3. Dynamic network analysis
   4. Agent-based model
   5. Microsimulation

SCOPE AND USE OF BEHAVIOURAL SCIENCE IN DENTAL HEALTH

- Identification of positive and negative behaviour of patients towards dental health advice
- Understanding the mechanism, causes and results of specific behaviour patterns in order to promote healthy dental practices
- Planning for short- and long-term behavioural changes among patients, which will result in better preventive, promotive, curative and even rehabilitative dental care.
- Use of specific behavioural change methods while communicating and counselling patients
- Devising coping techniques (i.e. adjusting and accepting) in dental health care practice, where the patient behaviour cannot be changed due to deep rooted social and cultural beliefs, etc.

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- Understanding and managing individual behavioural patterns of health team members, in order to promote harmony in work which will lead to the successful achievement of a common goal.
- Subsequently the roles of sociology, psychology and anthropology in dental health care behaviour is described.

SOCIOLOGY

Definition

Sociology is defined as the study of groups of individuals which form a society and how they interact and behave within themselves and the outcome of these interactions.

Sociological Factors Governing Dental Health Care Services in Community

Affordability of dental health services. In order to determine if the community can pay directly or indirectly for the health care services, there is a need to measure the socioeconomic status to which the particular community belongs. The methods of measuring the socioeconomic levels are: the modified Kuppuswamy's classification in urban areas, the Uday Parekh's socioeconomic scale in rural areas as well as the recently devised method of determining whether an individual is above poverty line (APL) or below poverty line (BPL). All the above methods involve surveying the occupation, income and education, etc. for each individual.

Accessibility to dental health care services. Dental health care services are not easily available in villages. Therefore provision for dental care can be created only if there are roads and better communications for the villagers to reach the cities, and the like. This is called accessibility and it can be improved if the services are extended in the form of community-based peripheral dental health services.

Acceptability of dental health care services. Even if community-based dental health services are present, the sociological behaviour of the people is important in accepting these services for their own use. This is called acceptability of services and this is controlled by social taboos and beliefs (e.g. it is wrongly believed that chewing pan or tobacco cleans the teeth).

However, this wrong behaviour can be changed by promoting a good social belief (e.g. *neem* tree twigs are commonly used as toothbrushes). Thus, community-based dental health services have to be modified to include these social beliefs which are relatively cheaper.

Behavioural changes are equally important for the dentists whose own urban behaviour needs to be adjusted to understand the real rural social behavioural needs of the community.

Community participation. For any community-based dental health programme to remain successful, community members themselves must participate in the planning, publicity, provision of facilities for the programme, motivating others to use the services and finally helping to suggest methods of making the programme more practical and useful. To achieve this, "local self-help groups" and local women's groups are trained as part of the programme.

Sustainability of programme. Most community-based dental health programmes are started through external funding by institutions, and the like, and when the funding stops, the programme is not continued by the people due to lack of finance, commitment, training of local trainers, lack of continued motivation and the like.

Therefore, in order to sustain or continue the programme forever, it is important to train the local self-help groups in economic activities which will generate funds for the dental programme. Thus, the health educator also becomes a catalyst or a facilitator who coordinates and links socioeconomic training in order to fund preventive and promotive dental health programmes in the community.

Types of Families

Dental health advice to community members also depends on the type of families since it involves the influence of various family members to promote or resist practice of dental health care. There are three types of families:

Joint family. This consists of many blood related married couples and their children living in the same house. Adoption of health practices involves decision making by too many members of the family and therefore proves to be very difficult.

Three generation family. This consists of an old couple living with one of their married sons and his family, but does not include families of other brothers, etc. This is very common in urban areas and it is important to convince not only the couple but also his parents so that decision making becomes moderately easy.

Nuclear family. This consists of only husband, wife and children. This is common in urban areas, and it is most easy to advise them to change their behaviour since the family size is small.

PSYCHOLOGY

Definition

Psychology is defined as the study of human behaviour of how people behave and why they behave in just the way they do.

Psychological Factors

Psychological factors affecting behaviour are depicted in Table 9.1.

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Table 9.1 Psychological factors affecting behaviour

a. Age and sex	j. Level of interest and motivation
b. Skills and habits	k. Coping or managing problems
c. Intelligence and emotion	l. Decision making ability
d. Beliefs and culture	m. Self-esteem
e. Past experience	n. Expectation of others
f. Behaviour during illness	o. Attitude
g. Behaviour when healthy	p. Emotional level
h. Independent or married	
i. Present environment	

Scope and Use

In any dental health programme, it is important to determine what is normal behaviour related to health. The question of what is normal is relative to what society expects you to do, and this may conflict with your own present behaviour.

- If a behaviour is good for your programme, then promote it further.
- If it is harmless then leave it alone.
- If it is harmful then you may need to change the behaviour to suit desired health behaviour.
- Psychological behaviour is different when an individual is alone as compared to when he or she is in a group. This means we have to use different methods for the individual and for the group, while planning our dental health programmes.

Psychological Factors Affecting Behaviour

Age and sex. Children and women are more interested in health and therefore are a good target group for community dental health programmes.

Skills and habits. Know the present habits and modify them to suit the needs of the dental health programme. This requires a method called Needs Assessment Survey.

Skills (e.g. method of brushing teeth, etc.) can be modified by training through demonstration and giving the reason for a need to learn the new skill. Giving the reason is more important for behavioural change than merely supplying information.

Intelligence and emotion. Intelligence is the ability to quickly and correctly interpret the situation. This can be either inborn or developed through training. The level of intelligence is usually measured through intelligence quotient (IQ). Therefore, dental health care provider should also develop his or her own skill to modify the dental health programme and respond correctly and rapidly. Emotion is the feeling or reaction, which is exhibited for any situation. Therefore, the aim of dental health programmes should be to promote positive reactions and create an emotional need for good health practices. Method of achieving this is part of psychotherapy and counselling.

Beliefs and culture. Beliefs are what you trust in and these may be harmful, harmless or beneficial. The dental health programme must aim to remove the harmful, promote the beneficial and leave the harmless beliefs alone.

Culture is the behaviour which has been learnt from childhood, from others in the community and from the family members. This kind of cultural behaviour can have very strong influence on the dental health programme. Therefore, it requires a great deal of time and involvement on the part of the dental health staff to change any harmful cultural behaviour.

Very often the staff would have to modify their programme in order to cope or adjust with the existing cultural factors rather than trying to change them. Use of *neem* stick for brushing teeth, use of charcoal and salt, etc. are cultural habits among rural people while the use of toothpaste and brush is common among urban people. Therefore the question of educated judgments and psychoanalytical reasoning for change of behaviour, becomes more important while planning dental health programmes in the community.

Past experience. Past experiences may have been bad and therefore any attempt to change the behaviour becomes difficult. In dental health programmes, past experience of the people with certain kinds of brushing techniques, use of different tooth powders, pastes, etc. needs to be considered in the dental health programme. Past experiences can also be pleasant and these could be utilized to strengthen the health programme. Detailed psychological surveys before planning health programmes are important to determine these experiences in the community.

Behaviour during illness. When a person falls ill, his or her behaviour is dependent on others' advice and his or her main goal is to remove the signs and symptoms as early as possible. This illness behaviour of patients is temporary and very often appears unreasonable and demanding for the dental health staff. However, the dental health programme must address the immediate needs of solving and removing the illness behaviour and then moving the patients towards what is called healthy behaviour.

Behaviour when healthy. Unfortunately, a healthy person gives the least importance to any dental problem as long as there are no signs and symptoms, which trouble him. Therefore, it is important to create a sense of responsibility towards preventive dental health care in order to maintain this healthy behaviour.

This is difficult because of the indifferent attitude of the patient when healthy as well as even the indifferent attitude of the health staff towards people with healthy teeth. However, it must be remembered that this state of healthful happiness due to good teeth must be highlighted much more in a dental health programme in order to promote a positive dental health practice.

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Unfortunately our present dental health programmes focus more on removing or preventing dental pain rather than giving priority to preserving and promoting the state of healthy and happy behaviour.

Independent or married. When married and with family, the individual tends to be more responsible and therefore more easily agreeable to changing towards healthy dental practice. Therefore dental health programmes must be aimed more at children so that parents respond more positively towards these health programmes because of their greater sense of responsibility for their own children's health.

Present environment. The present environment of indiscriminate marketing methods for even nonscientific dental products seems to attract the attention of the community. This interferes with well-planned and scientific community health dental programmes.

Level of interest and motivation. The level of interest or continued concentration is unfortunately of a very short duration due to rapid urbanization and ever changing advertisements of dental products and procedures. Therefore, there are special methods of sustaining interest and motivation through community participatory and motivational techniques, which need to be included in community dental health programmes. This will result in a permanent positive behavioural change.

Coping or managing problems. Problems with implementing dental health programmes can be due to various causes such as availability of dental staff, travel difficulties to the communities, lack of motivation among staff to do community services, etc.

Therefore, in order to avoid stress and its consequent problems, community-based dental health programmes need to adopt modern management techniques in personal management, materials management, operations research techniques, etc.

Additionally, psychoanalysis and psychotherapy help in changing our behaviour to cope or accept the problems and still go ahead with the programme.

Decision making ability. One of the major aspects to be considered in a dental health programme is the ability to make decisions correctly and rapidly. This applies to both the community people as well as the dental health team members.

Even though a dental health programme may be very well planned in advance, once the team reaches the community there could be field level difficulties, which would require changing and making new decisions. The ability to do this comes through special training on alternate strategy planning for the dental health staff.

Self-esteem. Self-esteem is being able to believe in ourselves that we are capable and confident of our own actions. Self-esteem is often based on personality, reactions to others, self-confidence, ability to judge, intelligence, etc. This is important for both the staff and the patients in believing that good dental health practices can be trusted and believed.

A person with high self-esteem is able to not only believe in himself but convince others as well, and therefore he or she makes a good health educator for community dental health programmes.

Expectation of others. Most community dental health programmes are planned, based on what the dentists think that the community expects. However, the real expectations of the others (i.e. community members) may be totally different and would need to be modified in the objectives of a dental health programme. Therefore planning of the dental health programme would need to include community felt need assessment methods.

Behaviour of the dental health service providers would have to be accordingly matched to satisfy what the community feels is important in dental care.

Attitude. Usually the community feels that dental health care is far less important than other illnesses. This community feeling or attitude towards dental health services needs to be modified by planning for behavioural change methods as part of the community dental health service programmes.

Emotional level. Emotion of the community towards any outside agency is always modified by the fear of the consequences of any change which the outside agency will ask them to do. Thus, emotional needs of the community must be taken into consideration, and this fear for outsiders needs to be removed by creating a confidence among the villagers. This can be achieved through community participatory methods while planning and implementing the dental health programme.

The emotional level of any individual can be measured by using the emotional quotient.

SOCIAL PSYCHOLOGY

Definition

Social psychology is a science that studies the influences of our situations, with special attention to how we view and affect one another. More precisely, it is the scientific study of how people think about, influence and relate to one another.

Difference Between Social Psychology, Sociology and Psychology

Social psychology lies at psychology's boundary with sociology. Compared with sociology (the study of people in groups and societies), social psychology focuses more on individuals and does more experimentation. Compared with personality psychology, social psychology focuses less on individuals' differences and more on how individuals, in general, view and affect one another.

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History

Social psychology is still a young science. The first social psychology experiments were reported barely more than a century ago, and the first social psychology texts did not appear until approximately 1900 (Smith, 2005). Not until the 1930s did social psychology assume its current form. Not until World War II did it begin to emerge as the vibrant field it is today. And not until the 1970s and beyond did social psychology enjoy accelerating growth in Asia—first in India, then in Hong Kong and Japan, and, recently, in China and Taiwan (Haslam and Kashima, 2010).

Components

Social psychology has three components namely *social thinking, social influence* and *social relations* (Fig. 9.1).

Social thinking. It describes how we perceive ourselves and others, what we believe, judgments we make and our attitudes towards situations. Our inner attitude affects our behaviour.

Examples: Our attitude towards smoking influences our susceptibility to peer pressure to smoke. Our attitude towards poverty influences our willingness to frame policies addressing the poor. Social thinking, therefore, is influenced by our judgements, attitudes, beliefs and perceptions which are internal to an individual.

Social influence. It describes how our attitude and behaviour are shaped by our external social forces. Social influence is a component which is attributed to culture, pressure to conform, persuasion and deals with behaviour of groups of people. All these social influences shape our individual behaviour.

Examples: Many decent people were used as instruments of Holocaust under the Nazi influence. Soon after a Tsunami or earthquake, we tend to offer help as we saw the entire world overwhelmingly offering assistance in response to major earthquake in Japan in 2011.

Social relations. Pertains to prejudices humans form, aggression, attraction and intimacy and helping one another. Social relations are also influenced by biological behaviour as we all know that nature and nurture together formed who we are.

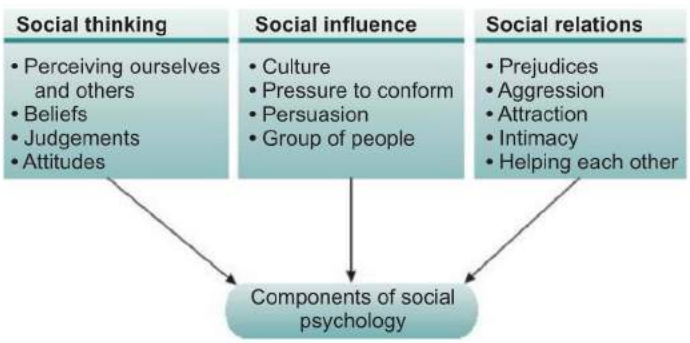


Figure 9.1 Components of social psychology.

Research Methods for Social Psychology

Social psychological research methods are based on the following:

It varies by location:	It varies by method:
1. **Laboratory research:** Research conducted in controlled situation	1. **Correlational research:** is to examine if two or more factors are naturally related or study of naturally occurring relationships
2. **Field research:** research conducted in natural, real-life settings outside the laboratory	2. **Experimental research:** Studies that seek clues to cause–effect relationships by manipulating one or more factors (independent variables) while controlling others (holding them constant)

Most social psychological studies are either **correlational** or **experimental.**

For *correlational studies* conducted using systematic survey methods recognize the relationship between variables, such as socioeconomic status and oral health, between income level and education level or between dietary habits and dental caries experience.

Limitation: Correlational studies do not provide the reliable information as to what is causing what. A third factor may be responsible for a naturally existing relationship between two variables. To overcome this limitation experimental research is conducted.

For *experimental research* if we want to know, if students learn more in online or classroom courses, we have to adopt an experimental design where participants are randomly assigned to either online or classroom courses and learning will be the dependent variable. Similarly questions on influence of oral health education programs in schools on tooth brushing habits of school children can also be experimented by randomly assigning school children to oral health education group and control group. Improvement in tooth brushing habits is assessed as a dependent variable.

CONCLUSION

In social psychology, everyday experiences generate ideas which are tested in correlational research, which leads to experimental research. Social psychology helps our understanding of life experiences by translating them to research questions and testing them so that practical solutions can be ultimately applied in real life.

ANTHROPOLOGY

Definition

Anthropology is the science of studying man or woman in terms of his or her physical, social, cultural characteristics.

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Anthropology deals with the scientific study of the origin and behaviour of man, including the development of societies and cultures. It is holistic in two senses: it is concerned with all humans at all times, and with all dimensions of humanity. A primary trait that traditionally distinguished anthropology from other humanistic disciplines is an emphasis on cross-cultural comparisons.

Anthropology is traditionally divided into four subdisciplines:

- Physical anthropology or biological anthropology
- Social anthropology
- Cultural anthropology
- Archaeology.

Charles Robert Darwin (12th February 1809–19th April, 1882) was a British naturalist who achieved lasting fame by convincing the scientific community of the occurrence of evolution and proposing the theory that this could be explained through natural selection. This theory is now considered the central explanatory paradigm in biology.

The modern evolutionary synthesis (often referred to simply as the modern synthesis or the evolutionary synthesis), neo-Darwinian synthesis or neo-Darwinism, generally denotes the combination of Charles Darwin's theory of the evolution of species by natural selection and Gregor Mendel's theory of genetics, is the basis for biological inheritance, and mathematical population genetics.

Components

1. Physical anthropology deals with human physical growth and various anthropometric parameters.
2. Social anthropology deals with social lifestyles, characteristics of society formations and components of society.
3. Cultural anthropology deals with various types of cultures, beliefs and traditional behaviour.

Physical anthropology. Often called "biological anthropology," studies the mechanisms of biological evolution inheritance, human adaptability and variation, primatology and the human evolution.

Physical anthropology was so called because all of its data were physical (fossils, especially human bones).

Social anthropology. This is the study of the development and various types of social life. It is also a specific branch of cultural anthropology dealing with comparative study of kinship and non-kinship organization patterns in different societies.

Cultural anthropology. It is the study of total way of life of contemporary primitive man, his or her ways of thinking, feeling and action. Culture means socially inherited characteristics of human groups. It comprises everything, which one generation can pass to the next.

Archaeology. It is the study of past cultures and civilizations and using their remains as the principal source of information and knowledge.

Scope of Anthropology

1. Cultural anthropology would be a major challenge for any form of change in habits and customs, especially in rural areas and traditional families.
2. Social interaction and communication, using body language such as facial expressions, matter a great deal. Orthodontics and dental hygiene play an important role in shaping the facial expressions (e.g. colour and shape of teeth while smiling), which could convey different ideas and perceptions while communicating.
3. In terms of physical anthropology, the dimension of the facial structure varies with racial features. This would be important from an applied orthodontic point of view. Therefore, in dental health services, it is not merely the dental hygiene but the placement and shape of the dental structure that needs to be considered.
4. With increasing urbanization and its influence on changing lifestyles, facial appearance has an increased role to play in communication strategies.
5. Decision making in the use of dental hygienic measures by the community, becomes an important component of cultural anthropology.
6. Community dentistry must take the above factors into consideration and go beyond mere dental hygiene education.

CONCLUSION

The interaction between social factors on health issues is dynamic, complex and sometimes unpredictable. Every society has its own customs, beliefs, traditions and practices. Every person acquires these in his or her everyday social interaction with the people and society. In this way, individual acquires culture and traditions and becomes member of social group. It is stated generally that social sciences, in turn behavioural science, have been brought to the field of public health, in terms of studying psychology, culture and other aspects of human behaviour. These are very important part of our environment. The public health workers including medical and dental personnel should have the knowledge and thorough understanding of the behavioural sciences, while undertaking any public health programmes. Probably social scientists are useful in assisting, planning and evaluation of public health programmes.

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REVIEW QUESTIONS

1. Define behavioural science. Enumerate its components and write a note on its scope and use in oral health care.

2. Write short notes on:
   a. Types of families
   b. Anthropology and its components
   c. Culture and oral health
   d. Culture effects in oral health and disease
   e. Sociological factors affecting oral health care services
   f. Scope of anthropology

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PART 2

DENTAL PUBLIC HEALTH

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10 Introduction to Dental Public Health

Manjunath P Puranik

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INTRODUCTION

From the earliest times, ancient Egyptians used a variety of remedies to treat the diseases of the mouth. Efforts related to prevention of oral diseases dates back to the period of Hippocrates. However, dentistry became more organized as a profession due to the efforts of many individuals, associations and regulations in the later part of the 19th century.

HISTORY OF DENTISTRY

Stages of Evolution of Dentistry

In retrospect, five evolutionary stages can be identified and analyzed to appreciate the gradual emergence of dentistry as a profession (Box 10.1).

Stage I: Undifferentiated occupation. In this stage, diseases of teeth were abandoned to their own courses. Folk medicine was used in the treatment of toothache and infections. A few individuals devoted some time to the performance of simple dental operations by simple methods and none depended solely on dentistry for their livelihood.

Stage II: Differential occupation. Indigenous practitioners emerged in this stage, without any type of formal training, who devoted entire time for the practice of dentistry. Skills were acquired under apprenticeship. Fabrication of dental prosthesis was done, and there was no restriction by the government for the practice of dentistry.

Box 10.1 Stages of evolution of dentistry

Stage I: Undifferentiated occupation
Stage II: Differential occupation
Stage III: Initial professionalization
Stage IV: Intermediate professionalization
Stage V: Advanced professionalization

Stage III: Initial professionalization. Dentists formed a guild/association, organized a course of formal training for a period of 6 months to 2 years. It is in this stage, profession came into being. Restrictive legislation was enacted in the interest of the people at large.

Stage IV: Intermediate professionalization. Independent dental schools were established with increased course duration with the minimum requirement for admission being secondary education. Courses of training and regulation were established for the auxiliaries. Dental education emphasized on technical aspects of the profession. Professional associations became stronger due to increase in the number of dental professions, but still unqualified personnels continued to thrive because of the deficiencies in the law and its enforcements.

Stage V: Advanced professionalization. Dentistry became recognized as a health profession with an increasing emphasis on biological sciences. Dentistry became strongly organized and institutionalized. Postgraduate education developed into number of dental specialties. Dental practice by unqualified personnel disappeared.

Historical Overview

Oral diseases have tormented humans since times immemorial. The history of dentistry is bound up with the history of man. Neolithic man surely suffered from toothache, as there is evidence of tooth decay in 7 out of 32 skulls dating from the Bronze Age. Early remains of Cro-Magnon people, show evidence of tooth decay (25,000 years ago). An ancient Sumerian

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text (5000 BC) describes "tooth worms" as a cause of dental decay. The Chinese used acupuncture (2700 BC) to treat pain associated with tooth decay. Prehistoric man did not require dentistry as dental problems escalate with social development. As the need arose, the service improved. In fact, at first the dentist had no separate professional existence.

Dentistry in Ancient Times

Egyptians and Babylonians believed toothache to be an indication of divine displeasure. Incantations and prayers were performed for relief. As per Herodotus, Egypt was full of specialists, enumerating the various parts of the body, including the teeth. A method to reduce a dislocated mandible has been described. Early man was necessarily a craftsman who could readily master crude splinting, bandaging and suturing.

2900 to 2750 BC: Much of early dentistry was practised as part of the general practice of medicine. There is evidence of two holes drilled through the bone, presumably to drain an abscessed tooth in an Egyptian in lower jaw.

700 and 1500 BC: References to diseases of the teeth, as well as prescriptions for substances such as olive oil, dates, onions, beans and green leaf, to be mixed and applied "against the throbbing of the bennut blisters in the teeth" are found in the Papyrus Ebers contains 400 BC, Mesopotamia, the assumption can be made that the extraction of teeth was performed regularly, as per legend written on a clay tablet. The Chaldeans were known for magical powers and could cite charms to drive out the worm believed to be the cause of toothache. This "worm in the tooth" theory was believed by primitive people in all parts of the world till the 20th Century.

Greek Civilization

1300 and 1200 BC, the concept of extracting diseased teeth has been credited to Aesculapius—a Greek physician,

500–300 BC, Hippocrates and Aristotle wrote about treating diseases of the teeth and oral tissues. Tooth extraction and the use of wires to stabilize jaw fractures or bind loose teeth were described. Hippocrates refers to accidents and illnesses affecting children during teething. Extraction of teeth was only recommended when teeth were actually loose.

Etruscan Approach

700 BC, the Etruscans were more practical and skilled dentists. They were able to make dental appliances with exceptional skill. Partial dentures(bridgework type) were found in Etruscan tombs. Wide bands of pure gold were soldered together to fit over the natural teeth. Galen, a Greek, who settled in Rome in the 1st century was the first person to speak of nerves in the teeth. Attention was gradually given to the filling of cavities.

Roman Period

The Romans absorbed the Etruscans and learnt their skills from them.

100 BC, Celsus, a renowned Roman medical writer wrote extensively of oral diseases, including bleeding gums and ulcers of the oral cavity, as well as dental treatment such as narcotic-containing emollients and astringents.

Arabian Contribution

Arabian civilization existed while Europe was in the Dark Ages. Arabian physicians attached great significance to clean teeth. Various procedures to "scrape" the teeth using sets of specialized instruments were described. Mouthwashes and dentifrice powders were applied by the Arabians using a "toothbrush," a small polishing stick that was beaten and softened at one end.

Abulcasis, described extraction, scaling, reduction of fractures and the treatment of dislocated jaws in a treatise. He designed 14 different kinds of scrapers. He suggested the binding together of sound teeth and filling the existing gaps with a bone substitute.

Rhazes (850–923), a Persian physician, wrote about filling cavities with alum and mastic.

Decline in the Dark Ages

During the Dark Ages, Europe witnessed economic depression and internal collapse. Dentistry in Europe sank to a very low level, remaining so for several centuries.

In the early period dental therapy was provided by so-called "barber surgeons" who later formed the Guild of the Barber Surgeons. In 1540 this Guild joined that of the surgeons to become the United Company of Barber Surgeons, which existed until the mid-eighteenth century. Dentistry was available to richer individuals by physicians or surgeons. Dentistry for poorer people took place in the marketplace, where self-taught individuals would extract teeth for a small fee.

While the Barber Surgeon functioned in the urban areas, the work of barber and blood letter were left to the blacksmith and shoemaker in the rural districts. They handled the extractions, assisted by itinerant tooth drawers who visited the market places very often.

Decay was removed from teeth with a "dental drill," a metal rod that was rotated between the palms. Soft filling materials provided short-term alleviation of discomfort by keeping air from the open cavity. An Italian professor, Arculanus (1412–1484), advocated the use of gold leaf in fillings, a technique still in use today.

The Renaissance

The renaissance brought a general revival in learning; dentistry shared in the intellectual awakening. Ambroise Pare, known as the father of modern surgery, was the author of an illustrated practical treatise on dentistry. Charles Allen in 1685 wrote the first textbook to be published in English *'The Operator for the Teeth.'*

The next landmark of some importance was the discovery towards the end of the 18th Century that shiny rot-proof porcelain could be used for the manufacture of false teeth. Dentures were originally made from hippopotamus or whale ivory and later from porcelain.

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Pierre Fauchard (1678–1761), a French surgeon, known as "Father of modern dentistry" in his book, *Le Chirurgien Dentiste* described the basic oral anatomy and function, signs and symptoms of oral pathology, operative methods for removing decay and restoring teeth, periodontal disease (pyorrhea), orthodontics, replacement of missing teeth and tooth transplantation. English physiologist John Hunter, surgeon general to the British army wrote two popular books namely, *Natural History of Human Teeth* (1771) and *Practical Treatise on the Diseases of the Teeth* (1778).

By 1736 dental training was included in the curriculum of the French Naval School at Rochefort. They were only taught to extract teeth. The naval surgeons had to serve in the colonies for three years.

In the 1700s dental practitioners migrated to the American colonies and performed primarily the removal of diseased teeth and insertion of artificial dentures.

The Nineteenth Century

In 1840, two American dentists, Horace H Hayden and Chapin A Harris founded the Baltimore College of Dental Surgery. The standard of dentistry was gradually improved by raising the standard of the curriculum and examination.

The *American Journal of Dental Science* was published in 1839 in Baltimore by Eleazar Parmly of New York and Chapin A Harris of Baltimore. The University of Maryland recognized the DDS degree and the precedent was established that a dentist could use the title 'Doctor.'

In 1844 Dr Horace Wells, a Connecticut dentist, initiated the use of nitrous oxide inhalation during dental therapy and founded the concept of inhalation analgesia and anaesthesia.

Greene Vardiman Black (1831–1915) revolutionized American dentistry. Black devised a foot engine that helped the dentist to keep both hands free while powering the dental drill. He developed modern techniques for filling teeth. Black proposed that dental caries and periodontal diseases were infections initiated by bacteria.

American dentists practising in Europe met in Switzerland in 1873 to establish "The American Dental Society of Europe" for dentists legally qualified in America. This society paved the way for the "Federation Dentaire International" which did much to facilitate the progress of the profession. In 1878, the first Dentist's Act provided for a register to be kept by the General Medical Council. The Odontological Society was formed in Britain with the *British Journal of Dental Science* as its organ.

In the third International Dental Congress held in Paris in 1900, Godon stated positively: "Dentistry can today be considered a science!" He attributed much of this recognition of the science of dentistry to the American practitioners responsible for following progressive improvements, viz. the technical schools open to everybody and replacing the system of apprenticeship, associations uniting people of the same profession and journals disseminating the new knowledge.

Later part of 19th century and the 20th century witnessed a drastic change in the concepts of oral diseases and paved ways for various theories, inventions and discoveries, improvement in materials, technology and techniques. Specialties and superspecialties have developed in dental education extending the scope of dentistry towards promotion of oral health and better quality of life.

PLANNING DENTAL CARE

Aims and objectives:

1. To establish rapport by listening and talking to the patient.
2. To define patient's requirements by taking case history.
3. To make a diagnosis and prognosis by means of case history, examination and investigation.
4. To plan a comprehensive treatment, tailored according to the status and needs of the patient.
5. To organize the care to be provided by listing to the needs in a logical sequence with delegation and referral as appropriate.
6. To establish that the patient has achieved a state of dental stability for a stated period of time and to plan periodic recall and reevaluation.

SCOPE OF DENTAL CARE

The term dental treatment encompasses a wide range of services ranging from simple local procedure applied on a particular tooth, to a comprehensive and considerate interest in the oral as well as general health of the patients. Dental care is preferable to dental treatment because care connotes to concern which in turn directs the dentist to attend, respect and regard the patient as well as tissues from further threat that exists in the environment. Dentist should possess the knowledge as well as resources to exercise his or her duties towards individuals as well as the community.

Of late there is a sea change in their approach and management of oral diseases. The emphasis is shifting from treatment to prevention of oral diseases and promotion of oral health, thereby increasing one's quality of life.

PUBLIC HEALTH

Dentistry exists to serve the public, making all efforts to protect and preserve the oral health with the right mix of public and private services. Surgeon General Satcher has stated in that oral health meant much more than healthy teeth, oral health was integral to general health, that safe and effective disease prevention measures existed that everyone could adopt to improve oral health and prevent diseases.

Definition of Public Health

CEA Winslow defines Public Health as "the science and art of preventing disease, prolonging life and

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promoting physical health and efficiency through organized community efforts for the sanitation of the environment, the control of communicable infections, the education of the individual in personal hygiene, organization of medical and nursing services for early diagnosis and preventive treatment of the disease and development of social machinery to ensure for every individual a standard of living adequate for maintenance of health.

Public health, in essence, determines the health status of the community, identifies populations potentially affected or at risk for a particular problem, analyzes the dimensions of the problem through the use of epidemiological methodology, and then plans, implements and evaluates the appropriate interventions.

The Public Health Method: Characteristics

Public health work exhibits a certain number of characteristics that are different from individual practice in the same field.

The characteristics are:

1. Public health work must concentrate on areas where *group responsibility* is recognized such as in the context of acute communicable diseases, contagious diseases, indigence and medical indigence, etc. where an individual is made safe from his or her neighbour. This led to the concept of quarantine and isolation procedure and later to mass preventive measures.
2. Public health depends upon *teamwork,* this is partly due to the necessity of efficient handling of large groups and partly to the fact that many processes, involved in prevention, adapt themselves particularly well to teamwork.
3. *Prevention* is a major objective of public health programme because prevention is ethical, has the advantage of teamwork and cost efficiency.
4. Ability to deal with all sorts of problems involving the host, agent and the environment, beyond the scope of individual physician or dentist-*epidemiologic approach.*
5. Dependence on *biostatistical methods* for analysis.
6. Deals with all types of people in the health spectrum such as *healthy or apparently healthy* people as well as with the *sick.*
7. Provides *education* to the public, a prime objective of public health work and also adapts public health programmes to community culture.
8. Consideration to *logistics,* to serve people in disadvantaged or isolated locations.
9. Insurance.

Tools of Public Health

Tools refer to those basic sciences, social sciences, approaches and principles which are essential to study of mass disease, whether it is systemic or dental and plan a programme for the prevention or control of the disease. The tools are:

1. Epidemiology
2. Biostatistics
3. Social sciences
4. Principles of administration
5. Preventive dentistry.

Basic Public Health Activities

Public health activities concentrate on education of the people, collection of vital statistics, provide hospital, nursing and laboratory services in the areas of maternal and child health and nutrition, adult health, dental health, mental health and industrial health, disease control and environmental sanitation measures.

Characteristics of Public Health Techniques

The use of the health centre, case finding and the community health council are important of these techniques.

Health centre. Typical health centre activities include the services offered by primary health centre providing preventive services not easily found at other than hospital.

Case finding. Case finding or screening is search for cases of unrecognized or early disease in apparently healthy populations and is based upon simple and rapidly applied tests. School physical examinations are done primarily for case finding.

Community health councils. The councils are formed by representatives from both voluntary and government agencies and the community at large. It provides a forum for the exchange of information between various health agencies and the public for the development of new ideas and programmes.

Functions of Public Health Agencies

As per Institute of Medicine

1. **Assessment:** The regular collection and dissemination of data on health status, community health needs and epidemiologic studies.
2. **Policy development:** Promoting use of the base of scientific knowledge in decision making on policy matters affecting the public's health.
3. **Assurance:** Assurance of the constituents that services necessary to achieve mutually agreed upon goals are provided, either directly by encouraging other entities or by regulation.

Identifying a Public Health Problem

Many a times in health scenario, poses a threat to mankind such as AIDS, road traffic accidents (RTA), substance abuse, etc. Over the years, some criteria have emerged. The following criteria seem to be relevant to define a public health problem as an issue:

1. There is a condition or situation that is widespread, actual or potential cause of morbidity or mortality.
2. There is a perception on the part of the public, government or public health authorities that the condition is a public health problem.

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DENTAL PUBLIC HEALTH

The American Board of Dental Public Health adapted Winslow's definition to develop and subsequently approved by American Association of Public Health Dentistry, the Oral Health Section of American Public Health Association and American Dental Association (ADA):

"Dental public health is the science and art of preventing and controlling dental diseases and promoting dental health through organized community efforts. It is that form of dental practice, which serves the community as a patient rather than the individual. It is concerned with the dental health education of the public, with applied dental research, and with the administration of group dental care programmes as well as the prevention and control of dental diseases on community basis."

Public health dentists should have broad knowledge and skills in programme administration, research methods, the prevention and control of oral diseases and the methods of financing and providing dental care services.

In short, dental public health is concerned for, and activity directed towards, the improvement and protection of the oral health of the whole population, a goal shared by organized dentistry. So public and private sectors need to understand each other and work cooperatively to achieve this worthy goal.

History of Dental Public Health

In the United States, the profession of dentistry grew to significant stature through the means of restorative procedures carried out in private practice. Dentists were essentially craftsmen who made beautiful restorations for the teeth of those who could afford the fees.

However there were a few early efforts, to aid the indigent or the poor:

1791 The first dispensary for the treatment of poor was established by Skinner in New York City. Dental services were also offered there.

1849 The Society of Dental Surgeons of the state of New York founded its own dental infirmary.

1861 Dental service became a part of the charity hospital of Philadelphia.

1867 Small dental clinic for low-income people was opened in Boston.

1884 ML Rhein of New York City coined the term "oral hygiene." He urged the dentists to teach their patients proper methods of toothbrushing.

1898 J Leon Williams, dental histologist gave a slogan "A clean tooth never decays" which led to higher standards of mouth hygiene.

Europe

The first children's dental clinic was established in:

1865 Strasbourg, Germany

1885 In Hanover

1898 In Offenbach and Wurzburg

1890 England—through the stimulation of W Mac Pherson Fisher of Dundee, BDA appointed a committee to carry on oral hygiene work in schools; this led to appointment of dentists to many elementary schools.

The Early Twentieth Century

1905 Dr Alfred Fones trained dental hygienist, the first professionally trained dental auxiliary.

1908 Epidemiologic investigations related to mottled enamel.

1910 Various groups in US approached the problems of dental public health on the lines of dental treatment of indigent children and education of all children on the subject of mouth hygiene.

Establishment of Rochester dental clinic and the incorporation of Forsyth dental infirmary for children in Boston.

1911 Establishment of Dental corps of US Army and Navy.

The Nineteen-Twenties

1919 Dental department of US Public health service was founded. Dental clinic for home office employees of Metropolitan Life Insurance Company organized by Thaddeus P Hyatt.

1920 Increasing recognition of the problem of dental health at the federal level.
Surge of interest took place in public dental care programmes at schools, private industrial plants, hospitals and remote locations.

1921 TA Hunter pioneered in the opening of the training school for dental nurses in Wellington, New Zealand.

The Nineteen-Thirtees and After

1930 Period of great depression. The need for health care increased and people were unable to purchase health care. Federal Emergency Relief Administration (FERA) established large clinics in which relief clients could receive proper care.

1935 Social Security Act—covered unemployment compensation, old age benefits with associated taxation, extensive aid to states for various health and welfare activities. This, in subsequent years, inspired a remarkable growth in state dental services.

World Wars I and II saw expansions in dental services for armed forces all over the world, gave young dentists a broad viewpoint towards the care of the people and equipped them for group programmes of present and future.

1945 Community water fluoridation at Grand Rapids, Michigan. Intensive medical and dental appraisal provided data on dental benefits and safety of water fluoridation, paved way for water fluoridation in Philadelphia (1954), Chicago (1956) and New York (1965). Voluntary prepaid comprehensive dental care.

1948 England—establishment of national insurance scheme including comprehensive dental service.

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1950s United States

1954 Washington State Dental Society organized the Washington state dental service corporation to help administer the prepayment dental care plan for children of the International Longshoremen's and Warehousemen's union pacific maritime association.

1966 Medicare (Title XVIII of social security act) for aged, Medicaid (Title XIX of social security act) for the poor.

1973 Health Maintenance Organization Act—provided government support for organizations providing standardized comprehensive care to individuals in enrolled groups.

In International scenario, WHO has collaborated with other international groups in studies of dental care delivery in as many as 12 developed countries. It has set Global Oral Data Bank in 1969, accumulating information about oral health and needs in many countries around the globe.

1980 Decline in the incidence of dental caries in developed countries.

Clinical and Community Health: Similarities and Differences

Examination/survey. In a dental office, the dental professional carries out a careful examination following the general health history. Similarly the public health dentist conducts a survey or some related form of needs assessment besides assessment of population demographics, mobility, economic resources and infrastructure. Like the examination of the patient, a survey may be initiated by chief complaint such as increase in the oral diseases or lack of access to dental care for indigent persons.

Diagnosis/analysis. Dental professional arrives at a diagnosis of an individual patient based on history, examination and investigation. Similarly public health dentist makes a community diagnosis by subjecting the data collected to statistical analysis leading to the significant factors which influence the pattern of the disease or a condition.

Treatment planning/programme planning. Treatment planning is done considering many factors like professional judgment, the patient's interest, cost of treatment and the subtle dynamics of dentist–patient relationship. Similar situation exists in the community, wherein the community's reaction to such plan, like that of the patient, may be to accept or reject it, to carry out only part of it or to compromise with a less costly alternative. Like the patient in the chair, it is ultimately the community that makes the decision.

Treatment/programme operation. A complex or comprehensive treatment plan may require the service of team of specialists to render certain procedures, though responsibility for coordination of these efforts rests with the patients' primary dentist. Similarly a team of professionals, paraprofessionals, nonprofessionals may be called on for programme operation.

Table 10.1 Clinical and community health: similarities and differences

Clinical Steps	Procedural Steps
Examination	Survey
Diagnosis	Analysis
Treatment planning	Programme planning
Treatment	Programme operation
Payment	Programme funding
Evaluation	Programme appraisal

Payment/programme funding. Similar to patient making payment to the dentist after receiving treatment, programme funding for the programme operation is very important. Programme funding in public health is often from local, state and federal funds, which the dental public health professional must be familiar with how to secure and how to administer.

Evaluation/programme appraisal. Evaluation of treatment is an ongoing process which begins during the course of treatment and is repeated at each visit. Observations made during initial examination such as extent of deposits or status of oral tissues is evaluated time to time on recall. Similarly data collected in the initial survey serve as the baseline, against which an appraisal can be made to assess the effectiveness of the public health programme. Public health workers are answerable to the community for a periodic appraisal of their performance, just as dental clinicians are answerable to their patients (Table 10.1).

Personal and community health care: The Differences. Differences exist although clinicians and dental public health professionals work towards the same goal: the oral health of the public.

Goals of public health are socially determined whereas the priorities of private care are only coincidentally related to social goals.

Private care seeks to maximize the chance that the best outcome will occur, often unlimited by financial restraints whereas public health seeks to minimize the chance that the worst outcome will occur.

The private practitioner works largely alone and relatively independent health care provider while dental public health professional works with a public health team and seldom is a major decision in public health made on one's own.

FUNCTIONS OF PUBLIC HEALTH DENTIST

The main functions of public health dentist are:

1. Programme administration
2. Preventive, diagnostic and corrective services

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3. Programme promotion and consultative services
4. Public health training and teaching
5. Dental health education and information
6. Research and study projects.

1. Programme Administration

a. Cooperation in dental health matters and other units within the health agency, and with official and voluntary agencies outside the health department.
b. Determining and publicizing private practice opportunities in areas with shortage of dentists.
c. Recruiting dental and dental hygiene students.
d. Compiling adequate dental statistics for records, legislative purposes, programme planning and programme evaluation.

2. Preventive, Diagnostic and Corrective Services

a. Provision of topical fluoride application for school children or the promotion of local dental programmes for this purpose.
b. Promotion of water fluoridation, or of defluoridation in areas with excessive natural fluorides.
c. Provision of laboratory services such as lactobacillus counts, cancer biopsy, fluoride analysis of water.
d. Provision of dental inspections and parent consultation for preschool and school children or the promotion of dental referral programmes to assure that children are seen by dentist in practice.
e. Provision of the dental treatment for the indigent, for those in isolated areas without dental service and for residents in institutions.
f. Provision of treatment and rehabilitation of the handicapped, including children with cleft lip and palate, and other dentofacial deformities and for other physically handicapped persons.

3. Programme Promotion and Consultative Services

a. Provision of adequate consultation to local dental programmes conducted by local health departments, welfare departments and boards of education or voluntary organizations.
b. Provision of funds and personnel to aid local dental programmes.
c. Making dental health consultation available to other state agencies such as department of education or welfare.

4. Public Health Training and Teaching

a. Provision of in-service training for state and local health department staffs.
b. Sponsorship or participation in lectures, conferences or workshops in public health or allied subjects for practitioners in dentistry, dental hygiene, medicine or nursing.
c. Sponsorship of postgraduate refresher courses in areas such as dentistry for children, periodontal therapy of oral cancer detection.
d. Teaching dental health in teacher's training courses, schools of nursing, medicine, dental hygiene or public health.
e. Promoting the utilization of auxiliary personnel by dental practitioners.

5. Dental Health Education and Information

a. Utilization of newspaper, radio and television to increase understanding about dental health.
b. Use of films, film strips and exhibits to promote interest in dental health.
c. Preparation and distribution of dental health education materials to schools, health personnel and the public.
d. Training of teachers through workshops, seminars, personal contact and participation in class room instructions.

6. Research and Study Projects

a. Conducting surveys to establish the nature and extent of dental disease.
b. Conducting surveys to determine the dental needs of special groups such as preschool children, the handicapped or the institutionalized.
c. Utilization of special studies for programme evaluation to determine the effectiveness of fluoridation, training, treatment or referral programmes.
d. Organizing studies of dental practice to determine dental manpower resources, need for training facilities, usage of auxiliary personnel or the economic or social barriers to dental care.

ROLES OF DENTAL PUBLIC HEALTH WORKERS

Dental public health workers have a multiple career options which can be challenging and interesting. They can work as dental public health providers, scientists, professional educators, administrators and policy developers.

ACHIEVEMENTS OF DENTAL PUBLIC HEALTH PROFESSIONAL

1. Conducting epidemiologic studies that established the basis of community water fluoridation.
2. Clinical trials to demonstrate the effectiveness of fluoridation and other uses of fluorides.
3. Implementation of caries control programmes that have been fundamental to the decline in the caries among children.
4. Epidemiology of periodontal disease, oral cancer and other public health problems.
5. Concept of providing regular dental care in a logical way for large population groups.
6. Efficient use of dental auxiliaries.

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CONCLUSION

Dentistry has come a long way. From being craftsmen, treating those who can afford to care of individuals at the receiving end, dentistry has witnessed sea change in its approach towards humanity at large. Dental public health has emerged effectively using research findings in the prevention of oral diseases, screening for an early diagnosis and prompt treatment and palliative care for those in the terminal stages. Scope of dental care has broadened to include those groups hither to deprived of such services. Concept of group practice, use of auxiliaries, attention to logistics, financing dental care, oral health education, etc. have provided an additional dimension in the management of oral diseases. In this scenario, co-ordination with allied professional groups can definitely enhance towards the achievement of optimal oral health.

REVIEW QUESTIONS

1. Write short notes on:
   a. Milestones in public health dentistry
   b. Functions of public health dentist
   c. Tools of public health
   d. Procedural steps in public health dentistry
   e. Identifying a public health problem
   f. Characteristics of public health method
   g. Public health dentistry vs. clinical dentistry

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11 Epidemiology of Dental Caries

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INTRODUCTION

Dental caries is an infectious microbiological disease that results in localized dissolution and destruction of calcified structures of the teeth. It is defined as a "progressive" microbial disease affecting the hard structures of the tooth resulting in demineralization of inorganic contents and dissolution of the organic constituents, thereby leading to a cavity formation.

Dental caries may be considered as a disease of modern civilization, since prehistoric man was rarely affected from dental caries. There was no evidence of dental caries in the relatively very few teeth found in skull fragments of our earliest known ancestors, Pithecanthropus. However, extensive decay was noticed in the skull of Rhodesian man from the Neanderthal age. And also evidence of caries was found among few skulls of the prehistoric race, which lived in central Europe about 15–18 thousand years ago.

In 1890, Miller gave the chemoparasitic theory for dental caries. Then, there was no reason to look beyond the oral cavity for the causes of dental caries. Dental research since that day has provided so many factors which seemed to influence the occurrence of caries. So, instead of finding "a cause" of dental caries, the concept of "multifactorial disease" became more acceptable.

EPIDEMIOLOGICAL STUDIES

- Day and Tandon (1940) conducted a survey among 756 subjects aged between 5–18 years in Lahore, and the point prevalence of caries was reported as 94.04%.
- Chaudhary and Chawla (1957) conducted a survey of 2900 school children of 5–16-year old in Lucknow. They found that dmft as 11.1 and decayed, missing and filled teeth (DMFT) to 1.9.
- Ludwig (1960) carried out a survey among school children and found that children in the age group of 3–5 years had an average of 0.9 deft (caries index for primary teeth).
- Dorothy et al (1969) carried a survey of oral health of preschool children in Israel and this revealed high caries rate among children and was attributed to increase in sugar consumption.
- Onisi and Shinohara (1976) in their survey of 1172 children in the age group of 13 years in Japan found that the mean DMFT score was 7.5, and this was higher in females than in males.
- Enwonwn (1981) noticed that with a rapid socioeconomic development and drastic changes in traditional dietary habits, dental caries, which was extremely low in the African countries in the past, is now posing serious dental health problems. This has resulted in increased caries experience which was very low earlier.
- Tooth pain due to permanent caries was more than 200 million incident cases in 2013. Prevalence estimates for asymptomatic permanent caries was 2·4 billion in 2013.
- In 2010, untreated caries in permanent teeth was the most prevalent condition worldwide, affecting 2·4 billion people, and untreated caries in deciduous teeth was the 10th – most prevalent condition, affecting 621 million children worldwide.
- Kalyana Chakravarthy Pentapati et al (2013) conducted a study in Manipal, Karnataka and found that dental caries experience was 62.1% among 13–15-year-old children, which was more in private school children with 80.5% compared to government school children with 19.5%.
- Sukhabogi et al (2014) conducted a study on oral health status among government and private school children in Hyderabad, Andhra Pradesh. The study showed a total dental caries prevalence of 41.4% in the study participants.
- Panwar NK et al (2014) conducted a study in Udaipur city and found that dental caries prevalence was 74.7% in deciduous dentition and 68.1% in permanent dentition among 8–12-year-old children.

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INDIAN SCENARIO

Coronal caries *(Table 11.1)*

Table 11.1 Prevalance of coronal caries (mean DMFT)

1993	0.86 dmft	National level
2003	0.5 dmft	Thiruvananthapuram
2003	3.94 dmft	Chennai
dmft-3.5, Prevelance-52%		Among 5-year-old children
2015	1.86 dmft	Global DMFT level

National Oral Health Survey and Fluoride Mapping, 2002 (DCI, New Delhi)

Caries experience was high in all age groups surveyed and the percentage of subjects with caries increased as age advanced in the population surveyed. The percentage of subjects with caries experience range from about 52% in primary dentition (5 years) to about 85% in the permanent teeth in older adults (65–74 years). The dmft/DMFT value of 1–3 teeth was most prevalent in children (5, 12, 15 years). The percentage subjects with higher dmft/DMFT values decreased as dmft/DMFT values increased. However, in the age group of 65–74 years, the highest DMFT value of 25–32 was most prevalent followed by DMFT values of 9–16, and 4–8. In 35–44 years the most prevalent DMFT value was 4-8 followed by 1–3.

There was no significant gender difference in the prevalence of dental caries and pattern of distribution of caries experience. There was no marked urban and rural difference, but urban residents appear to have marginally higher caries experience compared to rural residents.

Root Caries

Unlike coronal caries root caries does not normally appear in children. Root caries prevalence was 4.5% among the 35–44 year individuals, and 5.5% among the 65–74 years. The prevalence of root caries was higher in rural areas than in the urban areas in both age groups. In 35–44 years root caries appeared in more females than males while the opposite was true in older adults aged 65–74 years.

GLOBAL SCENARIO AND CURRENT TRENDS IN CARIES INCIDENCE

Dental caries is still a major oral health problem in most industrialized countries, affecting 60–90% of schoolchildren and the vast majority of adults. It is also the most prevalent oral disease in several Asian and Latin American countries, while it appears to be less common and less severe in most African countries. Global oral data bank highlights the dental caries experience among 12-year-old children in the six WHO regions in the year 2000, based on the DMFT (Decayed, Missing and Filled Teeth) index, which measures the lifetime experience of dental caries in permanent dentition. Currently, the disease level is high in the America but relatively low in Africa. In light of changing living conditions, however, it is expected that the incidence of dental caries will increase in many developing countries in Africa, particularly as a result of a growing consumption of sugars and inadequate exposure to fluorides.

The various studies conducted in different countries at different time periods have given evidence that a substantial decrease in caries prevalence in the last decade has been found among western countries, whereas in case of developing and underdeveloped countries prevalence of caries seems to be increasing. The best description of the downward trend is found in the report of first international conference on the declining prevalence of dental caries held in Boston in 1992. Caries decline has been found remarkably in England, Denmark, Sweden, Norway, Scotland, the Netherlands, New Zealand, Ireland and the USA. At the same time, percentage of caries-free children has started increasing gradually.

The extent of decrease of dental caries experience could be the result of individual fluoride preventive procedures in non-fluoridated areas. The combination of weekly rinses, daily supplemental fluorides and fluoride dentifrices produced 40% reduction in DMF surfaces in 12-year-old children and 62% in 14-year-old children. The WHO databank records show upward trend from 1.6–10.4 in DMFT over a period of 20–30 years among developing countries (Table 11.2). The use of refined carbohydrate foods has increased more rapidly in these countries and lesser use of various forms of fluoride. Increase in dental manpower along with an upswing in dental health education, as well as more demand for dental care have resulted in decrease in dental caries experience. These conflicting trends in caries incidence tend to make a suspicion whether the downward trend in developed countries can really be called secular. Barmes observed that among 12-year-old children in developed countries, the downward trend was towards 3 DMF teeth whereas among children of similar age in developing countries, the upward trend was also towards 3 DMF teeth. These figures may possibly indicate an approximation to an endemic caries level.

Table 11.2 Increase in prevalence of dental caries in children aged 10–14 years from selected countries (Global data bank)

	Increase in DMFT		
Country	**From**	**To**	**Within no. of Years**
Ethiopia	0.2	1.6	17
Kenya	0.1	1.7	21
Iraq	0.7	3.5	9
Thailand	0.7	4.5	15
Vietnam	2.0	6.3	11
French Polynesia	Negligible	7.5	50
Greenland	1.5	10.4	20

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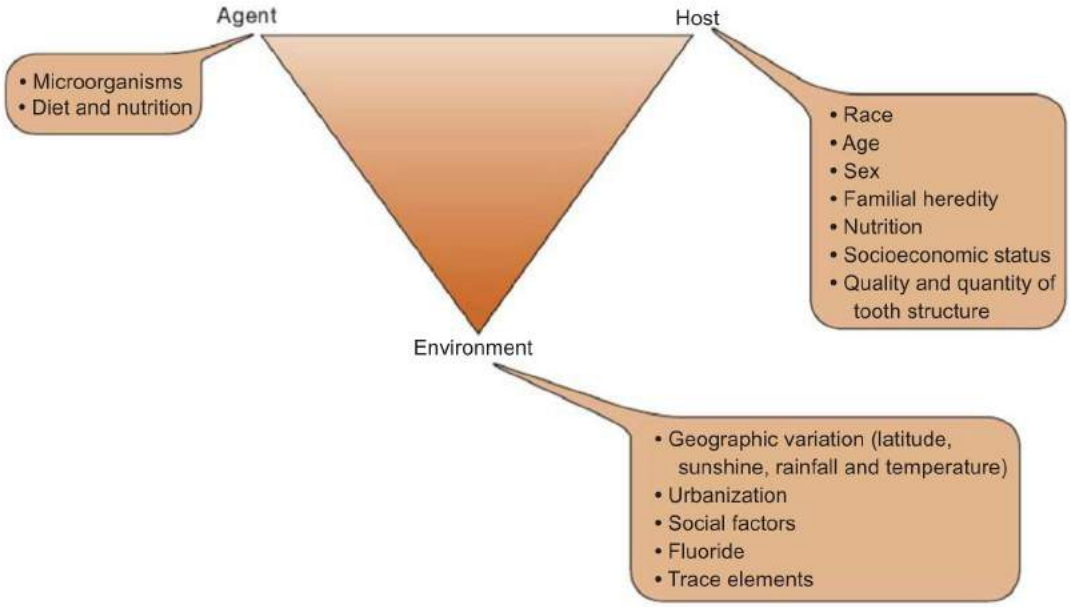


Figure 11.1 Epidemiological triad.

EPIDEMIOLOGICAL FACTORS OF DENTAL CARIES

I. Host Factors
II. Agent Factors
III. Environment Factors

The interaction of these factors under conducive conditions leads to dental caries development (Fig. 11.1).

I. HOST FACTORS (DEMOGRAPHIC FACTORS)

1. **Race or ethnic group:** Certain races enjoy high in dentistry for a long time. They probably stemmed from the earlier observations that certain non-European races such as African and Asian enjoyed freedom from caries than Europeans. These beliefs have faded as evidence suggests that these differences are more due to environmental factors than inherent racial attributes. Moreover, certain groups, once thought to be resistant to caries became susceptible when they moved to more economically developed areas with different cultural and dietary patterns.

   One of the best studies was on Army recruits during World War II (Hyde, 1944). Here, the environmental differences were less, as all of them resided in the same geographical area and had same diet. This study showed low caries experience in Chinese and blacks than white population.
2. **Age:** Previously caries was considered "essentially a disease of childhood" but it shows 3 peaks: at ages of 4–8 years, 11–19 years and 55–65 years. With the advent of better preventive measures like use of fluorides, maintenance of oral hygiene, etc, more and more younger people are reaching adulthood with many caries-free surfaces, and hence caries is becoming a "disease of lifetime."

   During old age, i.e. above 65 years, more prevalent type is the root caries, which is exaggerated due to gingival recession, which results in: (i) exposure of cementum, (ii) cervical abrasion and food impaction and (iii) reduced manual dexterity (toothbrushing).

   Hence maximum caries activity is noticed among children and later root caries prevalence will be more in elderly people.
3. **Sex:** Many studies have shown higher caries experience in girls than boys during childhood period and also later at adolescence period. However, there are some studies which have shown no difference between girls and boys. It is also true at later part of the life, that there is not much difference in caries experience among males and females. However, root caries prevalence is more and commonly seen in males. This could be attributed to poor maintenance of oral hygiene in older aged males.

   The increased susceptibility of girls to caries may be explained by: (i) early eruption of teeth, (ii) may be due to the morphological difference between the teeth of males and females, (iii) increased fondness towards sweets among girls (females) and (iv) due to hormonal changes.
4. **Familial heredity:** "Good or bad teeth run in the family." Family studies have shown that offsprings have the same score as parents. If the parent score is low, the children too have low caries score. If the parent's caries score is high, similar score is reflected in the children.

   Mansbridge found a greater resemblance between identical twins or fraternal twins than unrelated pair of children. While some researchers speculated that caries prevalence is hereditary or genetically based or shows sex-linked inheritance. Further research revealed that environmental factors like morphology,

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occlusion, salivary flow or composition are important contributory factors for variation in dental caries activity.

5. **Emotional disturbances:** Periods of stress have been associated with high caries incidence and with return to more normal mental health and caries rate. But this is difficult to measure as caries is a chronic dis ease, and it is difficult to define stress.

   Schizophrenics experience a reduced caries activity which may be attributed to increased salivation and higher pH of saliva.

   Patients with controlled diabetes have reduced caries prevalence due to drastic dietary changes. In all systemic diseases, emotional disturbances seem to be the common denominator leading to decreased salivary flow and increased caries rate.

6. **Diet and nutrition:** It is difficult to assign a single logical place to nutrition. This is the only factor that can be included under host, agent and the environ mental factors.

   Nutrition can be host factors because the individual, according to his or her like and dislike, instinctively selects specific foods from the array available to him or her. While some are natural protein feeders, and some are carbohydrate feeders.

   Lady May Mellanby, 1943 was the first to suggest that vitamin D deficiency was the causative factor for hypoplasia and development of dental caries.

   Limited epidemiological evidence shows that severe chronic malnutrition during the development of teeth can result in hypoplastic condition and later predispose to dental caries. The malnutrition itself does not produce caries without exposure to strong cariogenic challenge.

   Diet refers to the customary allowance of food and drink taken by any person from day to day. Thus, diet may exert an effect on caries locally in the mouth by reacting with the enamel surface and by serving as a substrate for cariogenic microorganisms. Sucrose has been indicated as 'the arch criminal' in the aetiology of caries. The evidence linking diet and dental caries has been taken from epidemiological studies, human clinical studies, animal experiments and plaque pH studies.

7. **Socioeconomic status:** It is difficult to correlate caries pattern with socioeconomic status (SES) due to its complexity. The first landmark research in 1930s and 1940s by Klein and Palmer showed that DMF values were not uniform in different SES groups. It was noticed that low SES groups had more number of decayed and missing teeth but less number of filled teeth and vice versa in higher SES groups. Similar findings were reported by United States Public Health Service (USPHS) in 1963–65.

   From 1960s onwards, after the introduction of fluorides and other preventive measures, the DMF values decreased in higher SES than lower SES groups.

   Nowadays caries is considered to be a "disease of poverty" or "social behavioural disease."

8. **Time factors for caries development** after **eruption:** Longitudinal studies have shown that caries susceptibility rises sharply after eruption and equally falls. In general, the peak of susceptibility occurs at about 2–4 years after eruption.

9. **Variation in caries within the mouth:** Variation of caries within the mouth can be grouped under three main headings
   a. According to the surface attacked
   b. Frequency with which the different teeth in the mouth are attacked
   c. According to bilateral symmetry

a. According to the surface attacked

Pit and fissure caries: They often represent actual structural defects in enamel "as enamel is" the most susceptible surfaces for the carries in the mouth. Attack commonly occurs fairly early in life.

Proximal caries: They are seen in deciduous teeth towards the end of their life span and in the permanent teeth predominantly between the age of 25 and 35, after which it becomes less frequent.

Cervical caries: This can be related logically to the progressive changes in the free margin of the gingiva which increase susceptibility for plaque formation.

Acute root caries: This can be described in connection with the degenerative process of old age.

b. According to the tooth attacked

The lower incisors are less frequently attacked than any other teeth. The opening of major salivary ducts near the lower incisors has been put forth as a reason for this resistance to caries but the opening of the parotid glands near the upper molar teeth has failed to give these teeth similar protection.

c. Bilateral Symmetry

Bilateral symmetry of caries in the mouth may not help our reasoning process in the causes of caries, but the knowledge that this symmetry exists is of great help to the public health worker in evaluating topical preventive measures for dental caries.

10. **Saliva:** Teeth are in constant contact with saliva which influences the state of oral health in person including dental caries. Salivary constituents related to dental caries are
    a. Composition
    b. pH
    c. Quantity
    d. Viscosity
    e. Antibacterial properties

a. Composition The composition of saliva varies from person to person, values are greater in slow flowing saliva and inversely related to the rate of flow. Calcium and phosphorus content is low in caries active persons. Turkheim (1925) noted that the saliva of caries immune persons exhibited greater ammonia content than saliva of persons with caries.

b. pH of saliva The pH will vary according to the bicarbonate content of the saliva, pH increases with flow rate. Other salivary components contributing to the ability of saliva to neutralize acid are salivary phosphate, salivary proteins, ammonia, urea and statherin.

Sialin is an arginine peptide which is the recently reported pH rise factor present in saliva which rapidly clears glucose from plaque and increases base formation and thus elevates pH in the plaque.

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c. Quantity of Saliva The quantity of saliva secreted normally is 700 to 800 mL/day. In cases of salivary gland, aplasia and xerostomia in which salivary flow may be entirely lacking can result in rampant dental caries.

d. Viscosity of Saliva Viscosity of saliva is mainly due to mucin content. Miller thought that salivary viscosity was not of great importance in the caries process.

e. Antibacterial properties of saliva Salivary antibacterial substances or enzymes are

1. Lactoperoxidase
2. Lysozyme
3. Lactoferrin
4. IgA

Lactoperoxidase: They participate in killing microorganisms by catalysing the hydrogen peroxide mediated oxidation for variety of substances present in the microbes. Utilizing thiocyanate ions in saliva or halide ions in the phagocyte system peroxidases generate highly reactive chemical compounds that bind and inactivate several intracellular microbial enzyme systems as well as microbial surface components. Lactoperoxidase has high affinity for the enamel surface and it forms an important defence mechanism limiting early microbial colonization of tooth surface.

Lysozyme: It is a small but highly positive enzyme that catalyses the degradation of the negatively charged peptidoglycan matrix of microbial cell walls. In areas of large plaque deposits, a locally low pH may interfere with optimal lysozyme binding and function.

Lactoferrin: It is an iron binding basic protein seen in the oral cavity it tends to bind and limit the amount of free iron. Since iron is essential for microbial growth, this salivary protein is an active host defence mechanism.

IgA: It is the predominant immunoglobulin present in saliva. It inhibits adherence and thereby prevents colonization of mucosal surfaces and teeth by organisms facilitating their disposal by swallowing.

II. AGENT FACTORS

In 1960, Keyes demonstrated that caries is a transmissible disease through the cariogenic micro flora.

1. **Micro flora:** The classical germ-free animal studies of Orland et al (1954), firmly established principal evidence that had been debated for more than a century that dental caries is a bacterial infection. These studies demonstrated that germ-free rats on a highly cariogenic diet containing sucrose did not develop caries and on the contrary when the gnotobiotic rats on the same diet were infected with combinations of an *Enterococcus* and a proteolytic *Bacillus,* caries developed.

   The organisms found capable of inducing carious lesions include mutans group of streptococci, *S. sanguis, S. salivarius, S. milleri,* lactobacilli strain, *Actinomyces viscosus* and *Actinomyces naeslundii* (root caries).
2. **Diet:** In a strict sense, diet should be taken as agent factor. However, this particular factor can also be included under host and environmental factors.

Food and beverages taken by individual serve as substrates for fermentation by the plaque micro flora, which form organic acids, thereby promoting demineralization of tooth structure and directly affecting caries activity. Food composition and dietary habits of individual persons also influence the growth and development of various types, proportions of specific cariogenic microorganisms found in the dental plaque, thereby indirectly affecting caries activity.

III. ENVIRONMENTAL FACTORS

1. Geographic variations

a. ***Latitude:*** In the USA, the northeastern region has the highest and south central region the lowest prevalence of caries. This is also true for erstwhile USSR. The countries near the equator like India, Ethiopia and China showed less caries compared to countries away from the equator like Australia and New Zealand.

b. ***Distance from seacoast:*** Caries prevalence is maximum at the seacoast and more the distance travelled away from the coastal region there will be less caries activity.

The following geographical factors influence these two parameters:

c. ***Sunshine:*** Sunshine varies with latitude. Total possible hours of sunshine per year actually increase a little as near to the equator, since long days in summer compensate for long nights in winter. But an actual hour of sunshine is less due to cloud covering the sun in the sky.

Ultraviolet (UV) light from the sun promotes synthesis of vitamin D and along with other factors it might account for lower caries experience. UV light may be blocked by the thickness of the atmosphere and by the water vapour.

d. ***Temperature:*** Temperature varies with latitude and altitude. It acts to vary the caloric *requirements and water intake of humans.* Carbohydrate food is not only a quick, but also relatively cheap source of caloric energy. One study by the US department of agriculture showed that the consumption of baked foods (cakes, breads, etc.) to be higher in the north where temperatures are low. Consumption of sugar is also higher in north. Hence lower the temperature, higher the caries prevalence.

e. ***Relative humidity:*** It is the ratio of the amount of moisture present in the atmosphere to the maximum amount that can occur without precipitation at a given temperature and barometric pressure. Humidity shows a higher correlation with caries prevalence. Higher the humidity, more moisture in the atmosphere which block the UV rays and sunlight; hence, increased caries activity.

f. ***Rainfall:*** Rainfall acts by leaching off minerals including fluoride from the soil and also by blocking sunlight. Rainfall and humidity are linked to dental caries prevalence, either separately or together.

g. ***Fluoride:*** Higher the fluoride content in soil and groundwater, lesser the caries. The maximum caries reduction is noticed at a level of 1 ppm of fluoride from all sources (from water, soil, atmosphere and food).

h. ***Total water hardness:*** Water hardness is measured by the concentration of calcium carbonate. An inverse relation is seen between caries and water hardness.

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i. ***Trace elements***: Trace elements are present in soil, water and foodstuffs. An increase in caries is seen in areas containing selenium particularly when selenium is consumed during the developmental period of teeth. Hence selenium is considered as caries promoter. Other trace elements like molybdenum and vanadium have found to be caries inhibiting.

j. ***Soil***: Soil composition bears an influence on caries, where populations consume largely locally grown foodstuffs. This was shown in a study, which was carried out on children in Napier, who consumed locally grown food containing a higher molybdenum and also higher pH, resulting in low caries prevalence. Now, the role of soil is not so important as modern methods of preserving and transporting food might alter and neutralizes the effect of local soil.

2. **Urbanization:** A careful study by WHO has showed higher caries scores in urban areas where the higher consumption of refined foodstuffs by the urban community is observed.

3. **Nutrition:** Nutrition can also be included under the environmental factors as geographic (soil, temperature), cultural or educational factors, which might influence food availability and, in turn, might contribute either for increase or decrease in caries activity.

   Example: Previously Eskimos' diet included only animal fat from fish and seals. But when the transport facilities were introduced, modern, refined foodstuffs have started invading their diet, and this in turn has resulted in increased cariogenic challenge, which has started affecting the teeth by dental caries among Eskimos.

4. **Social factors:** Social factors like economic status, social pressure, affordability, provision of good preventive measures, etc. might create more demand for better dental care and leads to lesser caries prevalence. However, in the absence of these factors especially among poor and disadvantaged population, socioeconomic factors might influence higher dental caries prevalence.

5. **Industrial hazards:** to the teeth probably belong in the economic category. Carbohydrate dust and acid fumes are both known to be deleterious to the teeth, the one promoting caries and other chemical erosion.

   Another influencing factor in the structure of society is war. Whole population is affected by drastic dietary change, and there are many other environmental changes which are difficult to measure that have significant influence on the lifestyle of the people. In turn all these changes will influence caries prevalence. Reduction in refined carbohydrate intake during war time reduces caries prevalence.

CONCLUSION

Dental caries is still a considerable burden largely in developing world and to a lesser extent in developed world. Remarkable caries decline is primarily observed in the developed countries in past three decades. Data pertaining to time trends is lacking in India. Nevertheless continuous and significant presence of dental caries in population and with its prime determinants (sugar consumption, poor oral hygiene, lack of fluoride use, etc.) is operating in relatively large number of populations.

Foregoing through the dynamics of epidemiology of dental caries, which has been primarily descriptive, is indicative of variety of causative factors for caries. Fluorides and streptococci have made it possible to advance beyond the descriptive phase of epidemiological strategy into hypothecation, analyses and finally experiment. Thus, it is now significant to do similar type of work in connection with the numerous other factors that will produce certain levels of caries attack in certain people, at certain places and at certain time.

Further exploration using epidemiology as a tool for probing the causal factors operating at a demographic level in our country will certainly throw a light in understanding and management of dental caries.

REVIEW QUESTIONS

1. Write in detail about the epidemiological studies conducted in India to study the dental caries prevalence.
2. Discuss in detail "trends in dental caries."
3. Describe the role of host, agent and environmental factors in the epidemiology of dental caries.
4. Discuss the role of saliva in prevention of dental caries.
5. Discuss the role of trace elements in dental caries.
6. Discuss the role of diet in dental caries.

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12 Epidemiology of Periodontal Diseases

Hiremath SS

CHAPTER OUTLINE

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INTRODUCTION

Periodontal disease is one of the commonest chronic infectious and inflammatory disease of the oral cavity which can lead to tooth loss quite often. Periodontal disease includes a group of chronic inflammatory diseases that affect the supportive tissues of the teeth and encompasses destructive and nondestructive diseases. Periodontal diseases share common aetiologic factors and have several inducing factors. Most periodontal diseases are infectious in nature, initiated as a consequence of dental plaque biofilm formation.

EPIDEMIOLOGY OF PERIODONTAL DISEASE

The epidemiology of periodontal diseases is one of the most important challenges for dental professionals because of many factors. In periodontal disease two areas are involved: (i) the gingival, and (ii) the alveolar bone. Gingivitis and bone loss often blend in such a way as to make periodontal diseases appear as a single entity, yet both aetiologically and treatment-wise are distinguishable.

Periodontal disease, unlike caries, has its greatest incidence late in life. Therefore, it is impossible to rely on the reasons for the loss of teeth which are found missing at the time of examination. The measurement of periodontal disease must be made with accurate estimation of disease process in missing teeth.

Periodontal disease cannot be measured objectively. Measurement of gingivitis is subjective and vague. Alveolar bone loss is difficult to measure clinically and need a radiograph, which is usually not feasible in surveys. The pocket depth assessment is enormous towards either underestimation or overestimation. Hence, interpretations are wide. Impairment of tooth function is difficult to estimate (e.g. loss of masticatory function).

Quantitative studies of periodontal disease are poor and unstandardized, and also indices are far from perfect and accurate to measure, hence comparison can seldom be done.

EPIDEMIOLOGIC STUDIES

- Ramfjord SP (1960) examined 827 boys in Bombay city in the age group 11–17 years using periodontal disease index (PDI) and reported 100% prevalence of periodontal disease occurring in boys. Urban children had a PDI score of 1.42, and rural children had a PDI score of 2.14. Direct relation between amount of calculus and severity of periodontal disease was reported. Severity of disease increased with age.
- Shiekh S (1960) to study the prevalence of gingivitis in two municipal schools in Bombay examined 807 children—age group 5–19 years (lower middle class) using papillary, marginal and attached gingiva (PMA) index. He reported 74.59% of gingivitis.
- Greene in 1960 conducted a survey among 1613 boys of 11–17 years age group belonging to low socioeconomic status in India. He found a prevalence of 96.9% in relation to gingivitis.
- McHugh et al conducted epidemiological survey among 2905, both girls and boys in Dundee, Scotland in 1964 in the age group of 13 years. Gingivitis was accounted in about 99.4%.
- Nanda RS et al (1969) used Glickmans method of periodontal examination and examined 1253 school children aged between 4–17 years in Lucknow. They found prevalence of gingivitis more among the boys than girls. Prevalence of gingivitis increased with age.
- Pandit K et al (1986) examined 480 boys and girls of Delhi aged 8–18 years using PMA index and found 41.7% prevalence of periodontal disease. In the age group of 8–10 years, the prevalence was found to be 42.2%

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while in the age group of 11–13 it was 44.2%, and above 14 years it was 54.6%. Study showed an increase in prevalence of periodontal disease with age.

- Chattopadhyay A (1990) studied self-assessed oral health awareness among medical and dental professionals in Calcutta. The study group included 300 physicians and 200 dentists. He found that most of the physicians, 64%, and only 37.5% of the dentists brushed their teeth, and other oral hygiene aids were used only by a negligible number.
- Maity AK, Banerjee KL and Pal TL (1994) examined 5969 subjects aged 15–65 years in a rural population in West Bengal using community periodontal index of treatment needs (CPITN) index. The subjects selected were mostly poor farmers. One of the remarkable findings was that there was relatively low percentage of people with deep periodontal pockets. They found CPITN index score 4 in only 2–3 subjects. They concluded that calculus appears to be associated with severe periodontal disease.
- Peter KP et al conducted a study in 2014 among 700 participants in Aurangabad. Results of the study revealed that there was a high prevalence of periodontitis of almost 72% among the studied subjects. In this about 41% of the subjects had at least a site where CAL ≥5 mm and about 21% of the subjects had at least three sites with CAL ≥5 mm. These findings elucidated that almost 63% of population was suffering from severe periodontitis with an involvement of at least one site out of which almost 21% of individuals showed an involvement of three sites. The study also showed that females had a better periodontal health status as compared to males.
- Kumar S et al conducted a study in 2008 among 18–25 years, 26-34 years, 35–44 years, 45 and above 513 male subjects in Kesariyaji, Rajasthan. Prevalence was 98.2%, which increased with increasing age. Maximum disease was present in 35–44 years of age and on an average 0.4% sextants had deep probing depth.
- Sumanth S et al conducted a study in 2008 among 300 subjects (150 tobacco chewers, 150 non-tobacco chewers). Deep pockets were more (30%) in pan chewers with tobacco than (7.3%) in pan chewers without tobacco.
- GPI Singh, J Bindra et al conducted a study in 2005 among 1000 subjects in Ludhiana, Punjab. The study found that bleeding was present in 68.8% of urban and 69.2% of rural population; calculus was present in 96.8% urban and 97.2% of rural population; Shallow pockets were present in 42.3% urban and 31.7% of rural population and deep pockets were present in 22.9% of urban and 11.0% of rural population.

NATIONAL ORAL HEALTH SURVEY AND FLUORIDE MAPPING 2002–2003 (CONDUCTED BY DENTAL COUNCIL OF INDIA)

Periodontal assessment was done using Community Periodontal Index (CPI) to assess the three indicators viz. gingival bleeding, calculus and periodontal pockets. The prevalence of periodontal disease was highest in 35–44-years-age group (about 94.3%) and lowest in 5 years (about 46.5%). Calculus was more than bleeding in subjects aged 15 years and above. The prevalence was more in males. The pattern of periodontal disease was similar in urban and rural areas although more disease was recorded in rural than urban areas.

Loss of Attachment

In addition to the CPI scores, the severity of periodontitis was assessed by the measurement of the loss of attachment for 15-year-, 35–44-year- and 65–74-year-age-groups only. The prevalence proportion of subjects with loss of attachment in one or more sextant was lowest in the 15-year-age-group (4.8%); it was much higher in 35–44-year-(33%); highest in the 65–74-year-age-group (47.9%). It was higher in males than in females across age groups. The least severe form of loss of attachment (4–5) was more prevalent than more severe forms in all age groups except in 65–74 years where loss of attachment of 6–8 mm was most prevalent. This was followed by more severe forms of 6–8 mm and 9–11 mm. The loss of attachment of 12 mm or more was 3.4% in 65–74-year-old subjects. The pattern of loss of attachment was similar in urban and rural areas and all the regions whereas the prevalence of disease in urban area is higher than rural area.

Periodontal disease accounts for the greatest loss of teeth among population. This could be due to lack of public concern, knowledge, lower socioeconomic status and poor oral health care facilities. The global prevalence of periodontal disease is variable with the highest being in South America and Asian countries both in terms of magnitude and severity and the lowest being in the USA. The prevalence is found to increase with age reaching almost 95–100 in fifth and sixth decades of life.

Periodontal diseases which include gingivitis and periodontitis are considered as serious infections which if untreated can lead to loss of one or more teeth. The word *periodontal* derived from Latin means "around the tooth." Plaque (the sticky, colourless film that constantly forms on teeth) is the primary aetiological agent which causes the inflammation of periodontal tissues (Fig. 12.1).

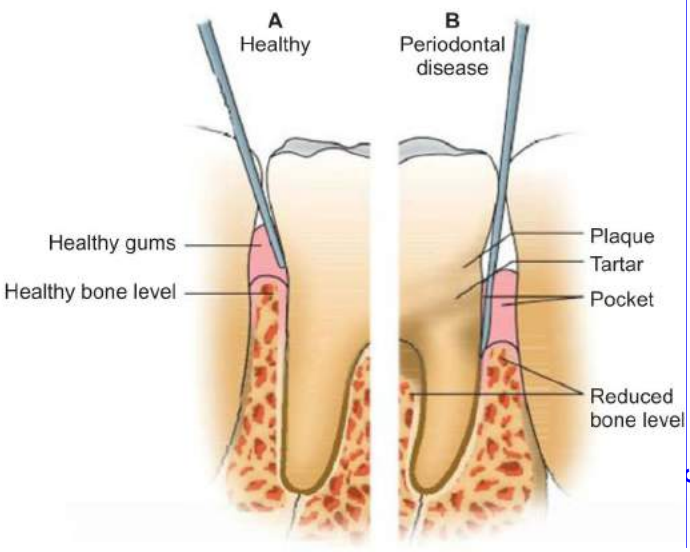


Figure 12.1 Comparison of periodontium of a normal healthy tooth and a tooth with periodontal disease.

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The first stage in periodontitis is, inflammation of the gums called as gingivitis which is often caused by inadequate oral hygiene. The gingiva appears red, swollen and bleeds easily The patient at this stage experiences little or no discomfort. This stage is reversible with professional care and good oral hygiene maintenance at home.

If left untreated, gingivitis can progress to periodontitis with time which is irreversible. The bacteria in the plaque can spread and multiply below the gum line producing toxins which irritate the tissues. The toxins stimulate a chronic inflammatory response in the tissues and bone that support the teeth which are ultimately broken down, leading to pocket formation. As the disease progresses further, the pockets deepen and more periodontal tissues and bone are destroyed. Many a times, this destructive process has very mild symptoms. Over time, teeth become mobile and may have to be extracted.

Periodontal disease is almost universal in its occurrence affecting 95% of the population, and is intimately related to plaque and pocket formation.

AETIOLOGY OF PERIODONTAL DISEASE

Periodontal diseases occur due to a number of local and systemic factors (Table 12.1).

Local Factors

Deposits. Dental plaque, also called as a host associated biofilm, is a sticky yellowish white deposit containing numerous bacteria, mucus, food particles and other irritants found on the surface of teeth. Dental plaque is a common causative factor in both dental caries and periodontal diseases.

Calculus acts as a predisposing factor in the aetiology of periodontal diseases by virtue of the presence of dental plaque in its surface rather than playing an active and direct role on itself in aetiology of periodontitis.

This deposit consists of food debris, necrotic tissue and virulent materials along with bacteria. Bacteria and bacterial products in the absence of proper oral hygienic measures can cause inflammation of gingiva which later might contribute for the development of periodontal disease.

Gingivitis is inflammation of the gums (or gingiva), the soft tissue that surrounds the base of teeth. Gingivitis is usually caused by the build-up of plaque. The toxic effects of the bacteria cause gums to become irritated, red and swollen, and the gums may bleed easily. The plaque also forces the gums to recede from the teeth.

Table 12.1 Factors responsible for periodontal disease

Local Factors

1. Deposits
   a. Supra- and subgingival calculus
   b. Materia alba
   c. Food debris and dental stains
2. Abnormal Habits
   a. Clenching, bruxism and abnormal biting habits
   b. Tobacco abuse
3. Abnormal anatomy (malocclusion)
4. Irritants (mechanical or chemical) – Improper tooth brushing

Systemic Factors

1. Malnutrition
   a. Nutrition and periodontitis
   b. Nutritional influences
2. Endocrine dysfunctions
   a. Diabetes
   b. Female hormonal alterations
3. Blood dyscrasias
4. Medication
5. Immune system disorders
6. Miscellaneous

Habits

1. *Clenching, bruxism and abnormal biting habits:* Excessive abnormal forces on teeth, which get transmitted to the attachment apparatus (i.e. periodontal ligament, etc.) and the bone can have traumatic effects. Over a period of time these abnormal and destructive forces will result in destruction of periodontal ligaments and necrosis.
2. *Tobacco use*: Periodontitis has long been associated with tobacco products. Cigarette smoking along with poor oral hygiene increases the risk for periodontal disease. Nicotine in cigarette has an effect on the circulatory system. It decreases blood supply and intake of oxygen by haemoglobin thus reducing the body's ability to fight infection and increases alveolar bone resorption. Hence, smokers, with periodontitis experience a faster bone resorption as compared to nonsmokers with periodontitis. Smokers have a greater incidence of recurrence of periodontal infection for this same reason. Smoking cessation is a key component to the success of periodontal therapy. It was originally feared that smokers could not have successful implant therapy.

   Tobacco use is an important modifiable risk factor for most human diseases and conditions such as cancer, heart and lung diseases, and has major deleterious effects on an individual's health. However, results obtained from many cross-sectional risk assessment studies and several longitudinal studies have suggested a causative association of tobacco smoking with the initiation and progression of periodontitis in humans.

   Tobacco users are found to have a 67% greater tooth loss and are three times more likely to get acute periodontitis than nonsmokers. Bleeding on probing is an important clinical diagnostic criterion for periodontitis, but the chemicals contained within tobacco ensure that the gingiva does not bleed as easily on probing, compared to nonsmokers.

Abnormal anatomy (malocclusion). Malocclusion of teeth usually results in conditions and circumstances favouring plaque deposition. Hence malocclusion results in a situation in which they become often inaccessible areas, favouring plaque and calculus formation. Hence they are more prone for gingivitis and periodontal disease.

Irritants (mechanical and chemical). Overhanging fillings, fractured restorations, improperly designed appliances

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favour microbial dental plaque formation. There has been a strong association between gingivitis and periodontitis in relation to such dental deposits.

Systemic Factors

Malnutrition

Nutrition and periodontitis: A balanced diet, containing adequate quantities of protein, vitamins such as vitamin C, essential fatty acids and micronutrients, has an important role to play in protecting against various infectious diseases, including periodontitis.

Nutritional influences: Though the main cause of periodontal disease is the accumulation of plaque biofilm on the tooth surfaces, nutritional influences may have a role in the development and progression of disease. Nutrition may affect periodontal disease in one of the following ways: (i) antimicrobial action, (ii) anti-inflammatory effect, (iii) immune system modification and (iv) antioxidant effect.

- Vitamin A, antioxidants, zinc, iron and dietary fish oils improve the resistance of the host to infections.
- Vitamin E, micronutrients such as zinc, copper, selenium, N-acetylcysteine and dietary fish oils reduce inflammation.
- Vitamins C, D, E and omega-3 fatty acids minimize tissue destruction, improve wound healing and help in increasing bone strength and rate of new bone formation.
- Calcium and vitamin D have beneficial effect on bones and on tooth retention.

A nutritious diet, consisting of a balanced mixture of good carbohydrates, proteins, lipids, vitamins and minerals, is essential for the maintenance of optimal general and oral health.

Effect of dietary texture. Though the role of dietary texture on the accumulation of plaque and in turn the development of gingivitis has been observed in dogs, no clear demonstration has been seen in humans.
Foods that encourage chewing stimulate salivary flow and help in keeping the mouth clean by mechanical cleansing. Saliva also contains antibacterial agents that help in keeping the mouth clean. It has also been hypothesized that chewing also helps strengthen the alveolar bone and periodontal ligament, thus minimizing the risk of developing periodontitis. However, the evidence in this direction is lacking and needs further study.

Endocrine Dysfunctions

a. ***Diabetes:*** Oral and periodontal effects are:
   i. Subjects with poorly controlled diabetes often complain of decreased salivary flow and burning mouth or tongue.
   ii. Diabetic subjects taking oral hypoglycemic agents may suffer from xerostomia, which could predispose to opportunistic infections with *Candida albicans.*
   iii. There is strong evidence to support the association between uncontrolled diabetes and periodontitis (Fig. 12.2).

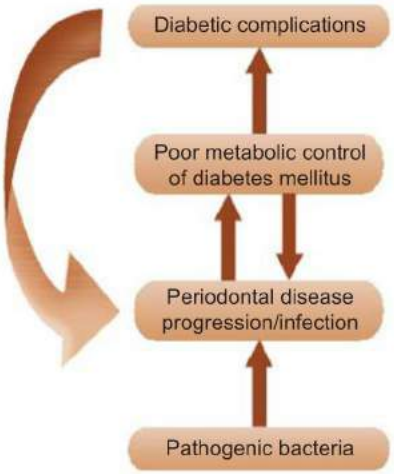


Figure 12.2 Relationship between diabetes and periodontal effects.

Factors that influence periodontal health among type 1 and type 2 diabetic patients may be variable and could be related to differences in their management. Factors include age, glycemic control, duration of disease, periodontal disease susceptibility, habits such as smoking, utilization of dental care, etc. Periodontal attachment loss has been found to occur more frequently in moderate and poorly controlled diabetic patients than in those under good control (Wesfelt et al. 1996). Diabetics with more advanced systemic complications present with a greater frequency and severity of periodontal disease (Karjalainen et al. 1994). Chronic bacterial infection as seen in periodontal disease can increase the insulin resistance resulting in poor metabolic control in diabetic patients (Grossi et al. 1996).

Mechanisms of interaction: Diabetes could affect the periodontium in numerous ways. These mechanisms may explain the alterations in periodontal disease expression, initiation and progression.

These mechanisms of interaction may be: (i) changes in subgingival environment, (ii) altered tissue homeostasis and wound healing and (iii) changes in host immune inflammatory response.

b. ***Female hormonal alterations:*** Periodontal health in the female patients could be altered due to hormonal fluctuations. Such changes can occur during puberty, menstrual cycle, pregnancy or menopause. Changes may also occur with the use of oral contraceptives. Marked periodontal changes can be seen during pregnancy, as a significant proportion of pregnant women suffer from pregnancy gingivitis. This manifests as transient and self-limiting condition and includes an increase in bleeding from gums, gingival inflammation and a subgingival microbial shift. Gingival tissues revert to healthy status after postpartum when the levels of hormones like oestrogen and progesterone reach baseline values.

Blood Dyscrasias

- *Leukaemia especially acute type:* It will result in reduced effectiveness of polymorphs and lymphocytes. Gingival hyperplasia, ulceration and haemorrhage are commonly

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seen in this condition including acute ulcerative gingivitis type infections.
- Anaemias especially iron and folate will increase incidence of inflammation of gingival and periodontal disease.
- Neutropenia especially cyclical or periodic type results in reduced neutrophils, thus increases the incidence and severity of periodontitis.
- Agranulocytosis or aplastic anaemia also increases the incidence and severity of periodontitis.

Medication

Drug-induced disorders: Another contributing factor in periodontal disease are drugs. Certain medications like anticonvulsants, calcium channel blockers, cyclosporin, etc, may induce gingival enlargement. In addition, drugs can also cause xerostomia, osteoporosis, lichenoid and other hypersensitivity reactions which, in turn, act as predisposing factors for gingival inflammation and periodontitis, and also following medications may contribute for gingivitis and periodontitis:

- Phenytoin/cyclosporin/calcium antagonists (e.g. nifedipine/amlodipine) cause excess fibroblast activity in the presence of inflammation. Severe overgrowth of gingiva is often seen.
- Nicotine addiction: The tar deposits on account of smoking increases plaque retention. The other chemicals in the tobacco lower the gingival resistance, hence increased incidence of periodontitis and acute ulcerative gingivitis is seen.
- Nonsteroidal anti-inflammatory drugs (NSAIDs): Increased incidence of desquamative gingivitis is seen. It may occur also with many antiarthritic drugs.

Immune system disorders. Severity of some forms of periodontal disease is found to be high in individuals with immune system disorders like human immunodeficiency virus (HIV) infection. Many a times, this periodontal manifestation could be the first clinical expression of the virus itself. The likelihood of necrotizing ulcerative gingivitis and necrotizing ulcerative periodontitis may increase in the patient with acquired immuno deficiency syndrome (AIDS).

The use of antimicrobial mouth rinses such as chlorhexidine at home has proven to be effective in providing symptomatic relief and also the recurrence of lesions. Antibiotics should be used with caution, due to the increased risk of overgrowth of opportunistic microorganisms such as *Candida albicans* and others associated with the HIV infection.

Miscellaneous

- Down's syndrome: In this condition, increased severity of periodontitis is often noticed.
- Dermatoses: Dermatoses cause increased incidence of desquamative gingivitis.

Local and Systemic Factors

There is a strong association between local and systemic factors with destructive periodontal disease as depicted in Table 12.2.

Table 12.2 Periodontal disease: local and systemic factors

• Specific bacteria	• Smoking
P. gingivalis	• Osteoporosis
T. forsythia	• Stress, distress
P. intermedia	Coping
• Gender	• PMN disorders
Male	• Genetic factors (IL-1 polymorphism)
• Age	
• Diabetes mellitus	
Type 2	• Dietary calcium
Type 1	• Preexisting periodontal disease

PATHOGENESIS OF PERIODONTAL DISEASE

Pathogenesis of human periodontitis was first documented by Page and Schroeder in 1976. It is virtually impossible to obtain pristine or non-infiltrated, histologically healthy gingival samples from humans.

When plaque is allowed to accumulate freely, the initial lesion (subclinical) establishes itself within 2–4 days of plaque accumulation characterized by:

- Increasing amount of dental plaque, dominated by facultatively anaerobic gram-positive cocci and rods
- Increasing vasculitis and exudation of serum proteins
- Increasing number of polymorphonuclear leukocytes (PMNs) representing the first line of the defence.

If the plaque is left undisturbed, the lesion becomes an established lesion (clinically visible), which is characterized by:

- Increasing amounts of gingival plaque (dominated supragingivally by gram-positive facultative anaerobic cocci and rods and subgingivally by gram-negative anaerobic rods
- Increase in size of the infiltrated connective tissue
- Predominance of plasma cells and T lymphocytes accumulated in the infiltrated connective tissue, representing the second line of defence
- Increased vascular proliferation and vasculitis
- Increased loss of collagen
- Clinical signs: redness, swelling, reduced resistance to probing, and an increased tendency of gingiva to bleed on probing.

After establishment of chronic gingivitis *equilibrium* is established between the increased mass of the bacteria and the host defence.

When periodontitis does supervene, it is either on account of increased proportion of the pathogenic bacteria within the subgingival bacterial flora or by impaired host defence, or by both factors in combination.

Thus, periodontitis is said to be characterized by the following:

- Adherent gingival plaque (dominated supragingivally and subgingivally by gram-positive facultative anaerobic cocci and rods)

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- Non-adherent, anaerobic, motile or semimotile gram-negative micro flora in deeper parts of the pocket
- Further loss of collagen
- Destruction of most coronal part of periodontal ligament attachment (clinical probing attachment loss)
- Resorption of alveolar bone next to infiltrated connective tissue
- Periods of quiescence and exacerbation.

EPIDEMIOLOGIC FACTORS

Epidemiological factors are being described as follows (Fig. 12.3):

I. Host
II. Agent
III. Environment

I. Host Factors

Age. The prevalence of periodontal disease increases indirectly and steadily with increasing age. Chronic destructive periodontal disease is associated with older groups. The loss of human teeth above 40 years is due to largely periodontal disease than caries in both sexes. Although, destructive periodontal disease is primarily a disease of adults, its onset during puberty has been observed in many countries.

There is a steady progression in alveolar bone loss with increasing age. Gingivitis worsens with bone loss, as bone loss is conducive to gingivitis because of abnormal contour it produces. But it is difficult to measure because of the confused picture of age changes, and also gingivitis is reversible depending on the nature of oral hygiene measures and plaque accumulation.

Sex. In general, females have less periodontal disease than males though the difference is not great. But relatively high incidence of juvenile periodontitis has been found in females. Generally gingivitis is also more prevalent in boys than girls. However, during puberty time gingivitis is more commonly seen in girls. In some less developed countries, periodontal disease is worse in females than males and may be due to frequent childbirth, ill health, poor nutrition and poor oral hygiene measures.

Day stated that in India, females show a significantly lower bone loss due to periodontitis than do males, but a relatively high incidence of bone loss from periodontosis.

Race. Some studies have shown greater prevalence and severity of periodontal disease among blacks than among whites. The prevalence of periodontal disease in some races, whether it is due to genetic basis or due to environmental factors such as food habits, type of food and material used for oral hygiene is not known. The difference may likely be associated with differences in socioeconomic status and educational background. The severity of periodontal disease among Spanish-Americans appears to be higher than that among both whites and blacks.

Intraoral variations. Upper molars and lower central incisors are the most frequently affected teeth followed by lower molars. The least affected teeth are lower bicuspids and upper canines. Even though, right-handed people brush better on left side than right side, periodontal disease is more prevalent on left side.

Endocrine changes. An increase in gingivitis in children noted as they approach puberty. Females show exaggerated picture during menstruation and pregnancy. Periodontal disease is aggravated in endocrine imbalances like hyperthyroidism and hyperparathyroidism.

Diabetes: Diabetes is now found to be the sixth leading cause of death in the USA. Nearly one-third of diabetics are found to have severe periodontal disease. In fact, periodontal disease is known as the sixth complication of diabetes (Loe1993). Periodontitis and Diabetes have a two-way relationship. While diabetes is considered as an important predisposing factor for chronic destructive

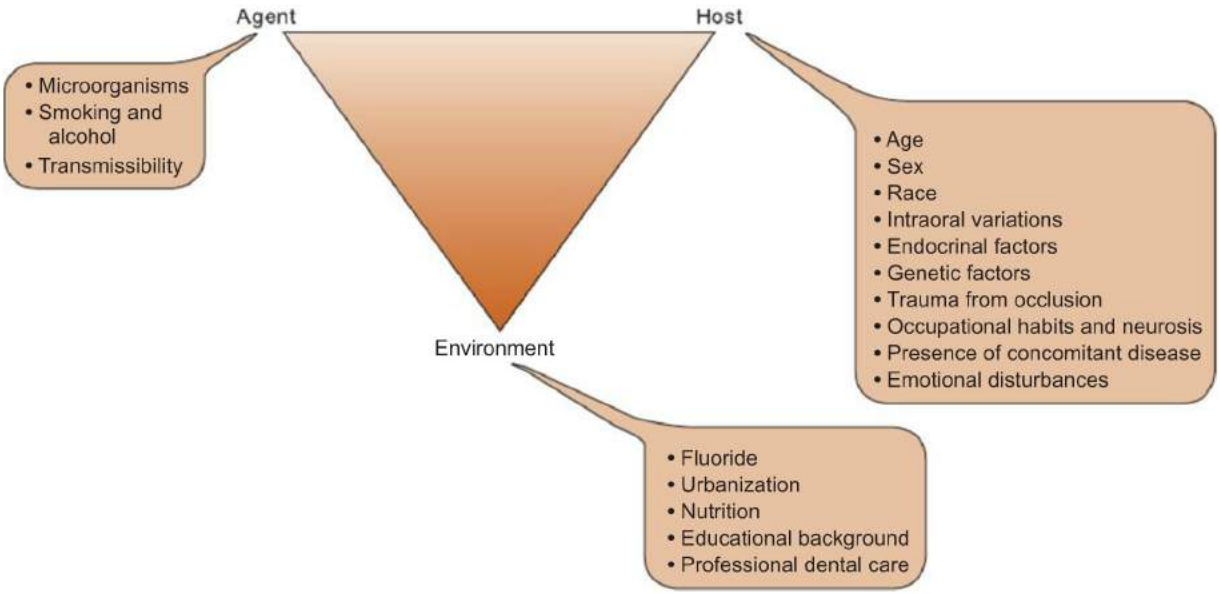


Figure 12.3 Periodontal disease: epidemiologic factors.

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periodontitis, the periodontal disease can have an effect on blood glucose levels in diabetics.

In general, periodontal disease in diabetics results in:

- Loss of attachment and bone at a faster rate
- Rate of advanced periodontal destruction which is at least three times higher
- Promotes osteopenia in bone
- Poor glycemic control
- Making diabetes difficult to manage.

Genetic factors. In patients with acatalasia, hypophosphataemia or cyclic neutropenia, the prevalence of periodontal disease is more. But these are rare and do not represent common periodontal disease. A greater discordance and intrapair variation among fraternal twins suggests some genetic relationship in subgingival calculus formation and prevalence of periodontal disease.

Trauma from occlusion. "Plunger cusps" are long sharp cusps that interlock with similar cusps in the opposite arch which apply severe torque upon lateral excursion of mandible leading to tooth mobility and alveolar resorption. Improper contact points and imperfectly contoured proximal restorations lead to food impaction in interproximal embrasure resulting in chronic gingivitis and destructive periodontal disease. Disuse leads to supraeruption and loss of alveolar support, and increased periodontal disease.

Occupational habits and neuroses. Occupational habits like holding nails in the mouth among carpenters and upholsteres, thread biting among tailors and pressure on reed or mouthpiece among players of woodwind and other musical instruments are predisposing factors for periodontal disease. Oral habits like bruxism, fingernail biting, pencil biting, mouth breathing, etc. also predispose to periodontal disease. Faulty tooth brushing results in cervical abrasion, gingival trauma and gingival recession and leads to gingivitis. In turn, later it acts as a risk factor for periodontal disease.

Presence of concomitant disease. Systemic conditions like diabetes (more in insulin dependent diabetes mellitus—IDDM), heavy metal poisoning, and HIV infections do not initiate periodontal disease, but act as predisposing or risk factor for periodontal disease. And also it may accentuate where periodontal disease has already started. Gingival enlargement is noted in acute monocytic leukaemic patients due to infiltration of the leukocytes in the gingival tissues.

Emotional disturbance. The prevalence of periodontal disease is seen more commonly among patients with emotional disturbances. Betting and Gupta showed that periodontal disease was more in mental patients regardless of frequency of tooth brushing. This could be due to salivary changes and changes in the intraoral environment.

II. Agent Factors

Bacteria, plaque and calculus. Plaque must be present for bacteria to gain a lasting hold in the periodontal area. Calculus gives plaque a firmer hold defying action of brushing and flossing. While gingivitis related plaque is nonspecific plaque, periodontitis is related to unique bacterial flora specifically gram-negative and anaerobic flora. Chemical and physical hazards like mercury, lead, thallium produce gingivitis and alveolar damage and loosening of teeth.

Smoking and alcohol. Tobacco smoke contains numerous poisonous chemicals which can affect the inflammatory and immune responses. The long-term effect of smoking is that it impairs the blood supply of the periodontal tissues. The suppression of neutrophil cell spreading, chemokinesis, chemotaxis and phagocytosis in smokers contribute to impaired defence.

Hence, healing is delayed in smokers through its effects on the blood supply, revascularisation, the inflammatory response and many aspects of fibroblast function.

Smokers are more likely than nonsmokers to have the following problems:

- More calculus and plaque formation
- Deep pockets between teeth and gums
- Loss of the bone and periodontal tissue supporting teeth.

Alcohol along with smoking results in dehydration of the oral mucous membrane including gingival epithelium. This, in turn, increases the susceptibility of the mucous membrane to the inflammation. Over a period of time that might result in gingival inflammation and periodontitis. Moreover alcohol and smoking have synergistic effect affecting the integrity of the tissues resulting in tissue damage.

Systemic diseases, blood dyscrasias and chemical agents. All these factors contribute in one or other way in decreasing the local resistance of the periodontal tissues and sometimes have a direct impact on periodontium. In the absence of good oral hygiene measures and in the presence of other contributing parameters, these factors influence or accelerate the inflammatory changes resulting in different levels of severity of periodontal disease.

I. Environmental Factors

Harvard university health services study showed that students from China, Japan, Philippines and also from India had more prevalence of severe periodontal disease at an early age compared to US citizens. This may be associated with underdeveloped infrastructure, lack of awareness and knowledge, lack of oral health care facility, poverty, low socioeconomic status and lesser number of dental manpower.

Degree of urbanization. Studies have shown that rural children have higher periodontal index (PI) scores than urban children in general. This could be on account of better education, availability of health care services and increased awareness among urban population.

Nutrition. Patients with vitamin C deficiency (scurvy) show acute periodontal disease and loosening of teeth.

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Niacin deficiency is manifested as severe type of necrotic gingivitis with pseudomembrane formation and sloughing.

Fluoride. A weak tendency was found for periodontal disease in relation to presence of fluoride intraorally. However presence of fluoride decreases the pathogenic microbial colonization, thereby decreasing the chances of development of gingivitis and periodontal disease.

Educational background. Periodontal disease severity is inversely related to educational background. This may be due to more systematic home care and dental maintenance care found among the well-to-do and the educated.

Professional dental care. The incidence and severity of periodontal disease are less among those who seek dental care regularly.

CONCLUSION

Periodontal surveys enable the determination of the prevalence, extent and severity of the periodontal diseases in populations and can generally be conducted in reasonable time frame at relatively moderate cost. The epidemiology of periodontal disease which are population based measurements may include the estimation of type, percentage of the population affected by the disease in terms of prevalence, incidence or occurrence of the disease (future risk). A better understanding of the causal relationship between risk factors and occurrence of disease, epidemiologic studies form the basis of the disciplines of risk assessment and disease control. Dental plaque induced gingivitis and subsequent chronic periodontitis are predominantly prevalent throughout the world. However, only very small percentage (10–20%) of the population seems to get affected from more severe or advanced form of periodontal destruction.

Periodontal disease affects on an average 80–90% of the Indian population. An array of factors affect its initiation, progression and recovery. These factors range from presence of dental plaque to oral hygiene practices, smoking and tobacco use, to as large and outside the domain of public health dentist that is socioeconomic status, etc. Again the periodontal disease is insidious in onset often difficult to diagnose in the early stages and usually takes its toll (tooth loss) later in life. It is a predisposing factor for cardiovascular diseases, diabetes, preterm birth and low birth weight. Of late more and more attention is being paid to the interrelationship and positive association between systemic conditions and various periodontal disease. Certainly a more clearer picture of the disease, its determinants and time trends yield vital data which will be greatly helpful to assess the current scenario and planning for the future preventive programmes at a population level.

REVIEW QUESTIONS

1. Describe the role of host and environmental factors in the epidemiology of periodontal diseases.
2. Discuss the role of nutrition in the aetiology of periodontal diseases.
3. Describe the relationship between diabetes and periodontal effects.
4. Discuss the role of local and systemic factors in the aetiology of periodontal diseases.
5. Write short notes on:
   a. Drug-induced gingivitis and periodontitis
   b. Adverse habits and periodontal diseases
   c. Aetiology of periodontal diseases

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13 Epidemiology of Oral Cancer

Hiremath SS

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INTRODUCTION

Malignant neoplasms in and around the mouth represent the most common potentially lethal disease process with which we, the dental profession, have to deal. Even though cancer of oral cavity and pharynx causes more deaths than all other craniofacial diseases and disorders combined, yet they have not always received adequate attention from medical and dental communities. The fact that the suffering, disfigurement and death are caused by oral cancer underscores the importance of oral cancer as a public health.

Tobacco and alcohol are strongly associated with occurrence of oral cancer making it an important public health issue. Appropriate behaviour modification could probably prevent majority of cases. Furthermore, treatment modalities of this type of cancer are often associated with severe loss of function, disfigurement, depression and reduced quality of life.

The FDI (Federation Dentaire Internationale) recognizes oral cancer as a major public health issue worldwide. Oral cancer remains a highly lethal and disfiguring disease. Hence knowing its magnitude, risk factors, presentation, diagnosis and treatment and prevention has become much more important, especially in countries like India.

GLOBAL SCENARIO OF ORAL CANCER

Cancer is identified as one of the major threats to public health in the developed world and increasingly in the developing world. Cancer is the second most common cause of death in developed countries. World Health Report 2004 describes cancer as accounting for 7.1 million deaths in 2003, and it is estimated the overall number of new cases will rise by 50% in the next 20 years.

Oral cancer shows marked geographic differences in occurrence. The incidence rate of oral cancer, which includes cancer of the oral cavity [International Classification of Diseases (ICD)-10th revision 141-145] and cancer of vermilion border of the lip (ICD-140), varies widely from one country to another, and from region to region within countries. Relative to the occurrence of newly diagnosed cancers of all sites, the overall incidence of oral cancer has remained stable, with absolute numbers only slightly increasing each year.

Oropharyngeal cancer is found to be more common in developing than developed countries. Oral cancer is the eighth most common cancer worldwide, the prevalence of which is particularly high among men. In many countries, incidence rates for oral cancer vary from 1 to 10 cases per 100,000 population among men. In south-central Asia, oral cancer ranks among the three most common types of cancer. In India, the age standardized incidence rate of oral cancer is estimated to be 12.6 per 100,000 population. It is remarkable that sharp increase in the incidence rates of oral/pharyngeal cancers have been reported for several countries and regions such as Denmark, France, Germany, Scotland, central and Eastern Europe and to a lesser extent Australia, Japan, New Zealand and the USA.

Between the 1960s and the present, male patients aged 30 to 39 years presented a nearly fourfold increase in oral cancer incidence. This was not observed among similarly aged females in the USA.

Prevalence of tongue cancer is noted in parts of Europe showing male incidence rates up to 8.0 per 100,000 per annum. As with other forms of oral cancer

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the majority of population-based data for tongue cancer comes from the western world with a paucity of reliable data from the so-called developing countries. Worldwide the most common intraoral site for oral cancer is tongue and in a number of countries it is a serious public health problem associated with significant morbidity and mortality. The incidence of tongue cancer appears to be stable or falling in some regions of the world, while in other areas it is rising, particularly among younger people.

While oral cancer is virtually unknown in parts of Asia, high male lip cancer rates are reported for regions of North America (12.7 per 100,000 per annum), Europe (12.0 per 100,000 per annum) and Oceania (13.5 per 100,000 per annum).

During the period 1986 to 2000, among males, a statistically significant decreasing trend in the overall age-adjusted incidence rates was observed, with a yearly decrease of 1.70%. This decrease was significant for men above the age of 40, but the level remained stable for young adult men below the age of 40. In females, the overall decreasing trend in the age-adjusted incidence rates of oral cancers was not significant, except in the age group 40–59 where a significant decline was observed. One out of every 57 men and 1 out of every 95 women will contract any oral cancer at some time in their whole life according to probability estimates. This probability of occurrence amounts to 97% of the chance after he or she completes the age of 40.

The combined effect of the ageing of populations, and the high or increasing levels of prevalence of cancer risk factors has resulted in the cancer epidemic in developed countries, and increasingly in developing countries. Tobacco, unhealthy diet, physical inactivity and infections are known to be the cause for an estimated 43% of cancer deaths worldwide. About 90% of cancers in the oral cavity are known to be due to tobacco use and excessive alcohol consumption. The oral cancer risk increases when tobacco is used along with alcohol or areca nut. The International Agency for Research on Cancer has confirmed the evidence recently that smokeless tobacco causes oral cancer.

According to WHO (1984) in Bangladesh, India, Pakistan and Sri Lanka oral cancer is the most common cancer and accounts for about one-third of all cancers. More than 100,000 new cases occur every year in south and south-east Asia, with poor prospects of survival (Table 13.1).

Table 13.1 Incidence of oral cancer in selected cities

	Male	Female
Bombay, India	16.7	10.6
Pune, India	18.6	7.4
Singapore (Indian population)	14.2	3.4
New York state (excluding New York city), USA	8.6	2.4
Germany	6.0	1.4

SPECTRUM OF ORAL CANCER IN INDIA

India stands with one of the highest incidences of oral cancer in the world. The habit of betel quid chewing incorporating tobacco has long been linked with the high incidence of oral cancer and oral pre-cancerous lesions in India. In India oral cancer ranks number one among men and number three among women and constitutes 12% of all cancers in men and 8% of all cancers among women. Oral cancer is a cause of major health problem in India. With an annual incidence rate of 64,460 in India, it is estimated that among the 400 million individuals aged 15 years and over, 47% use tobacco in one form or the other. However, total number of cases at any given time will be 2.5 to 3 times higher than this number. It is unfortunate that so far in India no proper epidemiological data on this disease is available. Information currently available is mostly from national cancer registry project on the basis of crude incidence rate available from three metropolitan cities.

Oral cancer presents a major health problem in India as its prevalence ranges from 15 to 70% of all cancers diagnosed. It is found that an estimate of one and half million cases of cancer in the country at any given time with about half a million new cases being added every year. Out of these one-third of the cases are that of oral cancer, which amounts to 5 lakh cases of oral cancer at any given time. Such a high incidence in the Indian population merits in-depth probing of various aetiological and contributory factors so that effective preventive measures could be identified and instituted.

EPIDEMIOLOGICAL STUDIES

Gupta et al conducted a systematic review of oral cancer registries in India in 2013 to enumerate the present epidemiological picture of oral cancer in India. According to the review Oral cancer, with ICD-10 codes ranging C01–C06, ranks amongst the three most common cancers in India. In some areas it accounts for almost 40% of total cancer deaths. The systematic review shows estimated incidences and mortality in men and women of all ages in India. In India approximately 70,000 new cases and more than 48,000 oral cancer-related deaths occur yearly. In most regions of India, oral cancer is the fourth most common in women whereas second most common malignancy diagnosed in men, accounting for up to 20% of cancers. Over 100,000 cases of oral cancer are currently recorded on cancer registers across India.

The overall incidence as high as 19 per 100,000 per annum has been derived from Indian databases. The National Cancer Registry Programme (NCRP) depicts that, Bhopal district has the highest age adjusted incidence rate (AAR) in the world for cancers of both the tongue (ICD-10 codes: C01, C02) (10.9 per 100,000) and mouth (ICD-10 codes: C03–C06) (9.6 per 100,000) among males. Among females, Bhopal has the second highest AAR (7.2 per 100,000) for oral cancer.

Raghavendra Byakodi et al conducted a study in 2012 in Sangli, Maharashtra and found that the prevalence of oral cancer was 1.12%. The findings in the study revealed a high prevalence of oral cancer and a rampant misuse of variety of addictive substances in the community.

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Coelho K.R conducted a systematic review in 2012 on oral cancer prevalence in India. The study found out that oral cancer was a major problem in the Indian subcontinent where it ranks among the top three types of cancer in the country. Age-adjusted rates of oral cancer in India was high, that is, 20 per 100,000 population which accounts for over 30% of all cancers in the country. Age-adjusted incidence of oral cancer was highly variable in India. The population-based cancer registry data, as well as the literature reviewed in search demonstrate the nationwide incidence can be as high as 20 per 100,000 population, which varied considerably based on study designs, sampling methodology and case ascertainment, as well as by age, gender and location. Variations in age-specific incidence rates also increased with age, which drops at the age of 70, a trend which is consistent in multiple studies.

AGE DISTRIBUTION

Although the incidence of oral cancer increases with age, the pattern differs markedly in different countries and with different risk factors. Ninety-eight percent of cases in the West are in patients over 40 years of age; whereas in the high prevalence areas due to heavy abuse of various forms of smokeless tobacco like south-east Asia including India, parts of South America (e.g. Brazil), the Western Pacific, France and Eastern Europe, many cases occur prior to the age of 35 years. During the previous two decades, in many western countries there has been an alarming rise in the incidence of such neoplasms among young men, a trend that seems to be continuing.

The observation that oral cancer generally occurs with advancing age indicates that over the time certain sequenced alterations in the biochemical/biophysical processes (nuclear, enzymatic, metabolic, immunologic) of ageing cells with a particular genetic predisposition undergo and accumulate mutations, resulting in carcinogenic transformation.

More than 50% of all cancers occur in persons over the age of 65 years and approximately 96% of oral cancer is diagnosed in persons older than 40 years. The average age at the time of diagnosis of oral cancer is 63 years. Recently however, evidence has emerged indicating that oral cancers are occurring more frequently in younger persons aged less than 40 years.

GENDER DISTRIBUTION

Men are affected almost twice as often as women in industrialized countries, probably due to their higher indulgence in risk factors such as alcohol and tobacco consumption for intraoral cancer and sunlight for lip cancer. However, the incidence of cancer of buccal mucosa, gingiva and other parts of oral mucosa for women is greater than or equal to that for men in high prevalence areas such as India, where chewing and smoking are also common among women. Men and women are also almost equally affected in some of the ethnic groups in Singapore, Denmark and Hawaii.

The ratio of males to females diagnosed with oral cancer is 2:1 over lifetime although the ratio comes closer to 1:1 with advancing age.

ETHNIC BASIS

Ethnicity strongly influences prevalence due to social and cultural practices. Such ethnic practices represent risk factors and their continuation by emigrants from high prevalence regions to other parts of the world results in relatively high cancer incidence in immigrant communities. Other studies show that black Americans, for example experience significantly more pharyngeal cancers than their white counterparts.

SITE DISTRIBUTION

Lip cancer is most common in fair skinned races, specifically in men who work out of doors and in rural areas. The site distribution of intraoral cancer in western countries most commonly affects the lateral borders of the tongue and the floor of the mouth, followed by the buccal mucosa, mandibular alveolus, retromolar region and soft palate. Comparatively hard palate and dorsum of the tongue are the lowest risk sites. In the high-risk areas of South Asia, the most prone sites are the buccal, retromolar and commissural mucosae.

TRENDS

In urban parts of high incidence regions, e.g. in Mumbai, there may be a fall in oral cancer which could be attributed to change from *pan* (betel) chewing and *bidi* smoking to the smoking of manufactured cigarettes.

Marked increase in alcohol consumption, perhaps combined with increased use of smokeless tobacco products has contributed to the rising trend of tongue cancer in young men in western countries, especially in the USA and the Nordic countries.

According to 15-year-prospective study carried out by Sunny et al in males, the overall age-adjusted incidence rates showed a statistically significant decreasing trend during the period 1986 to 2000, with a yearly decrease of 1.70%. This decrease was significant for men above the age of 40, but for young adult men below the age of 40, there was no significant decrease, the level being stable. In females, the overall decreasing trend in the age-adjusted incidence rates of oral cancers was not significant, but in the age group of 40–59, a significant decline was observed.

AETIOLOGY AND RISK FACTORS

The aetiology of oral cancer is almost certainly multifactorial. It involves many alterations in host immunity and metabolism, angiogenesis, and exposure to chronic inflammation in a genetically susceptible individual. The carcinogenic changes may be influenced by oncogenes, viruses, irradiation, drugs (tobacco and alcohol), hormones, nutrients or physical irritants.

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Established Risk Factors for Development of Oral Cancer

- Smoking tobacco
- Chewing tobacco/oral snuff
- Chewing betel quid (paan), especially if tobacco is included
- Heavy consumption of alcohol
- The presence of a potentially malignant oral lesion or condition.

Other Contributory or Predisposing Factors

- Dietary deficiencies, particularly vitamins A, C, E and iron
- Familial or genetic predisposition
- Viral infections, particularly certain types of human papilloma viruses
- Sunlight (for lip cancer)
- *Candida albicans* infection
- Immune deficiency diseases or immune suppression
- Environmental exposure to the burning fossil fuels
- Dental trauma or chronic oral sepsis.

Most cases of oral cancer can be attributed to certain lifestyle risk factors and are thus preventable.

In a minority of cases, particularly amongst younger patients, these risk factors are absent, producing a challenge for research into their aetiology.

A wide variety of risk factors have been described in oral cancer aetiology. The use of tobacco, alcohol, irradiation, oral sepsis, poor diet and nutrition, poor oral hygiene, chronic irritation from a sharp tooth or broken restoration, syphilis, genetic predisposition, altered immunity, etc have been implicated.

Tobacco. There is excellent evidence from many sources around the world that use of tobacco is by far the most important risk factor for oral cancer. Prevalence of tobacco use has declined in some high-income countries, but continues to increase in low- and middle-income countries, especially among young people and women. According to WHO (1984) the most important cause of oral cancer in developing countries including India, has been attributed to the chewing of tobacco, often in association with areca nut in the form of betel quids or pan.

Tobacco use can be broadly classified as smoking and smokeless forms (Fig. 13.1).

Smoking tobacco

- ***Manufactured cigarettes:*** Cigarettes are the predominant form of tobacco used worldwide which consist of shredded or reconstituted tobacco processed with hundreds of chemicals.
- ***Bidis:*** These consist of a small amount of tobacco, hand-wrapped in dried temburni leaf and tied with string. *Bidis* are found throughout south-east Asia, and are India's most used type of tobacco.
- ***Cigars:*** These are made of air-cured and fermented tobacco with a tobacco wrapper, and come in many shapes and sizes, from cigarette sized cigarillos, double coronas, cheroots, stumpen, chuttas and dhumtis. In reverse chutta and dhumti smoking, the ignited end of the cigar is placed inside the mouth. Use of this form is commonly seen in coastal areas.
- ***Pipes:*** These are made of briar, slate, clay or other substance—tobacco is placed in the bowl and inhaled through the stem, sometimes through water. The water pipe, also known as *shisha* or hubbly bubbly, is commonly used in north Africa, the Mediterranean region and parts of Asia. In south-east Asia clay pipes known as *suipa*, *chilum* and *hookli* are widely used.
- ***Kreteks:*** These are clove-flavoured cigarettes. They are widely smoked in Indonesia.
- ***Sticks:*** These are made from sun-cured tobacco known as brus and wrapped in cigarette paper.



Figure 13.1 Smoking and smokeless tobacco.

Smokeless tobacco

The two types of smokeless tobacco (ST) are chewing tobacco and snuff. Types of chewing tobacco are:

- ***Paan:*** Most common form of tobacco dating back to more than 2000 years. *Paan* means betel leaf usually derived from piper betel wine. Quid contains areca nut which may be used raw, baked or boiled lime obtained from limestone or seashells, and according to local customs may include aniseed, catechu, cardamom, cinnamon, coconut, cloves, sugar and tobacco (Fig. 13.2).
- ***Mainpuri tobacco:*** Includes tobacco, slaked lime, finely cut areca nut, camphor and cloves. About 7% of people in UP use this. A high prevalence or oral cancer and leukoplakia among persons who use Mainpuri tobacco has been found.



Figure 13.2 Paan with tobacco.

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- ***Mawa:*** A preparation containing thin shavings of areca nut with the addition of some tobacco and slaked lime. Usually sold wrapped in cellophane papers and tied in shape of small ball. Before consumption, the packet is rubbed vigorously to mix the contents; most commonly seen in Gujarat.
- ***Mishri/masheri:*** Prepared by roasting tobacco on a hot metal plate until it is uniformly black. It is then powdered and used with catechu. Catechu is a residual extract obtained by soaking hard wood of the tree *Acacia catechu* in boiling water; used in Maharashtra especially by women.
- ***Zarda:*** Tobacco leaf boiled in water along with lime and spices until evaporation. The residual tobacco is then dried and coloured with dyes.
- ***Gurakhu:*** It is paste of powdered tobacco, molasses and other ingredients primarily used to clean teeth. It is mostly used in Bihar.
- ***Gutkha:*** It is prepared by crushing the betel nut, tobacco and adding some sweet or savory flavour. *Gutkha* has originated from India but due to its sweetness, flavours and nuts, it has been taken up by young people in particular outside India.

The snuff consists of two varieties:

- Dry snuff: It is powdered tobacco that is inhaled through the nose or taken by mouth. Once widespread, its use is now in decline.
- Moist snuff: A small amount of ground tobacco is held in the mouth between the cheek and gum. Other products include *khaini, shammaah* and *nass* or *naswa.*

Areca nut alone can be carcinogenic and appears to be responsible for the high incidence of oral cancer in Melanesia, where it is often taken along with smoking. Areca nut is the major cause of the distressing condition. Oral submucous fibrosis, which has a high rate of malignant transformation (up to 6% over 10–15 years). The risk of oral cancer increases with amount of tobacco consumed per day and the number of years of consumption.

The case against tobacco is further strengthened by the findings that the cancers almost always occur on the side of the mouth where the tobacco quid was kept, and the probability of developing cancer is directly related with the duration and intensity of use.

Alcohol. The second most important risk factor for oral cancer is excessive consumption of alcohol. Alcohol acts synergistically with tobacco so that the combined damage is more than multiplied. There has been a doubling of the alcohol consumption per head of the population in the last few decades in many western countries, and this is thought to be the main reason for their rising incidence of oral cancer.

Diet. Next most powerful factor is probably the diet, since a healthy diet protects. Potentially mutagenic radicals from damaged cells are scavenged by antioxidant vitamins A, C and E. Trace elements like zinc and selenium and adequate supply and absorption of iron to prevent anaemia (with consequent mucosal atrophy) are also important.

Other Factors

- A patient is at increased risk of developing oral cancer if found present with potentially malignant oral lesions and conditions such as white plaques, red plaques and submucous fibrosis.
- Infections of oral mucosa may also be important as it has long been known that white patches harbouring yeasts or hyphae of the fungus *Candida albicans* carry an increased risk of progressing to malignancy.
- Possibility of a role for human papilloma viruses (HPV) is currently of great interest. The high oncogenic potential HPV types 16 and 18 are known to be important in cancer of the uterine cervix and are increasingly found in oral lesions.Therefore screening for their presence may become useful component of early detection of patients and lesions at risk of malignant transformation.
- Recent family studies have shown that first degree relatives of patients with oral cancer may have up to three or four times the risk of developing an oral cancer themselves—perhaps as much as 15 times the risk of getting a cancer somewhere in the upper aerodigestive tract of lungs. Such effects may result largely from shared environment—including passive smoking— but also point to a small effect of genetic predisposition.
- Poor dental health such as sharp, broken teeth, dental sepsis or trauma from ill-fitting dentures predisposes a person at slightly increased risk for developing oral cancer. However, these are often patients with poor diet, poor self-image, and folk who lead generally unhealthy lifestyles. Sorting out the really important causes of cancer in these individuals may be difficult.
- Immunosuppression regimes increase the risk of ultraviolet light-induced cancer of skin and lip (such as with renal or other organ transplantation). There appears to be no increased risk of intraoral squamous cell carcinoma in those with HIV disease. There is as yet no evidence that the characteristic so-called oral hairy leukoplakia in HIV/AIDS patients has malignant potential.

CLASSIFICATION OF ORAL CANCER

Table 13.2 depicts classification of oral cancers.

Types of Oral Cancer

- **Lip:** Carcinoma of lip most commonly occurs in elderly men. Lower lip is commonly involved than upper lip (Fig. 13.3).
- **Tongue:** Constitutes 25–50% of all intraoral cancers. More common among men (Fig. 13.4).
- **Gingiva:** Constitutes an important group of neoplasms as diagnosis is always delayed. Chronic irritation has been speculated as the cause (Fig. 13.5).
- **Floor of mouth:** Constitutes 15% of all intraoral cancers. Pipe or cigar smoking is considered as aetiologic factor (Fig. 13.6).
- **Buccal mucosa:** More common in men. Mostly seen in habitual quid chewers (Fig. 13.7).
- **Palate:** Not a very common lesion. Studies have reported around 9% incidence. Commonly seen with reverse smoking (Fig. 13.8).

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Table 13.2 Classification of oral cancer

Benign tumours of epithelial origin
Papilloma
Squamous acanthoma
Keratoacanthoma
Pigmented cellular naevus

Premalignant lesions of epithelial origin
Leukoplakia
Leukodema
Erythroplakia
Oral submucous fibrosis
Lichen planus

Malignant tumours of epithelial tissue origin
Basal cell carcinoma
Epidermoid carcinoma
Spindle cell carcinoma
Adenoid squamous cell carcinoma
Lymphoepithelioma and transitional carcinoma
Malignant melanoma

Benign tumours of connective tissue origin
Fibroma
Giant cell fibroma
Peripheral ossifying fibroma
Central ossifying fibroma of bone
Peripheral giant cell granuloma
Central giant cell granuloma
Aneurysmal bone cyst
Verruciform xanthoma
Haemangioma
Hereditary haemorrhagic telangiectacia
Encephalotrigeminal angiomatosis
Nasopharyngeal angiofibroma
Lymphangioma
Myxoma
Chondroma
Benign chondroblastoma
Chondromixoid fibroma
Osteoma
Osteoid osteoma
Benign osteoblastoma
Torus palatinus
Torus mandibularis
Multiple exostoses

Malignant tumours of connective tissue origin
Fibrosarcoma
Locally aggressive fibrous lesions
Synovial sarcoma
Liposarcoma
Haemangioendothelioma
Haemangiopericytoma
Multiple idiopathic haemorrhagic sarcoma of Kaposi
Ewing's sarcoma
Chondrosarcoma
Osteosarcoma
Malignant lymphoma
Non-Hodgkins lymphoma
Primary lymphoma of bone
Burkitt's lymphoma
Hodgkin's disease
Multiple myeloma
Plasmacytoma



Figure 13.3 Carcinoma of lower lip.



Figure 13.4 Carcinoma of tongue (right ventral side).



Figure 13.5 Carcinoma of gingiva.

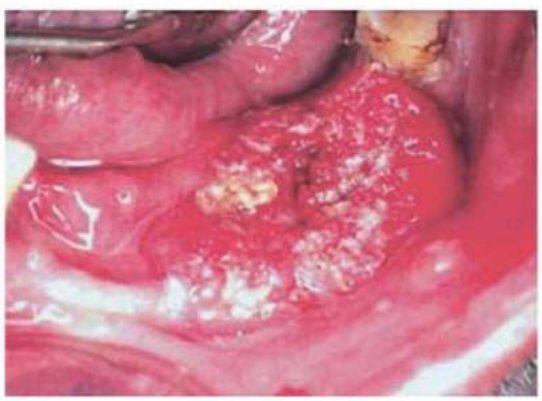


Figure 13.6 Carcinoma of floor of mouth.

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Figure 13.7 Carcinoma of buccal mucosa.



Figure 13.8 Carcinoma of palate.

CLINICAL PRESENTATIONS OF CANCER OF ORAL MUCOSA

More than 90% of oral cancers are squamous cell carcinomas. The other 10% are salivary gland tumours, lymphoma, sarcoma and others.

Many oral lesions are fortunately benign that may clinically present as ill-defined, variably appearing, controversial and poorly understood lesions, but may present changes that can easily be confused with malignancy. Conversely, an early malignancy may quite often be mistaken for a benign lesion. Some lesions are considered premalignant because they are statistically correlated with subsequent associated cancerous changes. A considerable amount of clinical uncertainty is involved in the early detection of malignancy as many of these lesions may not always remain benign. However, following clinical signs should be regarded with great suspicion.

- **Ulcer:** Any ulcer of the mucosa, which fails to heal within two weeks, with appropriate therapy and for which no other diagnosis, for example major aphthous ulcer, can be established.
- **Induration** of any mucosal lesion.
- **Fungation/growth** of the tissues to produce elevated, cauliflower surface or lump.
- **Fixation** of the mucosa to underlying tissues, with loss of normal mobility.
- **Failure** to heal of a tooth socket or any other wound.
- **Tooth mobility** with no apparent cause.
- **Pain/paraesthesia** with no apparent cause.
- **Dysphagia** for which no other diagnosis can be made.
- **White/red patches** of the mucosa are commonly considered as potentially malignant lesions, but occasionally they may be the clinical presentation of a malignancy.

Lymphadenopathy: Every dentist as part of clinical examination should palpate the lymph nodes of the head and neck. Enlargement of one or more nodes may be a response to infection of an ulcerated tumour, and may indicate metastasis, especially if multiple, hard, matted together or fixed to skin or deeper structures. The precise group of nodes likely to be affected depends on the location of the primary cancer. Submandibular, then upper, middle and lower deep cervical nodes are most commonly involved with intraoral cancerous lesions. The more node groups involved and the lower the level in the neck, the more serious is the prognosis for the patient, as this indicates more extensive spread.

DIAGNOSIS OF ORAL CANCER

Complete medical history and physical examination should be complimented with diagnostic procedures for oral cancer which may include the following:

- **Biopsy:** To determine if cancer or other abnormal cells are present, biopsy is a procedure of choice in which tissue samples are removed with a needle or during surgery from the body for examination under a microscope;.
- **Exfoliative cytology:** This is a histological examination of surface cells scraped from a suspected lesion with a tongue blade. The accuracy of this procedure is highly variable, and the procedure is especially weak in detecting premalignant lesions. Both false-positive and false-negative readings are common. The variety of clinical and histological appearances found in oral cancer casts doubt on the validity of diagnoses made from microscopic examination of surface cells alone.
- **Toluidine blue staining:** This has been used as an extra tool for the identification of patients suspected with oral cancer lesions, especially in high-risk individuals. The sensitivity and specificity of toluidine blue as test for early detection of "oral cancer" is adequate. Most studies show that only 50% or less of dysplasias are detected by this technique, although 100% of cancers may stain. One percent of toluidine blue mouthwash has been promoted by FDI in screening for oral mucosal malignancy and potentially malignant lesions in high-risk individuals and population groups, to be confirmed by a biopsy examination.
- **Computed tomography scan** (also called CT or CAT scan)**:** This is a diagnostic imaging procedure that uses a combination of radiography and computer technology to produce cross-sectional images (often called slices), both horizontally and vertically of the body. A CT scan shows detailed images of any part of the body, including the bones, muscles, fat and organs. CT scans are more detailed than general radiographs.
- **Ultrasound:** High-frequency sound waves are used to create an image of the internal organs in this diagnostic technique.
- **Magnetic resonance imaging (MRI):** MRI is a diagnostic procedure that uses a combination of large magnets, radiofrequencies and a computer to produce detailed images of organs and structures within the body.

Once a diagnosis is made, the cancer will be staged (to determine the extent of the disease) before a treatment plan is established (Tables 13.3, 13.4).

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Table 13.3 TNM staging of cancer (primary tumour, cervical lymph node metastasis and distant metastasis)

Primary tumour (T)
TX: Primary tumour cannot be assessed
T0: No evidence of primary tumour
Tis: Carcinoma in situ
T1: Tumour ≤ 2 cm in greatest dimension
T2: Tumour > 2 cm but ≤ 4 cm in greatest dimension
T3: Tumour > 4 cm in greatest dimension
T4: (lip) Tumour invades through cortical bone, inferior alveolar nerve, floor of mouth, or skin of face, i.e. chin or nose
T4a: (oral cavity) Tumour invades adjacent structures (e.g. through cortical bone, into deep [extrinsic] muscle of tongue [genioglossus, hyoglossus, palatoglossus and styloglossus], maxillary sinus and skin of face)
T4b: Tumour invades masticator space, pterygoid plates or skull base and/or encases internal carotid artery

Regional lymph nodes (N)
NX: Regional lymph nodes cannot be assessed
N0: No regional lymph node metastasis
N1: Metastasis in a single ipsilateral lymph node, ≤ 3 cm in greatest dimension
N2: Metastasis in a single ipsilateral lymph node, > 3 cm but ≤ 6 cm in greatest dimension; or in multiple ipsilateral lymph nodes, ≤ 6 cm in greatest dimension or in bilateral or contralateral lymph nodes, ≤ 6 cm in greatest dimension
- N2a: Metastasis in a single ipsilateral lymph node > 3 cm but ≤ 6 cm in dimension
- N2b: Metastasis in multiple ipsilateral lymph nodes, ≤ 6 cm in greatest dimension
- N2c: Metastasis in bilateral or contralateral lymph nodes, ≤ 6 cm in greatest dimension

N3: Metastasis in a lymph node > 6 cm in greatest dimension

Distant metastasis (M)
MX: Distant metastasis cannot be assessed
M0: No distant metastasis
M1: Distant metastasis

Table 13.4 American joint committee on cancer (AJCC) stage groupings

Stage 0	Tis, N0, M0
Stage I	T1, N0, M0
Stage II	T2, N0, M0
Stage III	T3, N0, M0 T1, N1, M0 T2, N1, M0 T3, N1, M0
Stage IVA	4a, N0, M0 T4a, N1, M0 T1, N2, M0 T2, N2, M0 T3, N2, M0 T4a, N2, M0
Stage IVB	Any T, N3, M0 T4b, any N, M0
Stage IVC	Any T, any N, M1

TREATMENT OF ORAL CANCER

The treatment of lip and oral cavity cancer may be by surgery alone, radiation therapy alone or a combination of these depending on the site and extent of the primary tumor and the status of the lymph nodes.

PREVENTION AND CONTROL OF ORAL CANCER

Primary Prevention

Health education. With the help of various communication media like television, radio, newspapers, films, posters, folk dramas and lecture demonstration series, health education should be imparted to masses. Health education can encompass the following aspects:

a. Programmes to educate adolescents including school children against tobacco use with the aim of preventing them from acquiring any form of tobacco taking habits.
b. Educational programmes for current tobacco users including their family members to stop or decrease their use of tobacco.
c. People should be made aware of self-examination by educating them about warning signals of oral cancer and report at the earliest for necessary investigation and required treatment.
d. The importance of regular oral check-up by a qualified dental surgeon should be emphasized.
e. Importance of good oral hygiene and role of diet and nutrition in oral cancer prevention should be emphasized.
f. Health education should stress the importance of various sources of protein, vitamins, minerals and trace elements, balanced diet, as well as the right method of cooking and preserving the nutrient of food items as these are not well understood by people.

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Secondary Prevention

- Screening
- Early detection and referral.

Primary health care givers should take up community-level early detection of oral cancer programmes to detect precancerous lesions and to educate those with such lesions against tobacco use.

Screening for Oral Cancer: Key to Early Detection at Community Level

Owing to the high incidence of oral cancer every year especially in south-east Asian countries, including India, and the high degree of morbidity and mortality resulting from with or without treatment of oral cancer, many of which are diagnosed, detection of oral cancer in its earliest stages assumes prime importance. It is the key to increase the survival rates of patients with oral cancer with an improved quality of life.

- A sore that bleeds easily or does not heal
- A colour change of the oral tissue
- A lump thickening, rough spot, crust, or small eroded area
- Pain, tenderness or numbness anywhere in the mouth or on the lips.

Dentists can perform a brush biopsy which is a quick, painless test, in which tissue specimens, taken from the mouth by a brush, undergo computer analysis to determine the presence of precancerous or cancerous cells. This test may also help determine the need for a surgical biopsy or other follow-up.

Adults can perform self-examinations, hence taking an active role in the early detection of oral cancer. This can be performed by looking into a mirror and checking the lips, gums, cheek lining and tongue as well as the throat, floor and roof of the mouth for signs of the disease.

Contact the nearby dentist immediately for a professional examination, if any of these signs or symptoms is noticed. Survival rate for oral cancer is high when diagnosed early. In its earliest most treatable stages, oral cancer generally causes no pain or discomfort and cannot always be diagnosed visually which may be a major problem in detecting early.

Knowing the risk factors and taking steps to prevent potentially cancerous lesions from developing can contribute greatly towards limiting the influence of oral cancer that could have on the people's life. People should be encouraged and motivated to collaborate with that of the health professionals, especially of dentists in maintaining a good oral health for life.

Screening Guidelines for Low-risk Individuals

The two most common methods of screening for oral cancer are visual inspection and cytology, neither of which has been shown to reduce mortality from this disease. It has been stated that, although screening can lead to early detection, there is insufficient evidence to recommend for or against routine screening for oral cancer.

American Cancer Society has no official guidelines for oral cancer detection. However, it encourages primary care physicians to perform an examination of the whole mouth as part of a routine cancer-related check-up.

Screening Guidelines for High-risk Individuals

United States Public Service Task Force recommends a regular oral health examination in patients at high risk of oral cancer. It also suggests annual examinations by a physician or a dentist to screen for oral cancer in patients older than 60 years with risk factors such as smoking and heavy drinking. Large, foreign studies of oral cancer screening, which show that primary care physicians can detect pre-malignant lesions and early cancer in high-risk patients, support these recommendations. With the exception of the Kerala study (cluster randomized controlled setting, started in 2000), no controlled trials have been conducted recently to demonstrate the effect of oral cancer screening on mortality or on interim outcomes (e.g. reducing the incidence on invasive disease). An update of these trial reports show that after completing two rounds of screening oral cancer mortality rates were similar in the screened and unscreened study groups. No other literature on randomized controlled trials, meta-analyses, or systematic reviews were found on the harms of screening or the benefits of early treatment.

Tertiary Prevention

- **Surgery:** Surgery is generally indicated as a primary treatment or combined with radiotherapy for tumours involving bone tumours that lack sensitivity to radiation, recurrent tumours, etc. Surgery may involve mandibulectomy resection and radical neck dissection may be conducted as a part of an en bloc resection of tumours with lymph node metastasis.
- **Radiotherapy:** Radiotherapy is the treatment of choice which is main modality for treating malignant lesions. The general principle of radiotherapy is to deliver uniform dose of radiation to all parts of the tumour bearing areas (tumour bearing zone). The lower dose is delivered outside the tumour zone. The treatment dose of radiotherapy is expressed in terms of rad **(It is the absorbed radiation dose of ionizing radiation and is equal to 100 ergs/g of any absorbent, produces damaging effects on tissue).**

The unit dose of radiation, the grey (Gy) measures the energy absorbed in matter as a result of exposure to radiation.

1Gy = 100 rad

Bone marrow, breast, thyroid, developing ameloblast cells are more sensitive to radiation.

Intraoral therapy doses vary from 5000 rad, 15 fractions/3 weeks to 5500 rad 20 fractions/4 weeks depending upon the size of the lesion. Their spacing of radiation dose varies with type and energy of the radiation.

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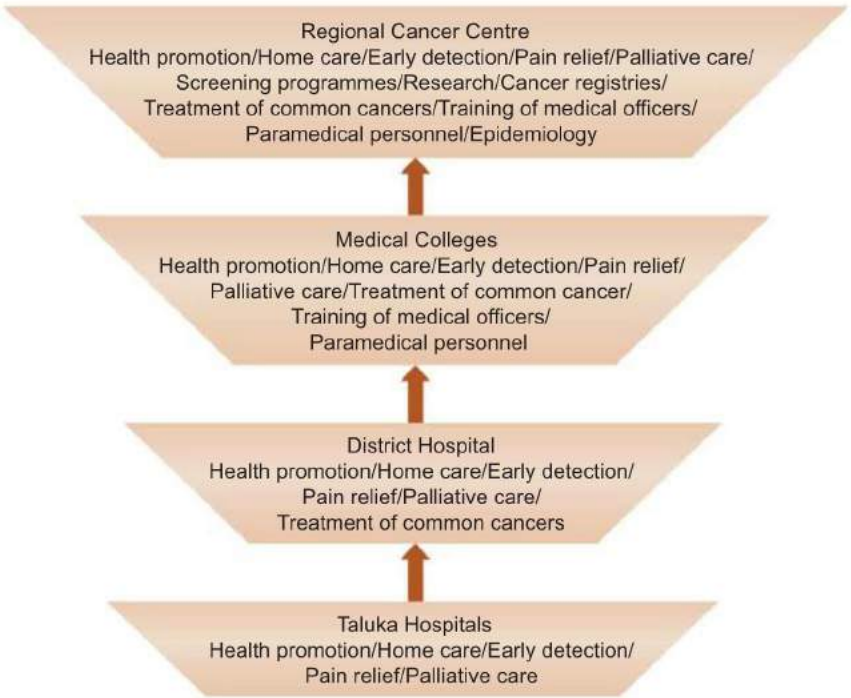


Figure 13.9 Diagram depicting facilities and services to be made available at different levels of health care delivery in India.

Four radiotherapy techniques are there:

1. External radiation
2. Perioral radiation
3. Interstitial radiation
4. Surface radiation.

- **Chemotherapy:** Chemotherapy is the use of chemical substances to treat disease. In its modern day use, it refers primarily to cytotoxic drugs used to treat cancer. The era of chemotherapy began in the 1940s with the first uses of nitrogen mustard and folic acid inhibitors.

This is considered in patients with advanced tumours or recurrent diseases in whom surgery or radiation is unlikely to result in cure. Chemotherapy is used as induction therapy prior to local therapies, as simultaneous chemoradiotherapy and as adjuvant chemotherapy after local treatment.

The targeted-therapy revolution has arrived, but the principles and limitations of chemotherapy discovered by the early researchers still apply (Fig. 13.9).

To select the most appropriate drug it is necessary to know the range of activity against disease for the various drugs and to use those which have the minimum toxicities in relation to the particular patients (Table 13.5).

1. Each drug in the combination should have been demonstrated to have some activity on its own against the tumour
2. Drugs with similar mechanism of action should not be combined
3. As far as possible major dose limiting toxicity of each drug should differ from that of the other components in the combination.
4. There should be no known adverse interaction between the drugs.

Table 13.5 Anticancer drugs: Classification

Antimetabolites
Methotrexate
6-Mercaptopurine
6-Thioguanine
5-Fluorouracil
Cytosine arabinose

Alkylating agent
Nitrogen mustard
Cyclophosphamide
Chlorambucil
Busulphan
Melphalan
Isophosphamide

Plant alkaloids
Vinblastin
Vincristine
Vindesine
VP-16-213 VM26

Antibiotics
Doxorubicin—choice of drug
Daunorubicin
Actinomycin D
Bleomycin
Mitomycin C

Nitrosoureas
BCNU
CCNU
Streptomycin

Miscellaneous synthetic compounds
DTIC
Cisplatin
Procarbazine
Hexamethylmelamine
Hydroxyurea
Mitoxantrone

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ROLE OF DENTIST IN DETECTING AND PREVENTING ORAL CANCER

Dentists play a vital role in the prevention and early detection of oral cancer. This is primarily due to their familiarity with the structures and health of the oral cavity and its associated tissues, and also because they regularly attend their patients for routine examination.

Since screening and examination are both elements of dental practice routine, these two activities are unquestionably vital ways in which practitioners can help detect individuals with unhealthy lifestyles. The detection of earliest signs of the disease permits the greatest opportunity for successful resolution and preventing progression to advanced lesions. As a profession we must apply ourselves with renewed vigour at all levels of prevention and intervention.

POPULATION-BASED CANCER REGISTRIES: INVISIBLE KEY TO CANCER CONTROL

Two decades ago, International Agency for Research on Cancer came to the conclusion that population-based cancer registries are an essential part of any rational programme of cancer control. However, cancer registries are vulnerable to a range of well-documented problems. Nevertheless, well-resourced registries play a major role in expanding and fulfilling some vital functions.

To monitor the burden of cancer and the trends in the frequency of cancer in the population is the traditional but important function of population-based cancer registry. Planning cancer services essentially should consider projections of cancer frequency along with the assumed trends in risk factors and interventions. Cancer registration data are also used to assess variations in frequency of cancer between and within countries according to age and sex, and sometimes according to ethnic origin, occupation, socioeconomic status and area of residence.

Variations in the frequency of patients with cancer between populations and of migrants gave insights about the causes of cancer. The effect of primary prevention campaigns can be monitored by looking at trends of risk factors, frequency and based on the trends in cancer frequency.

Cancer-screening programmes can be monitored by using cancer registry data by observing proportion of patients detected by screening and shifts in stage distribution. The effectiveness of treatment is best monitored by assessing the survival trends. Based on review of medical records, cancer registries can supply a suitable population sample for more detailed, unbiased studies of cancer care.

An important new role of cancer registries is involvement in genetic counseling, subject to the written informed consent of any living relatives.

Guide for tobacco cessation (quitting)

The 5A method

1. **Ask** about tobacco use at every visit
2. **Advise** nonusers to never use tobacco, advise users to quit
3. **Assess** the patient's readiness to quit
4. **Assist** with quitting
5. **Arrange** for follow-ups

1. **Ask patients about the use of tobacco at every visit**
   - Regarding use of tobacco—current/former/ never
   - Type/form of tobacco
   - Duration
   - Number
   - Frequency
   - Look for oral signs of tobacco use:
     - Stained teeth
     - Foul smelling breath (halitosis)
     - Gum disease
     - Loose teeth
     - Discoloured patches on the mucosa: white, red, dark precancerous lesions.
   - Record tobacco use status.
2. **Advise patients:**
   - Advice for quitting should be clear, strong and personalized
   - Quitting tobacco use is the most important thing you can do to protect your health.
   - Cutting down while you receive dental treatment is not enough
   - Tobacco use is hurting your oral health, your finances and your family's happiness.
   - Encourage nonusers to stay away from tobacco, affirm nonuse of tobacco and advise them to never use tobacco in future.
   - Affirm and congratulate those who have quitted the use tobacco and offer support, if required.
3. **Assess the patient's readiness to quit:** Ask every tobacco user if he or she is willing to quit at this time. If the patient is willing to quit assess the level of dependence. Tobacco users who are heavily dependent on tobacco usually have a harder time quitting than less dependent users.
   - **High level of dependence:** Individuals who use tobacco within 30 minutes of waking up or those who use it 25 or more times per day.
   - **Moderate level of dependence:** Individuals who use tobacco later than 30 minutes after waking up or less than 25 times per day.
   - **Low level of dependence:** Those who neither use tobacco before 30 minutes of waking up nor use it more than 25 times a day

If the patient is only thinking of quitting but not willing to quit it now, then provide a tailored message to increase motivation. If the patient is not prepared to quit shift them to the 5R method.

These patients may respond to a motivational intervention built around the 5 Rs

- Relevance of quitting
- Risks of continuous tobacco usage
- Rewards of quitting
- Roadblocks to quitting, and
- Repetition at each visit

4. **Assist tobacco users to make a quit plan:**
   - Set a firm quit date, ideally within 2 weeks. Get support from family, friends, coworkers.
   - Review past quit attempts—what helped and what led to relapse.

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- Identify reasons for quitting in writing and keep a copy.
- Reduce tobacco use during the 2 weeks before quitting.

Anticipate challenges, particularly during the first few weeks, including nicotine withdrawal symptoms.

- Throw out all tobacco products in his or her possession.
- Avoid places where tobacco is available.
- Encourage other tobacco users around to quit along with him or her.

Advise the patient:

- Total abstinence is essential to quitting—not even a single puff or portion.
- Alcohol intake is strongly associated with relapse.
- Having other tobacco users in the home hinders successful quitting.
- Withdrawal symptoms typically decrease considerably after 1–3 weeks of quitting. Suggest alternatives to tobacco.

Recommend or provide pharmacotherapy for depressed patients and those who have tried to quit several times and failed, pharmacotherapy can be especially helpful.

5. **Arrange for follow-up visits:**
   - **Methods:** Use revisits, telephone contact or assist the patient in arranging an appointment with his or her physician or a trained community health worker.
   - **Timing:** Set a schedule. The first follow-up visit should occur within a week of the quit date, that is why it is important for the patient to set a quit date for few days prior to the revisit date for dental treatment. A second follow-up visit is best within one-month of the quit date. Further follow-up visits are helpful after 3 months, 6 months and 1 year.

During follow-up contact:

- Congratulate the patient on successes even if they are small ones and empathize with difficulties.
- Ask the patient to suggest how he or she can overcome the difficulties.
- Assess pharmacotherapy: Ask the patient about the severity of withdrawal symptoms and about any possible side-effects of medication being taken, such as irritation of the mouth, dry mouth, confusion, abdominal pain, backpain, bodyache, sleep disturbance, dizziness, palpitations.
- Counsel for relapse: If a relapse occurs, encourage a new quit attempt. Tell the patient that relapse is part of the quitting process. Review the circumstances that caused the relapse. Use relapse as a learning experience. Reassess the use of pharmacotheraphy and problems in general.
- Assess the need for intensive counselling: If the patient is interested, expresses the need or has had particular difficulty previously, intensive counselling is advisable. Patients especially needing it would include those who are with heavy tobacco users, alcohol users or depression. People using tobacco for a long duration may suffer from anxiety, restlessness, dysphasia or depressed mood, irritability, low self-esteem and poor coping with stressors; they may also have other addictions. Yet, anyone ready to quit can benefit from intensive counselling for cessation.

Preventive Dentistry

Dentists should introduce their patients to the concept of preventive dentistry and use these visits for tobacco cessation counselling as well. Half-yearly or yearly check-ups can detect dental and oral problems at initial stages and are thus early to treat. This can also help detect oral cancer at an early stage.

Use of Pharmacotherapy

There are two main types of pharmacotherapy for tobacco use cessation:

Nicotine replacement therapies (NRT): These replacements lessen the craving and other withdrawal symptoms and the individual learns to stop the behaviours connected with tobacco use. Eventually, patients need to give up using nicotine replacement.

Antidepressants: These also function as anticraving medications and can be combined with NRTs.

NRTs are commercially available in the following forms:

- Gum
- Patch
- Inhalator
- Sublingual tablet
- Lozenge
- Nasal spray
- Nicotine replacement therapy is an effective aid for tobacco cessation.
- Tobacco users who are motivated to quit but are dependent on nicotine should be given NRT.
- NRT should be prescribed for 6 to 8 weeks, in blocks of up to two 2, contingent on continued abstinence.
- Obtaining nicotine from NRT is considerably safer than smoke and smokeless tobacco.
- NRT is safe in stable cardiac disease, but caution is needed for unstable, acute cardiovascular disease, pregnancy or breast-feeding or in those under 18 years of age.

World No Tobacco Day

WNTD stands for World No Tobacco Day, which is celebrated around the world on **31 May** every year.

It was first suggested by World Health Organization (WHO) in 1987. The 40th anniversary of WHO, to be "a world no-smoking day." Since then, the WHO has supported WNTD every year, with each year linked to a different "ills of tobacco" related theme.

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CONCLUSION

As major risk factors of oral cancer are relatively well understood and with the known fact that oral cancer is mainly a lifestyle related disease, dentists in particular, physicians, hygienists and other health-related personnel in general have a responsibility to assist their patients in minimizing their risk factors, through effective health education.

Oral cancer can be reasonably well detected and diagnosed at early stages through a 5-minute thorough oral examination. Screening for oral cancer by visual examination is simple, inexpensive and causes little discomfort.

A certain proportion of cancers arise out of premalignant or potentially malignant lesions of the oral mucosa, and early diagnosis and effective treatment of these can reduce the incidence of oral cancer. Small cancerous lesions are easier to treat than advanced lesions from the point of improving the quality of life of the patients.

Most oral cancers are detected at a late stage, requiring complex, costly and often ineffective therapies.

Similarly, current research, educational and financial resources are focused on procedures burdened by high cost, high morbidity and unacceptable high mortality.

Here we suggest that it is time to change this common point of view towards this disease and to alter this trend, stressing that there is no other oncologic specialty in which the World Cancer Report (WCR) preventive guidelines could be applied in such an easy and effective manner, as in the field of oral cancer.

REVIEW QUESTIONS

1. Define epidemiology. Describe the role of host and environmental factors in the epidemiology of oral cancer.
2. Write notes on:
   a. Risk factors of oral cancer
   b. Smokeless and smoking forms of tobacco
   c. Screening of oral cancer
   d. Preventive modalities for oral cancer
   e. Tobacco counselling
   f. 5As in tobacco counselling
   g. Role of health education in prevention of oral cancer
   h. Passive smoking

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14 Oral Health Education

Manjunath P Puranik

CHAPTER OUTLINE

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INTRODUCTION

Oral diseases continue to bother mankind in spite of great advances made in the field of oral health in the last century. Although effectiveness of use of fluorides in caries prevention is documented beyond doubt, dental caries still exists because availability and accessibility of such measures are questionable in many of the developing and underdeveloped communities.

Similarly periodontal diseases, malocclusion, oral cancer, edentulism are still a public health problem. These diseases can be prevented or controlled by a positive dental health behaviour with stress on individual's oral health care. In this situation, oral health education can effectively be used to bridge the gap between the community and the dental fraternity for a better oral health.

CONSIDERATIONS IN ORAL HEALTH EDUCATION

Oral health education is defined as "a process that informs, motivates and helps persons to adopt and maintain healthy practices and lifestyles; advocates environmental changes as needed to facilitate this goal; and conducts professional training and research to the same end." Health education should provide a learning opportunity so that the learner voluntarily adapts to the desired behaviour. Successful educational programmes are found in association with preventive, promotive and curative programmes. While health promotion refers to combination of educational, organizational, economic, political and environmental supports conducive to oral health, education and promotion used in combination may bring out desirable oral health. It needs an intersectoral approach and a long lasting partnership with patients, parents, teachers, policy makers, etc.

Oral health education may be planned for the community at large or high-risk group based on the resources available. Priority should be given to expectant and lactating mothers, preschool and school going children, physically and mentally challenged and the elderly.

Oral health education should provide information on beneficial effects of fluoridation whenever applicable and on effectiveness of topical fluorides. Stress should be on oral self-care behaviours and positive lifestyles. Education on effects of tobacco on oral health and general health should reach the high school students so as to curb the tendency to use tobacco in any form. It is the responsibility of the community to provide a conducive environment for adopting positive health behaviour.

Early childhood caries can be prevented or controlled by targeting not only parents but also physicians, paediatricians, nurses and care givers who are informed about the causes, effects and various measures of prevention. Oral health education on effects of HIV/AIDS on oral health should be directed on individuals as well as dental professionals. Oral health education for the elderly must stress on oral self-care behaviour for the maintenance and preservation of oral health for rest of their lives. It is important to recognize the effects of age-related diseases and medications on oral health resulting in inadequate dentition, nutritional deficiencies, speech problems and difficulty in social interactions.

Oral health should address the people with special needs and also train dental professionals to understand their oral health needs, especially psychological needs. Preventive measures suited to the requirement should be advocated so as to maintain optimal oral health. Oral health education should take into consideration various factors such as cultural values, socioeconomic status of an ethnic group, language differences, misinterpretation of verbal and behavioural cues in the health care encounter, and previous medical experiences in a group when addressing specific health issues related to the community.

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NATURE OF LEARNING

As per Webster's Dictionary learning is "a process of acquiring knowledge or skills through study, instruction or experience." The process includes the learner, the task, the procedure and the learning situation going through the phase of reasoning, imagination and problem solving. Learning occurs in steps such as knowledge, comprehension, application, analysis, synthesis and evaluation.

Three domains are identified to understand the nature of learning: (i) cognitive domain, (ii) affective domain and (iii) psychomotor domain (Fig. 14.1).

Cognitive domain: This is concerned with memory, recognition, understanding and application, and is divided into hierarchical classification of behaviours. Health education should be directed towards the correct level to be effective.

Affective domain: This describes changes in attitudes and development of values. Existing attitudes and values are assessed before attempting to change one's attitudes and behaviours. This process needs support and encouragement from peers and family to reinforce new behaviours.

Psychomotor domain: This includes performance of skills that require some degree of neuromuscular coordination. It is facilitated by learner's ability, sensory image and practice opportunities.

EDUCATIONAL PROCESS

The educational process consists of identifying educational needs, establishing educational goals and objectives and selection of appropriate educational methods. This is followed by implementation of the educational plan and evaluation of the educational process.

Oral health educator is bound to commit errors if he or she places too little or too much emphasis on knowledge. If the individual is treated as if he or she is devoid of any knowledge and education is given, the very purpose gets defeated because the individual has some knowledge and might consider the very process as one sided, imposing and incompatible to his or her viewpoint. While if the educator presumes that by providing knowledge desirable behaviours can be brought out, he or she is mistaken. So, knowledge coupled with meaningful learning experience is a requisite for a positive health behaviour.

Oral health educator should take into cognizance the possible blocks or barriers in the environment or within the individual, such as attitudes, values, beliefs, which interfere with the transformation of knowledge into action. This necessitates the educator to be more patient, without imposing his or her values on the individual and at the same time adapt methods to the requirement of the situation.

Learning happens by application of information gained through instruction to the performance of certain activities. Method of brushing is easily said than done. Thus, dental skills can be acquired if learning involves seeing, hearing and doing under supervision, and later can be done independently once manual dexterity is attained. Reinforcement of positive health behaviour is a must for continued use of skills.

Learning is accomplished in stages, and amount of time varies from person to person. In this process, facts are transformed to concepts, and concepts, in turn, to values. To start with, let us presume that patient has incomplete/inaccurate information about health, as a

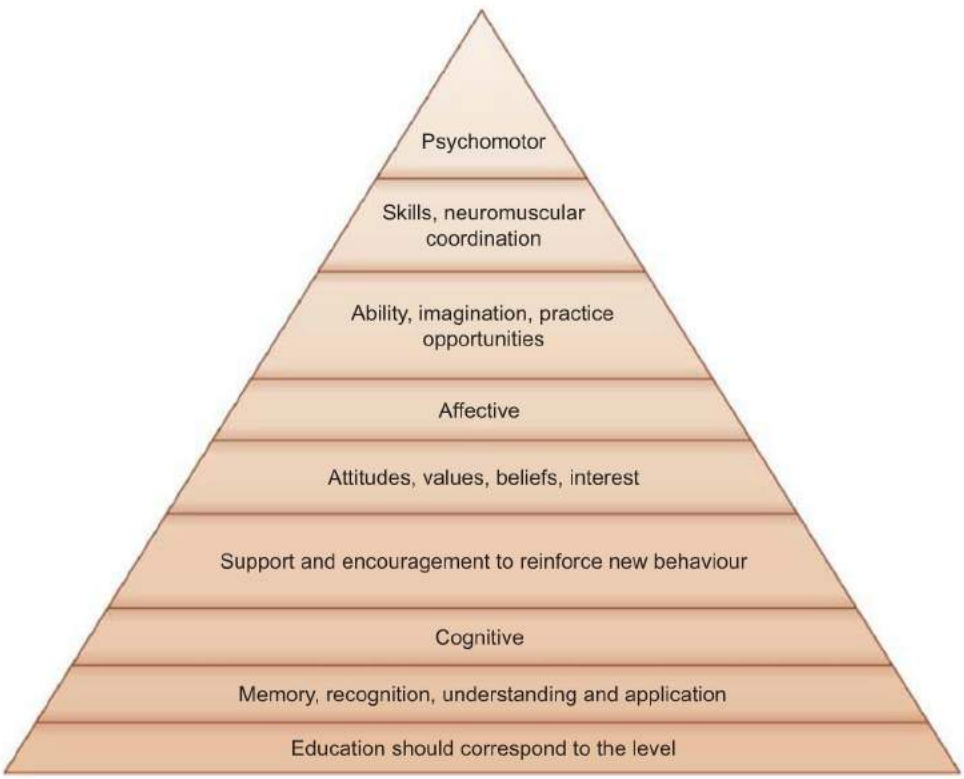


Figure 14.1 Domains of learning.

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result he or she is unaware of its importance to him or her. By providing correct information, awareness can be created. If the information, is meaningful or relevant to him or her individual starts taking self-interest. Dental health educator should utilize this stage to provide clarifications to his or her queries, concepts and make the individual think about the importance of oral health, and how health can be maintained in the present lifestyle. If he or she finds these values are inconsistent with his or her behaviour, tendency to act or involvement is seen.

Involvement prompts the individual to act. In this stage, the patients take action to test facts, concepts or the practices instructed by the educator. If he or she is satisfied with the results, he or she makes permanent cognitive and behavioural changes that become a habit, and a new value is formed.

Motivation. Oral health educator should know or assess the factors which motivate the patient. Motivation is defined as internal and external driving forces that prompt an individual to act to satisfy his or her need. Motivation involves a driving force influencing the individual to take action. This force is based on goal or need to be achieved. Dental pain can be a motivating factor or driving force pushing the individual to visit the dentist. The basic need/goal is elimination of pain and visiting the dentist, for receiving prompt treatment, thereby elimination of pain provides some satisfaction.

Motivation may be intrinsic or extrinsic. Intrinsic motivation is self-generated such as hunger, thirst, sex and so on. Satisfaction derived from these forces is likely to induce long-term changes in attitude and behaviour. While extrinsic motivation or incentives are found outside the patient, within his or her environment; it takes the form of rewards or punishments, material or abstract. Based on the motivation or a driving force, dental health educator plans to meet the needs of the patient. Behaviour is based on satisfaction of a need or the goal. Motivational strategies should be planned only after assessing the patient's level of need.

As per Maslow's hierarchy of needs, five basic needs exist: physiologic, safety, belonging and love, esteem and ego and self-actualization. Physiologic needs are basic needs such as food, water, oxygen and sleep required for life. Safety needs aim at protection against physical threat/harm, develop during childhood when the child starts controlling its physiologic functions. This is followed by desire to be loved, social recognition and so on. Desire to be successful and respect, lead to ego/esteem need. Above all, it is self-actualization desire to utilize one's capacities fully.

The oral health educator should formulate the goals based on the individual's level of need which is relevant and realistic. New goals are formulated when the needs change. Individuals who have physiologic needs may be advised to pay periodic visits to the dental office. It is the right time to enlighten about preventive measures (home care and professional) for those who have safety needs, and also appropriate curative procedures can be rendered to restore oral health and function. Aesthetic dentistry appeals to all those who have identity needs. When the individual desires success, esteem, functional dentition which provides speech, mastication and aesthetics will matter most. Those in the stage of self-actualization measures to achieve optimal oral health will be a goal to be achieved. Goals are reached by designing objectives which are meaningful and appealing to the patient as well as measurable for the health educator. It should be based on patient's motive, values and needs, and should be explained to the patient in such a way that he or she understands and follows the instruction.

COMMUNICATION

Communication is the key to success of health education programme. Interpersonal or two-way communication is a must to motivate the patient to change his or her attitudes and behaviour. The oral health educator should be clear about his or her objectives and goals, available resources and also the barriers of communication.

Communication may be verbal or written language, and nonverbal. It is said that nonverbal messages is more effective than verbal messages. Nonverbal system is a basic form of conveying emotions, feelings, attitudes and preferences. Nonverbal messages have profound effect in communication (Fig. 14.2).

Accurate interpersonal communication is of great value in health education. It is said that if the dentist-patient relationship is positive then the chances of changes in behaviour are more. Dentist has to show concern for the patients' problems by questioning, listening, supporting as and when required without criticizing or rejecting their ideas as baseless. The educator should be able to communicate with the level of the individual, anticipate probable objections, allow the listeners to question back if the

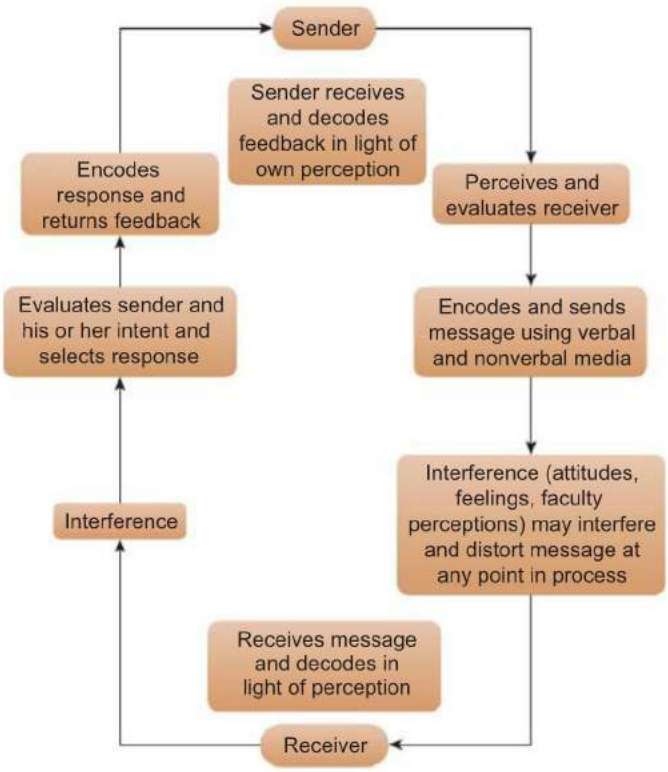


Figure 14.2 One-to-one communication.

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information is not clear, and it is clarified. Besides educator should not just excel in communication but also be a good listener of patient's queries.

Listening is as important as communication. Poor listeners miss vital information and tend to misunderstand the proceedings. Active listening can be accomplished by paraphrasing, verifying consequences and preparing to listen.

Oral health educators often are invited to speak in a formal setting. Based on the topic and the target group speech is prepared which is organized, focused to the point, accurate, relevant and brief. Appropriate audiovisuals may be used as an adjacent effective personal communication.

The basic sequences of instruction include:

- Gaining attention
- Informing the learner of the objectives of instruction stimulating recall of prior learning
- Presenting the stimulus
- Providing the learning guidance
- Eliciting performance
- Providing feedback
- Assessing performance
- Enhancing retention and transfer of knowledge.

The rate at which learning takes place depends on type, magnitude, clarity and the situation, and varies from person to person. The health educator should present the information in small amounts stepwise and in a logical sequence. Review, reinforcement and recapitulation are required to ascertain that the learner has acquired the knowledge and skill before moving ahead.

Effective education can be rendered by following basic principles such as:

1. Sending a clear message
2. Selecting the learning format that matches the objectives and goals of the programme and adapted to the learning need of the recipient
3. Selecting the learning environment
4. Organizing learning experiences incorporating the principles of continuity, sequencing and integration
5. Encouraging participatory learning, providing evaluation and feedback.

Learning can be enhanced by designating place and time for mutual interaction. Desirable changes in a patient are brought about by a conducive environment, continuous attention and supervision, good rapport and the recognition of educator's effort and interest. The learner should be made responsible for his or her oral health, and educator's role is to help or facilitate him or her to achieve this goal through planned objectives. Active participation is the key to success of health education.

Feedback is essential to the patient as well as the educator to monitor the progress of the health education programme. The educator should point out the deficiencies with realistic solutions, and praise him or her whenever the tasks are performed as per requirement. The outcome of educational process is the educational product which is measured both qualitatively and quantitatively. Short- and long-term evaluation of the educational product is done to assess health and behavioural changes.

GENERAL EDUCATIONAL THEORIES

Educational theories aid in understanding how individuals learn and how to design and implement education programmes. More often combination of these theories is required in a wide variety of situations.

Theories: Educational theories can be categorized as: (i) behavioural theory, (ii) social learning theory, (iii) cognitive theory, (iv) humanist theory, (v) developmental theory and (vi) critical theory.

Behavioural Theory

The main goal in this approach is behavioural change. This is achieved by identifying the target behaviour followed by reinforcement, if behaviour is to be increased or punishment if behaviour is to be decreased. This approach is of much use when the educator has full control over feedback system and also when the learner has cognitive limitations, for example school dental nurse giving incentives or punishments to children from the point of maintaining oral health.

Social Learning Theory

Social learning theory focuses on changing expectations about the importance or value of outcome or inducing belief in oneself in achieving the desired goal. This is done by providing information, making relevant case presentations in which the individual identifies oneself, and get motivated to change his or her target behaviours, for example education regarding cessation of habits in smokers by providing information through series of presentations.

Cognitive Theory

In this theory, the emphasis is on changing the thought patterns. The health educator provides information in various ways with repetition and reinforcement influencing the change in thought pattern and ultimately resulting in change in behaviour, e.g. convincing about oral self-examination by changing the thought patterns.

Humanist Theory

As per this theory, behaviour is influenced by feelings, emotions and personal relationships. This theory encourages development of self-expression, provides a forum to create awareness and classification of values, thereby facilitating the individuals to do what is best for themselves, for example self-determination about their own health following group discussion.

Developmental Theory

In this theory, learning occurs in concert with developmental stages wherein each stage of development is a major transformation from the previous stage, and learning occurs differently in different stages. Health educator should provide opportunities matching with readiness to learn to attain desired behaviour, for example educating children and adults is consummate with the level of development.

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Critical Theory

Critical theory considers learning as a continuous process. Learning is facilitated by increasing the depth of knowledge through ongoing interactions and open enquiry till the change in thinking and behaviour is brought about, for example diabetics learning about impact of diabetes on oral health.

BASIC CONCEPTS OF ORAL HEALTH EDUCATION

Oral health education has derived concepts, models and methods from allied sciences such as medicine, public health, and physical, biological, social and behavioural sciences. Various theories of health education, proven to be effective as well as relevant are reviewed here.

Cognitive Model

Cognitive model is based on the following sequence: Knowledge → attitude → behaviour change.

It is assumed that increasing a patient's oral health knowledge helps to change dental care behaviour. But in reality, the relation between health educator's efforts and the resultant behaviour is not straightforward as conceived. It is mainly because the educator fails to assess the learners' level of knowledge before the process of education and treats them as if they are empty pot without any knowledge or past experience. But there already exists a healthy behaviour which is a result of internal and external forces such as beliefs, attitudes, interests, values, needs, motives, personality, expectations, perceptions and biologic factors, besides the influence of family, peer groups and mass economic factors such as occupation, education and media. Similarly socio-demographic factors such as age, race or culture, sex, occupation, education and income have a strong influence on oral health practices.

The interactions of these forces are demonstrated in Young's dynamic model (Fig. 14.3). A model developed by Kressin also illustrates interaction of these forces.

Factors influencing dental education process/aspects of the learner(s) to consider when designing dental education programme are:

- Socio-demographic factors (e.g. age, sex, race/culture, income)
- Values, attitudes, beliefs
- Readiness to change behaviours
- Education.

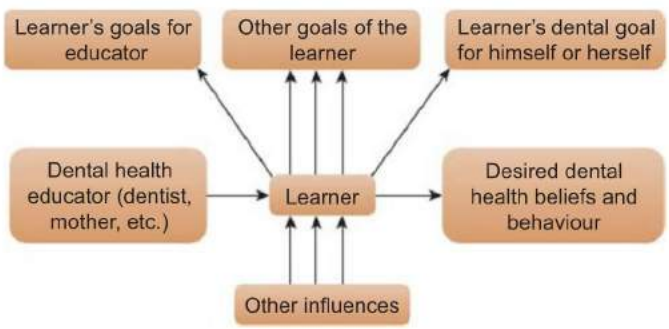


Figure 14.3 Young's dynamic model.

Aspects of social environment to consider when designing dental health education programmes are:

- Cultural norms
- Cultural values/expectations
- How supportive is the environment for the behavioural change
- Possible ways in which education/information can be offered.

Health educator must develop rational educational programme that will result in sustained behavioural change, keeping in mind the influence of interaction of those forces on the learner.

Social Cognitive Theory

As per this, individual's behaviours are motivated by both beliefs (cognitive factors) and factors in the social environment (family, friends and community). The beliefs are related to individual's perception of self-efficacy, and aspects of social environment include learning specific behaviours by watching others to do so and receiving support or reinforcement from others to do so and receiving support or reinforcement from others in the environment for practicing certain behaviours.

Studies conducted by Tedesco and associates support this theory in the development and maintenance of oral self-care behaviours such as brushing and flossing.

Theory of Reasoned Action

This theory states that individual's behaviours are primarily determined by intentions to perform the behaviour, and these intentions are determined by attitudes and beliefs about the behaviour. Also important to understanding attitudes are beliefs about how others will respond to the behaviours.

Efforts based on this theory should be directed to influence individual's intentions to oral health care by:

1. Emphasizing the importance and value of oral health and retaining the natural teeth
2. Reassuring they can effectively take care of oral health and prevent oral disease
3. Changing the community and societal norms where oral health becomes a value so that individuals are motivated to take care of their oral health and sup port their family and friends in doing so.

Stages of Change Model

This model describes common stages of change through which individuals go when trying to change health-related behaviours such as: (i) precontemplation, (ii) contemplation, (iii) action and (iv) maintenance (Fig. 14.4).

Precontemplation is a stage during which an individual is not actively thinking of changing a particular behaviour. In the next stage, contemplation, individual begins to think about behavioural change. He or she may think or read or talk or may become open to health educator, in preparation for taking actual steps to change behaviours. In the action stage, individual actually takes steps to change the behaviour. This is an important stage wherein the individual needs a professional support (education or

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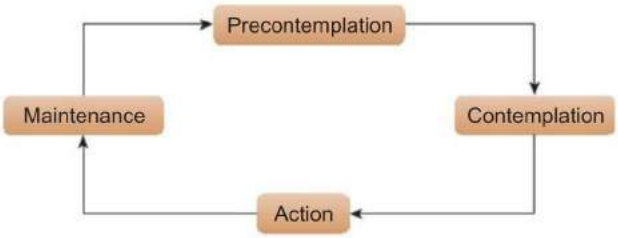


Figure 14.4 Stages of change model.

training) and social support (family and friends). Assuming that successful actions are taken, individual moves into the maintenance stage, in which attempts to continue the behaviour change are seen. Relapse occurs when the individual is unable to continue to maintain the changed behaviour. Such factors are to be prevented, avoided or suitably dealt. As per this model, education should be offered to those who are ready to listen to it.

Health Belief Model (Rosenstock)

Health belief model considers various factors thought to influence individual's health behaviours such as:

1. Readiness to act
2. Consideration of the perceived costs and benefits of performing a certain behaviour
3. Cues to action.

Individual's readiness to act is vital to bring out a change in particular behaviour. This depends on individual's perceptions about the severity of the disease and susceptibility to it. Then comes consideration of the perceived costs and benefits of performing a certain behaviour. The possibility of change in behaviour depends on how the individual perceives about the cost incurred, benefits gained on physical and oral health while cues promote individuals to act by reminding them the need to change their behaviour which could be internal (pain or discomfort) or external (media or health education). This model is beneficial in assessing health protection or disease prevention behaviours.

Health Promotion Model

Health promotion model is developed as a complement to health protection models such as health belief models. It explains the possibility that healthy lifestyle patterns or health promoting behaviours will occur. This model is made up of three categories of determinants:

1. Cognitive perceptual factors which include individual's definition and importance of health, perceived health status, control of health, self-efficacy, benefits and barriers of health promoting behaviour.
2. Modifying factors include demographic (age, gender, race, ethnicity, education and income), biological characteristics (body weight, body fat and height), interpersonal influences, situational/environmental factor and behavioural factors.
3. Variables affecting the likelihood of initiating actions depend on internal and external cues such as desire to feel well, individualized health teaching and mass media health promotion campaigns.

Behavioural Learning Model

Behavioural learning model relies on changing the learner's behaviours through prescribed activities that present the appropriate skills, behaviours and knowledge with the hope that the desired attitudes will follow. Based on one's lifestyle, psychomotor development and oral hygiene practices, appropriate preventive regimens are prescribed. The learner must be motivated to practise these activities on daily basis. Programmes focus on student participation in learning, brushing and flossing rather than attending a demonstration or a lecture.

According to research conducted by Rosenstock and later by Kegeles, four factors influence the preventive dental practices such as:

1. Individuals must feel they are susceptible to dental disease
2. They must perceive dental disease as serious consequence
3. They must believe that dental disease is preventable
4. They must attach salience or importance to dental health.

If any one of these factors is absent, the likelihood of an individual being motivated to adopt and practise the preventive procedure is significantly reduced. Also the health educator must assess impact of informal messages produced from other sources (family, friends and media) on the learner to develop an appropriate educational programme, which should increase the learner's awareness of these informal messages and teach critical evaluation of their content.

Self-care Motivation Model (Horowitz and Associates)

Self-care motivation model is a whole person approach to motivating self-care based on values, awareness, choice and action. This model addresses elements and functions common to all individuals and underlying health behaviours. This model was developed with a specific intention of addressing noncompliance issues in behaviour and lifestyles that result in negative health consequences. It emphasizes the concept of linking healthy human development and greater self-efficacy to setting personal health goals based on a greater clarity and appreciation for health values (Fig. 14.5).

Choice making is based on personal awareness of physical, mental and emotional feedback, which leads to cognitive self-regulation.

Precede–proceed Model

Precede–proceed model provides a method for planning and evaluation of health education programmes. The PRECEDE–PROCEED acronym stands for:

Predisposing	Policy
Reinforcing and	Regulatory and
Enabling	Organizational
Causes in	Constructs in
Educational	Educational and
Diagnosis	Environmental
Evaluation	Development

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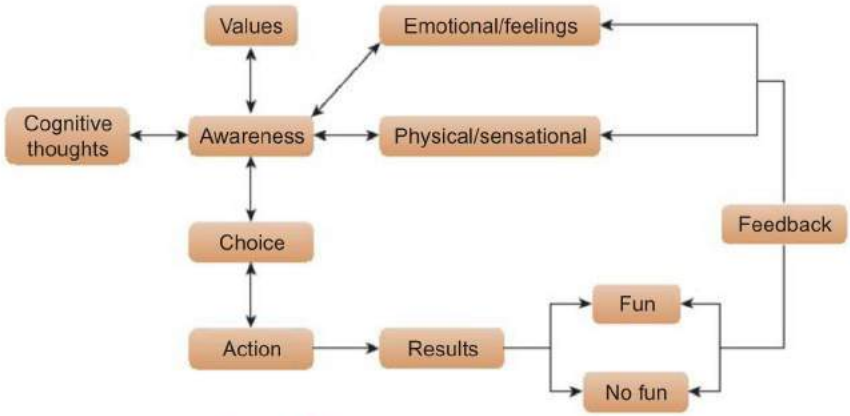


Figure 14.5 Self-care motivation model.

There are nine phases of this model:

1. **Social diagnosis:** Social concerns of the community are identified.
2. **Epidemiological diagnosis:** Epidemiological data are used to suggest health problems.
3. **Behavioural and environmental diagnosis:** Between behavioural and environmental risk factors are identified.
4. **Educational and organizational diagnosis:** Predisposing, reinforcing and enabling factors are identified.
5. **Administrative and policy diagnosis:** Planning related to health education and policy regulation occurs.
6. **Implementation:** The health education programme is implemented.
7. **Process evaluation:** Education process is evaluated in an ongoing fashion.
8. **Impact evaluation:** Immediate effects or objectives of the educational programme are evaluated.
9. **Outcome evaluation:** Short- and long-term effects of the educational programme are evaluated.

The highlight of this model is that it involves the recipient in a problem-solving approach to provide health education for an identified area of need. It considers environment in which the community lives and the social factors that influence the behaviour. It examines the internal and environmental factors that predispose certain health problems. Then factors that help the group in adopting healthy actions are identified, priorities are set. The programme is developed, implemented and finally evaluated.

Contemporary Community Health Model

Contemporary community health model takes into account social, cultural, economic, political and environmental factors that influence health and advocates the need for changes to facilitate health. The emphasis is on the role of public involvement in identifying individual and community health problems, setting priorities and developing solutions to these problems, and it empowers population groups with accurate information about health and health care technologies. WHO advocates the need for using sound community organization and community development principles of working with focus populations, such as sharing in decision making.

The main objective of community organization is to create awareness, interest and desire to solve a problem while working with others to solve the problem. By involving people in decision making about measures or programmes for the improvement of their own health, commitment and motivation to carry out necessary actions to solve the problems are seen.

APPROACHES IN ORAL HEALTH EDUCATION AND HEALTH PROMOTION

Oral health educator may use a combination of approaches in providing health education and achieving health promotion such as social marketing, media influence and parents and school programme.

Social Marketing

It combines the use of advertising and marketing strategies and applies them to change people's ideas and behaviours. It aims at understanding the needs. Then the health education product must be made available through the media or other communication channels with consideration for the price and opportunity costs of adopting a new behaviour or idea.

Social marketing has been used in achieving the objectives of various programmes related to tobacco consumption, health and safety, nutrition, HIV/AIDS. Similarly it could be used in the field of oral health.

Media Influence

Media has a role in promoting behavioural change. Besides, product advertising may influence public opinion and behaviour. Many products advertised in media such as tobacco products, alcohol, nonnutritious foods, etc. have profound deleterious effect on children, adolescents and young adults. Parents have to take an active role in educating their children to become responsible and informed consumers. They have to view media as a potentially toxic exposure that could adversely affect their children's healthy behaviour. In this context, media literacy becomes important and should be taught to children in schools and in a variety of other settings.

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The success of product advertising is based on linking personal satisfaction or enhanced self-esteem with the use of the product. So far, oral health promotion has not achieved success in linking preventive dental behaviours with motives other than health. Thus media-based campaigns to promote oral health for a longer period of time appealing to motives other than health with social support and training can probably bring about the desirable social change in oral health.

Parents and School Programmes

Many programme developers and evaluators do not consider enlisting the support and cooperation of parents although they directly influence on the oral habits. Minnesota home team project demonstrated effectiveness of combined approach of school, parent and the community to child health behaviour. It showed how to accomplish sharing responsibility and the superior impact of shared responsibility between school and home on children's knowledge, skills and practices with respect to dietary intake of more healthy foods.

The school health education evaluation (SHEE) suggests that exposure to health education curricula in schools can result in substantial changes in student's knowledge, attitudes and self-reported practices. It has provided the evidence for such a change, and this change has increased with amount of instruction. In this scenario, teachers with additional training on health issues can be considered as a workforce for the dissemination of health education with the assistance of health professionals in the community.

CONCLUSION

Oral health education is the need of the hour in spite of advances made in the direction of prevention of oral diseases. Carefully planned health education based on educational theories relevant to the target population is mandatory. Learning takes place in steps and the changes occur in cognitive, affective and psychomotor domain. The educator should follow logical sequence of instruction bearing in mind the basic principles of health educator. The process should inform, motivate and provide learning opportunity for the learner. Evaluation should point out deficiencies so that realistic solutions can be given.

REVIEW QUESTIONS

1. Write notes on:
   a. Levels of learning
   b. Domains of learning
   c. Theories of learning
   d. Models of oral health education
   e. Learning about your oral health
   f. Tattle tooth II
   g. North Carolina dental public health programme

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Nutrition and Oral Health

15

Pushpanjali K and Ranadheer R

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INTRODUCTION

Through centuries, food has been recognized as important for human beings in health and diseases. The word "nutrient" or food factor is used for specific constituents such as proteins, vitamins, and minerals, etc. that are present in the food. Human growth, development and maintenance of health mainly depends on nutrition. Until the turn of the century, the science of nutrition had a limited range. Protein–energy malnutrition (PEM) occurs when there are deficiencies in protein, energy foods, or both relative to a body's needs. Over a third of the world's children are affected by PEM which results in lower resistance to diseases. Of over 13 million annual childhood death, it has been estimated that more than one half are associated with PEM.

Protein-energy malnutrition, while generally considered a health problem in developing countries, is not rare in developed countries. Now, issues regarding nutrition are in the forefront, and people are more aware about their health and role of nutrition. We as dentist also need to know more about the impact of nutrition on general and oral health, and how dental treatment can have an impact on nutritional status of the patient.

NUTRITION

Nutrition can be defined as the science of how the body utilizes food to meet requirements for development, growth, repair and maintenance, or as the science of food and its relationship to health.

CLASSIFICATION OF NUTRIENTS

Nutrients are organic and inorganic complexes contained in the food. Nutrients can be classified as **macro** and **micronutrients**. The macronutrients include carbohydrates, fats, proteins and they form the main bulk of food, and micronutrients include vitamins and minerals. They are called micronutrients because they are required in small quantities.

Carbohydrates

The carbohydrates are the main source of energy. They provide 4 kcal of energy per gram. They are found within the body as glycoproteins and glycosaminoglycans. The body stores carbohydrates as glycogen. The Recommended Daily Allowance (RDA) for carbohydrate is 130 g/day. The carbohydrate reserve of a human adult is about 500 g.

Carbohydrate-containing foods are categorized based on the presence or absence of sugar and starch, and the degree of processing of the starch. The rationale for this categorization as far as its relation concerned with caries activity was on the hypothesis that foods composed of sugars, cooked sugar and starch combinations, highly processed starches (i.e. short glucose chains) and relatively unprocessed starches (i.e. long glucose chains) would have different caries risks.

Sources of carbohydrates

1. **Starch:** Found in abundance in cereals, roots and tubers. Starch is found in two forms, i.e. soluble and insoluble. Sources of starch are whole grains, nuts, seeds, vegetables and fruits. Starch prevents constipation, reduces blood cholesterol and helps to stabilize blood glucose levels.
2. **Sugars:** Comprise of *monosaccharides* like glucose, fructose, galactose, *disaccharides* like sucrose, maltose and lactose.
3. **Cellulose:** Cellulose is normally found in vegetables, fruits and other cereals.

Functions of carbohydrates. Apart from providing energy, they also have an important role in:

1. Fat metabolism.
2. Synthesis of ground substance of the connective tissues like chondroitin, keratin and dermatan sulphates.

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3. Synthesis of certain non-essential amino acids.
4. Glucose is essential for erythrocyte and brain function.

Deficiency of carbohydrates. The deficiency of carbohydrates is not experienced much as they are found abundantly in most of the foods.

Effects on oral health. Dental caries is a local phenomenon caused by the diet, especially the carbohydrates. The most important among them is the sucrose, which is utilised by the bacteria to produce both intra and extracellular polysaccharides. The extracellular polysaccharides help in adhesion of the bacterial plaque to the tooth surface, and intracellular polysaccharides act as reservoirs of carbohydrates. The type, consistency, time of intake and frequency of the carbohydrates are the major factors in causation of dental caries.

Proteins

Proteins are the most common substances found in the body after water, making up about 50% of the body's dry weight. When protein is eaten in the diet, it is broken down into its component amino acids, which can be used for protein synthesis and repair. Protein provides 4 kcal of energy per gram. The RDA for protein for adults is 0.8–1 g of protein per day per kg of body weight.

Sources

Animal sources: Milk, meat, eggs, cheese and fish (milk and egg proteins have a pattern of amino acids considered most suitable for humans).

Vegetable sources: Pulses, cereals, beans, nuts.

Functions of proteins

- Provides amino acids, which are the building blocks.
- Forms collagen which is a major organic component of bone, teeth, periodontal ligament and muscle.
- Proteins make up the enzymes.
- Maintenance of osmotic pressure, synthesis of certain substances like antibodies, plasma proteins, haemoglobin, enzymes, hormones and coagulation factors.
- Proteins are also connected with immune mechanism of the body.

Protein on breakdown yields amino acids. Amino acids are of two types, **essential** and **non-essential**. Essential amino acids are not synthesized in the body, hence they should be obtained through dietary means, and nonessential amino acids are synthesized in the body. The nine essential amino acids are: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. The non-essential amino acids are: arginine, asparaginic acid, serine, glutamic acid, proline, glycine, etc.

Effects of protein deficiency. PEM occurs when there are deficiencies in protein, energy foods, or both relative to a body's needs. Dietary energy and protein deficiency usually occur together. Mild PEM has an acute course and has a main deficiency in energy whereas moderate PEM is chronic in nature and has main deficiency in protein, while severe PEM is both chronic and acute, and is composed of deficiencies in both protein and energy.

However, PEM during the first 5 years of life cannot be viewed solely in terms of nutritional intake (malnutrition), refers to the syndrome of inadequate intakes of protein, energy and micronutrients combined with frequent infections.

Deficiency of proteins leads to poor bone calcification, retarded centres of ossification, small teeth, delayed tooth eruption, retarded jaw growth. Crowded dentition is related to protein deficiencies during critical growth periods.

Effects on oral health. Small amount of proteinaceous foods like nuts, seeds, peas, eggs, hard cheese can be replaced with processed food for people with high risk of caries. Patients with ill-fitting dentures, edentulousness and poor oral health status will be unable to consume enough protein which predisposes such person to decreased immune function, impaired wound healing and oral infections. Oral defence mechanism depends on an adequate supply of proteins. The glycoproteins that result in aggregation of bacteria arise from salivary glands. Lysozyme, salivary peroxidase and lactoferrin are also glycoproteins. Secretory IgA arises mainly from the labial and buccal glands and is an immunoglobulin. The cell types involved in cellular immunity (PMNs and macrophages and the enzymes used in phagocytosis) also require protein for their production.

Fats

Fats and oils form the dietary lipids. Fats are solids at room temperature and oils are liquids. Both of them are concentrated sources of energy. They provide 9 kcal of energy per gram. Fats are further classified as

a. Simple lipids—triglycerides
b. Compound lipids—phospholipids
c. Derived lipids—cholesterol.

Body can synthesize triglycerides and cholesterol. 99% of the fat in the body is present in adipose tissues as triglycerides. Adipose tissue, in normal subjects, constitutes 10–15% of body weight. WHO expert committee on prevention of coronary heart disease has recommended only 20–30% of total dietary energy to be provided by fats.

Sources

a. Animal fat—milk and its products like butter, ghee, cheese, meat, egg, fish, etc.
b. Vegetable fats—coconut, groundnut, sesame, etc.
c. Other sources—very small amount is present in cereals, pulses, nuts, etc.

Functions

- Produce high energy.
- Spare proteins from being used up for energy in the absence of carbohydrates.
- Serve as vehicles for fat soluble vitamins.
- Fats support viscera like heart, kidney and intestine.
- Fat beneath skin provides insulation against cold.
- **Omega-3 fats**—linolenic acid—decreases cholesterol level and cardiac risk diseases by reducing blood pressure and preventing blood clots.

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On hydrolysis, fats yield fatty acids and glycerol. Fatty acids are of two types:

- Saturated fatty acids are commonly found in animal fats. Examples are lauric acid, palmitic acid, stearic acid. Polysaturated fats are further classified as omega-3 fats and omega-6 fats.
- Unsaturated fatty acids are further divided into mono-unsaturated fatty acids like oleic acid and polyunsaturated acids like linoleic acid, etc. Polyunsaturated fatty acids are commonly found in vegetable oil.

Fatty acids can be further divided into essential and nonessential fatty acids. Essential fatty acids are not synthesized in the body like linoleic acid, whereas nonessential fatty acids are synthesized in the body routinely.

Effects on general health. Diseases associated with fat include obesity, phrynoderma, coronary heart disease, cancer (colon, breast) and skin lesions.

Effects on oral health. Phospholipids, i.e. compound lipids are a structural component of cell membrane, tooth enamel and dentin.

Research also indicates high-fat foods tend to be inhibitory towards dental caries. Small quantities of nuts and cheese can be good between meal snacks for patients concerned with dental caries.

Vitamins

These are a class of organic compounds required in small amounts, but very essential to the body. They do not yield energy but enable the body to use other nutrients and also maintain metabolic reactions. As vitamins are not synthesized in the body, they have to be supplied through the food. Vitamins are of two types:

a. **Water-soluble vitamins**—Vitamin B complex and vitamin C
b. **Fat-soluble vitamins**—Vitamins A, D, E and K

Each vitamin has a specific function to perform and deficiency of any particular vitamin may lead to specific deficiency disease. A brief overview of vitamins along with their actions, sources and deficiency states is depicted in Table 15.1.

Table 15.1 Vitamins: actions, sources and deficiency diseases

Vitamins	Actions	Sources	Deficiency
Fat soluble			
A	Responsible for vision and growth maintenance of mucous membrane epithelium	Retinol in milk, fortified margarine, butter, cheese, egg yolk, liver, fatty fish, beta-carotenes in milk, carrot, tomatoes dark—carotenes in milk, carrot, tomatoes, dark green vegetables	Reduced night vision, blindness through corneal damage, reduced resistance to infection
D	Promotes calcium and phosphate absorption	Sunlight, fortified margarine, egg yolk, fortified cereals	Failure of bone calcification, rickets in children, osteomalacia in adults
E	Antioxidant	Vegetables and their oils, seeds, nuts, whole grains	May occur in premature infants or in malabsorption syndromes
K	Essential to the formation of blood clotting proteins	Synthesized by gut microorganisms, dark green leafy vegetables	Increased clotting time
Water soluble			
C (ascorbic acid)	Essential to collagen production used in the structure of bone and connective tissues, aids wound healing and iron absorption	Fresh fruits/citrus fruits, red and green peppers, broccoli, snow peas, Brussels sprouts	Scurvy, poor wound healing, and bleeding gums
B_1 (thiamine)	Coenzyme in carbohydrate metabolism	Lean pork, enriched breads, cereals, legumes, seeds, nuts	Beri beri, Wernicke-Korsakoff syndrome in alcoholism
B_2 (riboflavin)	Coenzyme in fat and protein metabolism	Enriched and whole grains, meats, liver, eggs, dairy products, fish, poultry, dark leafy vegetables	Ariboflavinosis with glossitis, cheilitis and seborrhoeic dermatitis
B_3 (niacin)	Cofactor to enzymes involved in energy metabolism glycolysis and tricarboxylic acid (TCA) cycle	Meats, poultry, fish, whole and enriched breads, cereals, milk	Pellagra; toxicity leads to vasodilation, liver damage, gout and arthritic symptoms
B_6 (pyridoxine)	Coenzyme in energy metabolism, antibody and haemoglobin formation	Meat, poultry, fish whole grains fortified cereals, eggs	Altered nerve function
B_{12} (cobalamin)	Transport/storage of folate energy metabolism, blood cell and nerve formation	Animal foods, fortified cereals	Pernicious anaemia
Folic acid (folate)	Coenzyme metabolism, fetal neural tube formation	Green leafy vegetables, legumes, citrus fruits	Megaloblastic anaemia

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Effects on Oral Health

- Vitamin A is essential for the development and continued integrity of all body organs and tissues including the epithelial mucosa of the oral cavity. Vitamin A and beta-carotene are very important for the growth and development of periodontium, teeth, salivary glands and oral epithelium. Vitamin A is vital to wound healing as it contributes to epithelialization, collagen formation and immune response during the inflammation stage of healing. Recent studies have shown that beta-carotene has a role as a chemotherapeutic agent in oral cancer.
- Vitamin B complex deficiency may manifest as magenta raw fissured smooth swollen tongue, angular cheilitis and itchy eyes; scaly dermatitis may also be evident.
- Vitamin C is essential for synthesis of collagen, defective formation of which, leads to loss of connective tissue, gingival haemorrhage, tooth mobility. It also has antioxidant properties. It is important in the healing of oral soft tissues and hard tissue wounds.
- Vitamin D, Ca and P are essential for the formation of bones and teeth. Deficiency during critical growth period leads to retarded jaw, tooth and condyle development, reduced quality of the tooth enamel and dentin, generalized jaw bone resorption and loss of the periodontal ligament. Vitamin E and selenium have antioxidant properties.

Minerals

There are more than 50 chemical elements found in the human body which are required for growth, repair and regulation of vital body functions. Minerals make up about 4% of body weight.

Minerals are divided into three major groups:

1. **Major:** Calcium, phosphate, sodium, potassium, magnesium (these are required from dietary sources in amounts greater than 100 mg per day).
2. **Trace elements:** Iron, iodine, fluorine, zinc, copper, cobalt, chromium, manganese, molybdenum, selenium, nickel, tin, silicon and vanadium (these are elements required by the body in quantities of less than a few milligrams per day).
3. **Trace contaminants** with no known function: Lead, mercury, barium, boron and aluminium.

Functions

- Provide structure for bones and teeth.
- Maintain normal heart rhythm, muscle contraction, nerve conduction, acid–base balance.
- They form an integral part of many enzymes and hormones.

Sources. Include both plant-based and animal-based foods.

Some minerals like calcium, phosphorus, sodium, iron, iodine are associated with clearly recognizable clinical situations. Man, anyway, is not likely to suffer from trace element deficiencies as long as he/she is omnivorous. Trace elements should not be used as dietary supplements, since excessive amounts can have injurious effects (Table 15.2).

Effects on oral health. Calcium in association with vitamin D and phosphorus is essential for proper development and maintenance of mineralized tissues like teeth and bones. Deficiency especially during developmental periods results in hypomineralisation of teeth.

Fluorides have an anticaries effect on teeth. Presence of fluoride during developmental stages results in formation of fluorapatite which is resistant to acid dissolution.

Iron deficiency anaemia manifests in oral cavity by pallor of oral tissues, especially the tongue.

Zinc deficiency can inhibit collagen formation and reduces cell-mediated immunity. The effect of zinc in modifying periodontal defence mechanisms has been shown in rabbits.

Table 15.2 Minerals: actions, sources and deficiency states

Minerals	Actions	Sources	Deficiency
Calcium	Bone/tooth formation, blood clotting and nerve muscle function	Milk-based foods, sardines with bones, green leafy vegetables, legumes	Reduced bone density
Phosphorus	Bone/tooth formation, metabolism, acid-base balance	Dairy foods, eggs, meat, fish, poultry, legumes, whole grains	Rare
Magnesium	Bone/tooth formation, nerve and muscle function, blood clotting, cofactor in metabolism	Whole grains, green leafy vegetables, hard water, meat, dairy products, fish	Associated with fluid volume deficit (FVD) weakness, muscle twitching, convulsions
Potassium	Fluid/electrolyte balance, muscle and nerve function, and hormone release	Whole grains, green leafy vegetables, meats, legumes, dairy foods, fruits, unprocessed food	Associated with FVD weakness, confusion and arrhythmias
Chloride	Fluid/electrolyte balance, gastric digestive acid	Table salt, processed foods	Associated with FVD
Sulphur	Component of body proteins (e.g. hair, cartilage, nails)	Protein foods, eggs, meats, fish, poultry, legumes	Associated with protein deficiency
Sodium	Electrolyte/fluid balance, nerve function, blood pressure, acid-base balance	Table salt processed foods	Associated with FVD, headache, cramps, weakness, confusion, decreased appetite
Fluoride	Bone/tooth formation increases resistance to caries	Natural water, fluoridated water, tea, seafood, seaweed	Increased dental caries

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Table 15.2 Minerals: actions, sources and deficiency states—cont'd

Minerals	Actions	Sources	Deficiency
Zinc	Required for digestion, metabolism, wound healing, tissue growth and repair, reproduction	Protein foods; meats, fish, poultry, eggs, legumes	Retarded growth taste/smell alterations; decreased immune function and wound healing, slow physical, sexual maturity
Iron	Growth; immune system of health, haemoglobin and myoglobin formation, energy production	Liver and other meats, fish, eggs poultry, green vegetables, legumes, enriched breads and cereals	Microcytic anaemia (women and children at risk)
Copper	Coenzyme in antioxidant reactions and energy metabolism; iron use, wound healing, blood and nerve fibre production	Organ meats, seafood, green leafy vegetables, nuts, seeds, water from copper pipes	Bone demineralization and anaemia
Iodine	Thyroxin synthesis, regulates metabolism, growth and development	Iodized salt, seafood	Goitre, tiredness, weight gain
Selenium	Antioxidant may be helpful in periodontal disease	Meats, fish, eggs, whole grains	Predisposition to heart disease, increases dental caries
Chromium	Carbohydrate metabolism	Whole grains, cheese, meats, brewers yeast	Possible cardiovascular disorders and insulin dysfunction
Molybdenum	Coenzyme	Whole grains, legumes, milk	Decreases dental caries
Manganese	Metabolic reaction participant	Whole grains, green leafy vegetables, legumes	Unknown

RECOMMENDED DIETARY ALLOWANCES

Recommended Dietary Allowances (RDAs) are the levels of intake of essential nutrients that, on the basis of scientific knowledge, are judged by the Food and Nutrition Board to be adequate to meet the known nutrient needs of practically all healthy persons.

ASSESSMENT OF PATIENT'S NUTRITIONAL STATUS

Nutritional status is defined as "health condition of an individual as influenced by his/her intake and utilization of nutrients determined from correlation of information from physical, biochemical, clinical and dietary studies."

"Oral health is an integral part of general health," following these lines, the importance should be first given to general health in nutritional status.

Data required to assess nutritional status are:

1. Patient's complaints and medical and social histories.
2. Dietary history and evaluation.
3. Physical examination including anthropometric (size, weight, body proportion) measurements.
4. Pertinent laboratory tests.

The data obtained by the above routes should be compiled and interpreted.

DIETARY HISTORY AND EVALUATION

Information can be collected for a dietary history from a 24-hour recall or a 7-day record of food intake. Choice depends upon the amount of details required. The dietary history and evaluation provide information on the amount of food ingested and the patient's eating habits and attitudes about food and health.

Features of 24-hour recall

1. Very rapidly (15–20 min) obtained.
2. But the quantities consumed may be over or underestimated.
3. It may not represent the usual intake.

Dental health diet score is a simple scoring procedure for a 24-hour recall period of diet history, which discloses a potential problem that is likely to adversely affect a patient's dental health.

Food Diary

An accurate, complete record of food intake is best achieved by asking the patient to record all that he/she consumes from morning until he/she goes to bed. Recording from memory details is not reliable process, and should be discouraged.

Details can be recorded on a standard proforma or any note book. It should include *morning coffee*, tea or milk, *breakfast*, snacks, lunch, evening snacks, dinner and later whatever consumed specifying the quantities. Preference to add extra sugar is also to be noted (Table 15.3).

Patient is asked to maintain this record for 7 consecutive days including one weekend day. Instruct patient the importance of these details and to record everything he/she consumes (including the medicated syrups). When the patient revisits the dentist with the 7-day food diary, the visit should be wholly reserved for counselling, avoiding any other treatment procedures. Thus signifying the importance of counselling, the food diary is analyzed to know the appropriateness of the diet and type of sweetened food consumed and its frequency of consumption. Encourage the involvement of the patient in this session, and ask him or her to circle all the foods that are sweet and sweetened with sugar with red ink, e.g. coffee, milk, tea, bread, jam, dry fruits like raisins, dates, cookies, cakes, pastries, candies,

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Table 15.3 Food diary: recording of whatever consumed throughout the day

Example Time	Food Consumed
7.30 am	Milk/tea/coffee with sugar
9.00 am	Breakfast Bread, butter, jam, idly, dosa, chapati, Rice item Topped with sugar (yes or no)
11.00 am to 12.00 pm	Snacks Fruits, cakes, sweets, dry fruits
2.00 pm	Lunch Rice, dal, vegetables, sweets, etc.
5.00 pm	Snacks—cakes, chips
8.30 pm	Dinner, medicines, especially syrups

cough syrup, fruit juice, etc. This exercise highlights the cariogenic food.

Explain regarding dental caries, role of sugar with respect to its consistency, frequency and time of intake, production of acids and development of lesion. Then ask patient to delete these foods from the diet and help for possible replacement by non-cariogenic diet, e.g. fresh fruits, vegetables, salads, nuts, etc. (provision of suitable non-cariogenic snack substitutes is one of the major reasons for the success of counselling). Help patient to select alternate means, which is nutritive and non-cariogenic. Encourage him to evaluate the adequacy of the new self-prescribed healthy diet.

Dietary data, which were reported by the parent or care giver, do not necessarily reflect the actual consumption. Food categories were selected to emphasize sugar and starch combinations and did not completely account for other nutrients. Although dietary data were collected longitudinally, the oral examination occurred at one time point, which limits our ability to track dietary intake and caries experience simultaneously. Changes in dietary patterns resulting from preventive guidance provided by local care providers could have limited our ability to identify association between dietary factors and caries experience. Therefore, inconsistent or one-time association must be viewed with caution.

Focus on Reduction in Number of Sugar Exposures

Schedule a follow-up visit after 2 weeks. The patient is asked to complete a second 5-day food diary in the same manner just before the second visit. Remind patients that the number of red circles should be reduced compared to the first chart.

Compare and evaluate the new food diary. Check if the modifications are followed, clear any misinterpretations, misunderstandings, and clarify any problems raised during this period.

Diet counselling imparted by an empathetic and knowledgeable counsellor to a patient with positive attitude for oral health will be very successful in improving both general as well as dental health.

DIET COUNSELLING AND DIETARY ADVICE

As nutrition is very important for growth and development of the children right from the beginning, hence through balanced diet the general health of the growing child can be achieved along with good oral health. This is based on the concept that "oral health is integral part of general health." Thus during diet counselling with mothers and expectant mothers, they have to be informed about the importance of good diet and nutrition for the development of good dentition.

Coming to the diet part, the main objectives of diet counselling and dietary advice are to prevent and control caries development. Diet counselling is tailor made. It is done on one-to-one basis based on the needs of individual patients. Dietary advice is a set of general instructions given to people at large.

Patients who are at risk for dental caries are ideal candidates for diet counselling. The candidates should have positive attitude and interested in understanding his/her problem and its prevention, accept responsibility for dietary modification. Only then the counselling will be successful.

A dentist or hygienist is ideal to counsel the patient. Face-to-face interview; keeping eye contact with the patient is a persuasive and powerful device.

Communication can be verbal or non-verbal. The interviewer's tone of voice, facial expression and gestures convey sincerity, enthusiasm and empathy. These actions help in motivating the patient to change their behaviour.

The modified diet should not deviate too much from his/her regular diet and should be adapted to the patient's needs and daily routine lifestyle.

Counselling should take place in a different room and not on the dental chair. Non-directive approach is preferred where the patient is active and allowed to clarify and understand his/her own situation.

Maximum patient co-operation and acceptance is required. Qualities essential for a counsellor are patience, sound knowledge about nutrition and health, and good communication skill. The counsellor needs to help the patient to make his/her own final decision regarding diet, which is good for oral health. Patients should be encouraged to have more of fresh fruits, raw vegetables and other fibrous foods which is non-sticky and stimulates saliva and soft tissues. Patients should be explained about the local effects of diet on caries especially the role of refined sugars like sucrose.

A systematic, logical approach which will help the clinician to counsel and easy for the patient to follow should be used. In medical practice, a commonly used approach for any case note is S-O-A-P method.

- **S-Subjective:** What the patient reports?
- **O-Objective:** What the clinician observes?
- **A-Assessment:** Clinician's evaluation based on subjective and objective findings.
- **P-Plan:** How to go about treatment for the patient based on the evaluation/diagnosis done?

Step 1: Subjective

- Explaining the need for counseling
  - In dental office, we deal with dental caries and periodontal disease. We need to explain the patient that

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in order to prevent future dental problems we need to rule out the role of diet, as it is one of the important risk factor.
- Why/Reason for consuming the type of diet?
  - Factors influencing the selection of diet-like lifestyle and peer influences.
- What are you consuming?
  - Minimum 24-hour recall, ideal one week including weekend.

Step 2: Objective

- Clinical examination
  - Screening for any physical signs of malnutrition.
- Role of diet in causing oral diseases and how it can be prevented by controlling diet.

Step 3: Assessment

- Food/Diet adequacy
  - Reinforce the importance of diet and its influence on oral health.
  - Ask the patient to compare his/her diet chart with the RDA.
- Cariogenic potential of the diet/Sugar score
  - Explain the patient the role of sugar, their forms (solid, liquid, sticky) and their cariogenic potential.
  - Ask the patient to circle and read all the potentially cariogenic food in his/her diet chart.
- Diagnosis
  - Ask the patient to review his/her diet chart and with the help of education provided and self-assess
    - Diet adequacy.
    - Cariogenic potential of the diet/Sugar score.
    - Reason for following the particular diet pattern.

Step 4: Plan

- Solution
  - Now that the patient has himself/herself identified the problems in the diet, what are the alternatives that they prefers to improve his/her diet adequacy and reduce cariogenic potential
- Summary and closure
  - Ask the patient summarize
    - Role of diet/nutrition in oral disease
    - Results on diet self-assessment
    - Reasonable strategies and commitment for improvement
  - Follow-up and revaluation
    - After few weeks of initial assessment, recall the patient and ask him to fill a new diet chart
    - Compare with the original, check for improvements and clarify any misconceptions.

Community-Based Nutritional Programmes

A number of community-based programmes have been launched to improve the nutritional status of the community. Most of these programmes are targeted towards children as they form one of the vulnerable groups for development of malnutrition. The most important among these are the school lunch programme or the midday meal programme.

School Lunch Programme

The school lunch programme or the midday meal programme has been in operation since 1961 in India with the objective of attracting more children for admission to schools. Principles which are followed during formulating midday meals are:
- It should be a supplement for the home food and not a substitute.
- Should supply one third of the total calorie and half of the protein requirement.
- As far as possible, locally available foods should be used.

This programme is currently in operation in many schools, both urban and rural.

CONCLUSION

Growth and development of tissue and organs are affected by nutritional environment. Excess or deficiency of nutrition does have some effect depending on the time and duration of excess or deficiency of nutrition and the phase of growth. Nutrition is important in allowing the body to attain its full growth and development potential. Oral tissues are no exception, i.e. even they are influenced by nutritional disorders.

As tooth development begins in utero and extends to adult life, nutrition exerts a pre-eruptive and a post-eruptive effect. Studies have demonstrated the relationship between nutrient deficiencies and tooth development with its influence on tooth size, formation/eruption of tissue and caries susceptibility.

Primary dentition caries has been associated with early childhood malnutrition. PEM has a remarkable influence on the permanent dentition which might alter the eruption timing, enamel hypoplasia and salivary hypofunction, suggesting a possible biological mechanism for a PEM-caries association. External enamel hypoplasia or hypomineralisation may create a surface that is more retentive to a pathogenic microbial flora. And also there is some indirect evidence that any hypoplasia or hypomineralisation may be structurally more susceptible to demineralisation.

Oral tissues reflect the nutritional status of a person due to rapid turnover of cells in the oral cavity. Inadequate nutrition leads to the development of oral lesions and exaggerate the response of oral tissue to trauma leading to tissue breakdown and infection.

Although it is reasonable to consume a nutritionally adequate diet to maintain host resistance and the integrity of the periodontal tissues, insufficient evidence is available to justify treatment with vitamins and mineral supplementations in the adequately nourished individuals.

However, malnutrition leads to retarded jaw, tooth and condyle development, reduced quality of the tooth enamel and dentin, generalized jaw bone resorption and loss of the periodontal ligament.

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REVIEW QUESTIONS

1. Define nutrition/food. Write a note on how nutrition affects oral health.
2. Classify nutrients. Add a note on vitamin K.
3. Write notes on:
   a. Protein-energy malnutrition
   b. Vitamins and oral health
   c. Trace elements
   d. Anticaries diet
   e. Balanced diet
4. Describe the steps in dietary counseling.

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16 Surveying and Oral Health Surveys

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SURVEYING

INTRODUCTION

Successful programmes are based on the felt needs of the people. Before planning and implementation of such programme, survey is conducted wherein information is collected related to their prevailing conditions quantitatively as well as qualitatively and is subjected to statistical analysis.

Definition: Surveying is generally taken to imply a collection of facts and analysis, evaluation or interpretation of facts. Once they are collected, comparison is being made between the current survey data and comparable data from other times or places.

Surveys are initiated by simple statements on needs and objectives followed by a logical and scientific method of data collection and interpretation. Surveys should select those tools that measure tangible features in a community and later use them for good in planning, implementation and evaluation of the programme.

Assessment of the magnitude of interest in oral health in the community should precede all other efforts, and their attitude, concepts and values towards oral health matters a lot. Also economic status, educational levels and other social and demographic factors relevant to health are considered in a community as well as in subgroups based on region (urban/rural) or culture (ethnic/religion), budget of health department for dental health indicators and their outlook in improving oral health.

Voluntary organizations most often lend a helping hand for such endeavours. Similarly, taking professionals in paediatric practice into confidence can further strengthening goals of preventive dentistry. A list of dental manpower working in the community should be made. Efforts that have a direct or indirect bearing on oral health in areas such as environmental preventive services, school health education programmes and other health care programmes operating in the community are also considered.

STEPS IN SURVEY

The investigator should follow a scientific method in conducting a survey such as:

1. Establishing the objectives
2. Designing the investigation
3. Selecting the sample
4. Conducting the examination
5. Analyzing the data
6. Drawing the conclusions
7. Publishing the results.

Establishing the Objectives

The investigator must be clear about the objective or the purpose of the study before planning further. Based on this, objectives may be stated as required such as in the form of a hypothesis to be tested or disease to be measured, and so on.

Designing the Investigation

Based on the objectives, investigator has to design the investigation from the point of type and method of study. Regarding type and method of study, descriptive studies

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can be planned to assess prevalence (cross-sectional studies) or incidence (longitudinal studies) of a disease or a condition in terms of time, place and person. Analytical studies can be planned to assess the association between the cause and effect. In this regard, case-control studies (retrospective) and cohort studies (prospective) can be planned.

Both descriptive and analytical studies are observational studies whereas experimental studies such as randomized controlled trials are interventional studies done in order to provide scientific proof between cause and effect relationship. Blind trials and studies with matched controls minimize bias and provide authenticity to the results.

Selecting the Sample

It is usually not possible to include everyone in the population under study due to lack of resources. At times, relevant information can be obtained by taking small group/quantity for the study such as little blood drawn can give a complete blood picture. The principal objective of sampling is to get maximum information about the population from an unbiased, unselected sample. Sampling techniques are:

a. Non-probability sampling technique
b. Probability (random) sampling technique.

Non-probability sampling techniques

i. *Convenience sampling:* It is done for administrative convenience with the ease of access being the sole concern. It lacks "representativeness." It is also known as accidental accessibility, incidental or haphazard sampling.
ii. *Purposive sampling*: In this type, the investigator exercises, deliberate subjective choice in drawing what he/she regards as a "representative" sample. It aims at the elimination of anticipated sources of distortion, but distortion may occur due to prejudice, lack of knowledge on crucial features of the population. It is also known as judgmental sampling and used for assessment of various disorders.
iii. *Quota sampling*: It is a combination of convenience and purposive sampling. In this type, statistical design may be used to determine the numbers needed in each of the quota.

Probability (random) sampling techniques

1. Simple random sampling
2. Stratified random sampling
3. Systematic sampling
4. Cluster sampling
5. Multistage sampling

Simple random sampling: In this method, every member (sampling unit) of a population has an equal chance of being selected in the sample. The randomness of the sample is achieved by the use of lots (lottery method) or the table of random numbers. This method is employed for homogeneous population only.

Stratified random sampling: When the population is heterogeneous, it is divided into "strata" or levels, and sample is then drawn from each stratum by means of simple random sampling method. For an instance, a community can be subdivided based on social or demographic factors and independent samples are drawn from such subgroups.

Systematic sampling: In this type, every nth member from the list is chosen for the study. The first value to be selected is determined by lot or the table of random numbers. It is more convenient.

Cluster sampling: Any method of sampling wherein a group is taken as a sampling unit is known as cluster sampling. It is more convenient for administrative and economic reasons, e.g. schools.

Multistage sampling: In this type, there are progressively higher levels of subsampling (the process of drawing samples from selected clusters). The simple random sampling method is used to draw the samples.

Sample size. The size of the sample is dependent on the statistical characteristics of the data to be collected. It varies with size of the population, prevalence of the disease, amount of error tolerated, and power of the test. Regardless of the sampling techniques, the sample should be as large as possible to increase accuracy and precision of data collection, reduce the standard error of sample mean so that it accurately represents the population.

Conducting the Examination

Once the sample is drawn from the population, the investigator has to conduct the examination with due considerations for the following aspects to avoid disagreement and misunderstanding in investigating team:

- Examination methods and diagnostic aids
- Diagnostic criteria
- Indices
- Consent
- Selection of examiners.

Examination methods and diagnostic aids. Examination in epidemiological studies should be as automatic as possible to eliminate excessive intrusion of subjective thought so that uniformity is maintained in large numbers that are examined.

American Dental Association (ADA) has classified types of inspection and examination as under:

Type 1: Complete examination, using mouth mirror and explorer, adequate illumination, thorough roentgenographic survey, and when indicated, percussion pulp-vitality tests, transillumination, study models and laboratory tests. This method can seldom be used in public health work.
Type 2: Limited examination, using mouth mirror and explorer, adequate illumination, posterior bitewing roentgenograms, and when indicated, periapical roentgenograms. This method is suggested when the survey is followed by public health programme.

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Type 3: Inspection, using mouth mirror and explorer and adequate illumination. This is indicated in public health surveying.
Type 4: Screening using tongue depressor and available illumination. But it is not a reliable method for public health surveying.

Basic requirements for oral health survey are: chair, preferably with a head rest; source of illumination, either a headlight that examiner can wear or any other light source available; some means to clean teeth of debris when necessary and assisted by a recorder. Due considerations are given to instruments and supplies (such as mouth mirrors, explorers, CPI probes, pans for sterilizing instruments/keeping disinfectant solutions, gauze pads, etc.) which should be in sufficient numbers and observance of infection control and sterilization protocol.

Diagnostic criteria. Diagnostic criteria should be clear, unambiguous and simple. It should be both valid and reliable.

Indices. Index should be selected based on the objectives of the study.

Consent. Consent should be obtained from the local authorities or school officials/parents or individual adults. Informed consent is particularly necessary when restorative care will follow the survey through public health facilities. Clinical trials should be conducted in accordance with national policy on the use of human subjects.

Selection of examiners. Selection of examiners and examination procedure is critical in achieving the objectives of the survey.

As a word of caution, it is suggested to keep the number of examiners to a minimum to minimize inter-examiner variability. To ensure uniformity in interpretation, examiners are trained and calibrated. Divergence of observation/opinion and borderline problems are discussed and minimized. Printed materials regarding rules/systems are given when necessary.

Examiners are advised to use standard instruments (one make and design) and discard when it fails to serve the purpose. Reversal rate, that is reversing decision on repeated examination, should be checked. The supervisor is advised to recheck an occasional case throughout the entire survey.

To improve efficiency, recorders such as auxiliaries, volunteers or parents should be involved, and number of examinations per hour should be carefully planned for adults/children based on the objectives of the study.

Analyzing the Data

The task of assembling the materials begins after the survey. Tally sheets can be set up in such a way so as to produce frequency distribution. Calculation of percentage, means and standard deviation related to status and treatment needs is done as appropriate. Tests of significance may be used, if indicated.

Classification of treatment needs (ADA)

Class 1: Individuals apparently requiring no dental treatment related to the type of examination or inspection performed.

Class 2: Individuals requiring treatment but not of an urgent nature, such as:

a. Moderate calculus
b. Prosthetic cases not included in Class 3.
c. Cases—not extended or advanced
d. Periodontal diseases—not extensive or advanced
e. Other oral conditions requiring corrective or preventive measures.

Class 3: Individuals requiring early treatment of conditions such as:

a. Extensive or advanced cases
b. Extensive or advanced periodontal diseases
c. Chronic pulpal or apical infection
d. Chronic or oral infection
e. Heavy calculus
f. Surgical procedures required for removal of one or more teeth and other surgical procedures not included in Class 4
g. Insufficient number of teeth for mastication.

Class 4: Individual requiring emergency dental treatment for such conditions as:

a. Injuries
b. Acute oral infections (periodontal or periapical abscesses, Vincent's infections, acute gingivitis, acute stomatitis, etc.)
c. Painful conditions.

Drawing the Conclusions

Adequate care should be exercised in drawing the conclusion. It should be made clear that these conclusions are specifically related to the study that has been carried out, and no extrapolation is made to the general population unless the study is designed accordingly.

Publishing the Results

The final step in a survey procedure is publishing the results. It should be clear and simple, include recommendations and directions for future action. Report should include:

- Statement of the purposes of the survey—should include introduction, review of literature, reasons for conducting the present investigation, objectives and the hypothesis to be tested.
- Materials and methods—should include description of area and population surveyed, types of information collected, methods of collecting data, sampling method, examiner personnel and equipment, statistical analysis and computational procedure, cost analysis and reliability and reproducibility of results.
- Results—should contain tables, figures with relevant amplification in the text.
- Discussion and conclusion—the investigation, its findings and conclusions are discussed with valid conclusions.

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ORAL HEALTH SURVEYS

World health organization (WHO), in its endeavour to provide a systematic approach to the collection and reporting of data on the oral diseases and conditions and also to ensure comparability of the data collected, has published a manual on oral health surveys. The surveys conducted all over the world using the recommended methods have shown that dramatic changes have occurred in many populations, as a result of changes in disease trends and new treatment techniques as well as changes in age structures.

Basic oral health surveys provide a strong basis for estimation of the current oral health status of the population and its future needs. Baseline data thus obtained can be used for development of national or regional oral health programmes and planning for appropriate numbers and personnel for oral care. Surveys carried out over the past decade confirm that data on oral health status are important for surveillance of disease patterns. Oral health planners and decision makers may require information about the risk factors associated with oral health, oral health-related quality of life, service coverage and utilization of oral health services, intervention and care, administrative procedures and quality of care and interventions.

Besides, WHO offers pre- and post-survey assistance wherever possible to foster the use of uniform survey methods and interpretation of special characteristics of oral disease. The special considerations concerning the two major oral diseases (dental caries and periodontal disease) are:

1. The diseases are strongly age related as there is often an increase in severity and prevalence with increased age.
2. The disease exists in all populations, varying only in severity and prevalence.
3. One of the diseases, dental caries, is irreversible and hence information on current status provides data not only on the amount of disease present, but also on previous disease experience.
4. Variations of profile of dental caries for population groups with different socioeconomic levels and environmental conditions are documented.
5. Many observations are made in standard measurements for each subject, i.e. for each tooth in the case of caries and for the six sextants of the mouth in assessment of periodontal diseases.

PATHFINDER SURVEYS

The method used in surveys is a stratified cluster sampling technique, which aims to include the most important population subgroups likely to have different disease levels. It also proposes appropriate numbers of subject for obtaining the following information:

1. The overall prevalence of the common oral diseases and conditions affecting the population.
2. Variations in disease levels, severity and need for treatment in subgroup of the population. This enables groups in special need of service to be identified.
3. Age profiles of oral disease in the population to enable care needs for different age groups to be determined, to provide information about severity and progressions of the disease and to give an indication as to whether the levels are increasing or decreasing.

Types

Pathfinder surveys are of two types: (i) pilot survey and (ii) national pathfinder survey.

Pilot survey. A pilot survey includes only the most important subgroups in the population and only one or two index ages, usually 12 years and one other group. This survey provides the minimum amount of data needed to start planning. Further data should then be collected in order to provide baseline for the implementation and monitoring of services.

National pathfinder survey. Incorporates sufficient examination sites to cover all important subgroups of the population that may have different disease levels or treatment needs, and at least three of the age groups or index ages. This design is suitable for the collection of data for the planning and monitoring of services in all countries, irrespective of levels of disease, availability of resources or complexity of services. In a large country with many geographical and population subdivisions and a complex service structure, a large number of sampling sites are needed. However, the basic principle of using index ages and standard samples in each site within a stratified approach remains valid.

SUBGROUPS

Sampling sites are usually chosen so as to provide information on population groups likely to have different levels of disease. The sampling is usually based on the administrative division of a country—the capital city, main urban centres, small towns and rural areas. In countries where there are different geographical areas, it is usual to include at least one sampling site in each area type.

It may be necessary to include separate samples of each of these ethnic groups in the main subdivision for the survey. Knowledge about variations between the different groups in order to limit the numbers of additional subsamples need, will help in sample selection. For a national pathfinder survey, between 10 and 15 sampling sites are usually sufficient. If, however, there are large urban centres in the country, it may be necessary to locate several additional sampling sites in at least two cities.

INDEX AGES AND AGE GROUPS

These are: 5 years for primary teeth, and 12, 15, 35–44 and 65–74 years for permanent teeth.

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5 Years

Wherever it is practical, children should be examined between their 5th and 6th birthdays. Levels of caries in the primary dentition which may exhibit changes over a short time span than the permanent dentition at other index ages is the matter of interest. In some countries, 5 year is also the age at which children begin primary school.

Note: In countries where school entry is later, e.g. at 6 or 7 years, these ages can be used, though in the older age groups, missing primary incisor teeth should not be scored as missing because of the difficulty in differentiating between primary incisors lost due to exfoliation and those lost because of caries or trauma.

12 Years

It is generally the age at which children leave primary school, and therefore in many countries, it is the last age at which a reliable sample may be obtained easily through the school systems. At this age all permanent teeth, except third molars will have erupted. For these reasons, 12 years has been chosen globally for monitoring caries for international comparisons and monitoring of disease trends. In some countries, however, many school-age children do not attend school. In these circumstances, an attempt should be made to survey two or three groups of non-attendees from different areas in order to compare their oral health status with that of children still attending school.

15 Years

At this age the permanent teeth have been exposed to the oral environment for 3–9 years. The assessment of caries prevalence is therefore often more meaningful than at 12 years of age. This age is also important for assessment of periodontal disease indicators in adolescents. In countries where it is difficult to obtain reliable samples of this age group, it is usual to examine 15-year olds in two or three areas only, i.e. in the capital city or other large towns, and in one rural area.

35–44 Years (Mean = 40 Years)

This age group is the standard monitoring group for health conditions of adults. The full effect of dental caries, the level of severe periodontal involvement and the general effects of care provided can be monitored using data for this age group. Sampling adult subjects is often difficult. Sample, however, can be drawn from organized groups, such as office or factory workers. Use may also be made of readily accessible groups, e.g. at a market to obtain a reasonably representative sample in situations where truly representative sampling is not feasible. Care must be taken to avoid obvious bias, such as sampling patients at medical care facilities.

65–74 Years (Mean = 70 Years)

This age has become more important with changes in age distribution and increase in lifespan that are now occurring in all countries. Data for this group are needed both for planning appropriate care for the elderly, and monitoring the overall effects of oral care services in a population. Examination of representative members of this group is often not as difficult as for the previous age group, as elderly people are more likely to be found in or near their homes, or in day centres or institutions, and can therefore be examined during the day. Nevertheless, care should be taken to sample adequately both house bound and members of this age group.

NUMBER OF SUBJECTS

The number of subjects in each index age group to be examined ranges from a minimum of 25 to 50 with approximately equal number of males and females for each cluster or sampling site, depending on the expected prevalence and severity of oral disease.

Example: Sample design for each index age or age groups:

Urban—4 sites in the capital city/metropolitan area—4 × 25 = 100
2 sites in each of 2 large towns—2 × 2 × 25 = 100
Rural—1 site in each of 4 villages in different regions—1 × 4 × 25 = 100
Total 12 sites × 25 subjects = 300
For 5 index age groups—1500

ORGANIZING THE SURVEY

Preparing a Survey Protocol

It is important to prepare a written protocol for the survey such as:

- Main objective and purpose of the survey
- A description of the type of information to be collected and of the methods to be used
- A description of the sampling methods to be used
- Personnel and physical arrangements
- Statistical methods to be used in analyzing the data
- A provisional budget
- A provisional timetable of main activities and responsible staff.

Permission to examine population groups must be obtained from a local, regional or national authority such as school authorities, parents, health authorities, etc. Similarly, information may be given to local dental association and practitioners and their co-operation may be sought. Then a budget for the survey should be prepared, which should include all the resources required including personnel to carry out the survey.

Preparation of a schedule for data to be collected is a must, so that the time is not wasted. Keeping in view the time required for the examination of a child (5–10 minutes) and an adult (15–20 minutes), daily and weekly schedules are prepared which are not too demanding. Schedules should be available to survey personnel as well as schools or health authorities.

If a life-threatening condition or a condition that requires immediate attention is detected during the

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examination, it is the responsibility of the examiner or the team leader to ensure that referral to an appropriate care facility is made.

Courtesy reporting of the survey findings is appropriate and often essential such as the number of subjects examined and the observation made to local authorities.

RELIABILITY AND VALIDITY OF DATA

Training and Calibration

Training is essential to make consistent clinical judgments.

There are two main reasons for variability of clinical scoring:

- The difficulty in scoring the different levels of oral diseases, particularly dental caries and periodontal diseases.
- Physical and psychological factors, such as fatigue, fluctuations in interest in the study and variations in visual acuity and tactile sense. All these affect the judgment of examiners from time to time and to different degrees.

The objectives of standardization and calibration are:

- To ensure uniform interpretation, understanding and application by all examiners of the codes and criteria for the various diseases and conditions to be observed and recorded.
- To ensure that each examiner can examine consistently.

The examiner can be trained by an experienced epidemiologist for 2 days and calibrated for 2–3 days. In general, agreement for most assessments should be in the range of 85–95%. Unless all members of the survey team can examine in a consistent manner, regional or group variations in the disease prevalence may be missed or wrongly interpreted.

Duplicate Examinations

Examiners may change the way they apply diagnostic criteria during the course of survey. To allow detection and correction of this tendency, it is advisable for each examiner to perform duplicate examinations on 5–10% of the sample (no less than 25) in the main survey.

IMPLEMENTING THE SURVEY

In general, contact with persons in authority is necessary for their co-operation and co-ordination and can be a source for obtaining the basic information of the population. The organizer of the survey should maintain a logbook in which the location of each day's examinations, the number of persons examined and information about each survey location are recorded. Preliminary exercise of examining two classes of 12-year-old children in local schools is suggested for those planning their first survey.

Regarding sources of fluoride, a sample of drinking water should be collected at each examination site and sent for analysis of fluoride content. In addition, information should be gathered about sources of fluoride available in the survey population and the level of usage of topical fluorides.

Personnel and Organization

Each examiner should be assisted by an alert and cooperative recording clerk who is able to follow instructions exactly and to print numbers and letters clearly. It is desirable to have an organizing clerk who can coordinate with survey procedures (supply and verification of forms, instruments, etc.) and maintain a constant flow of subjects to the examination site.

Instruments and Supplies

The quantity and weight of instruments and supplies used in a survey should be kept to a minimum, about 30 sets of mouth mirrors and CPI probes besides tweezers, containers, washbasins, clothes or paper towels and gauze. Current national recommendation and standard should be followed for both infection control and waste disposal. The use of disposable masks and gloves and the wearing of protective glasses are recommended.

Examination Area

The area for conducting examination should be planned and arranged for maximum efficiency and ease of operations. The most comfortable examination position for the examiner is to have a patient on a table or bench so that the examiner sits behind the patient's head. The lighting should be as consistent as possible throughout the survey. Care should be taken to avoid crowding and noise, and ensure that survey forms are available, instruments and recording clerk are within reach.

SURVEY FORM

In WHO oral health assessment form (1997) (see Appendix 2), name of the country is recorded in the space provided. Box numbers 1–4 are left blank and the corresponding boxes year, month (5–8), day (9–10), identification number (11–14), examiner code (15) and original/duplicate (16) are recorded.

In general information category, name of the subject is recorded followed by date of birth (17–20), age in years (21–22), sex (23), ethnic group (24), occupation (25), geographical location (26–28) and reason should be specified and entered (29–30), and reasons should be given if there are contradictions to examination and no/yes codes in box number 31.

Clinical assessment consists of external examination (box 32), TMJ assessment for symptoms (box 33) and signs (34–36). Intraoral examination consists of assessment of oral mucosa where conditions with corresponding location are entered (37–42).

Enamel opacities/hypoplasia are assessed on index teeth (14, 13, 12, 11, 21, 23, 24, 36, 46) using DDE index (43–52) while dental fluorosis is assessed using Dean's criteria (53).

CPI (54–59) and loss of attachment (60–65) are assessed on index teeth (17/16, 11, 26/27, 36/37, 31, 46/47).

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Dentition status (crown and root) and treatment needs are recorded for maxillary teeth (66–113) and mandibular teeth (114–161). In maxillary and mandibular teeth, status of crown and root are recorded separately followed by treatment needs.

Prosthetic status for upper and lower arches are entered in Box no 162, 163 while prosthetic need in 164 and 165.

Dentofacial anomalies are assessed using dental aesthetic index (DAI) with boxes for entering number missing incisors, canines and premolars in the dentition category (166–167), crowding (168), spacing (169), diastema (170), largest anterior maxillary (171) and mandibular irregularities (172) in the space category and anterior maxillary (173) and mandibular overjet (174), vertical anterior open bite (175) and anteroposterior molar relation (176) in occlusion category.

Need for immediate care and referral such as life-threatening conditions (177), pain or infection (178), other conditions (179) and referral (180) are entered as the case may be.

Space at the bottom is earmarked for notes to enter any patient's information which is important.

The fifth edition of WHO *Oral Health Surveys – Basic Methods* makes the following recommendations for oral health surveys.

- Dentition status should be recorded in compliance with the recommendations given in previous editions of this manual. Recording of specific dental treatment needs for individual teeth is no longer recommended.
- Recording of periodontal status by sextants or index teeth has been modified to include assessment of gingival bleeding and recording of pocket scores for all teeth present. Presence of calculus is not recorded. The recommendation not to probe pocket depth in children less than 15 years of age remains unchanged. Loss of attachment should be recorded using index teeth except in children under 15 years of age,
- Recording presence of enamel fluorosis is recommended. Calculation of the community fluorosis index.
- Loss of tooth substance due to erosion as well as the number of teeth involved.
- Orodental trauma includes injury to the mouth, including the teeth, lips, gingivae and tongue, and jaw bones.
- Recording of presence of fixed or removable dentures has been included in the adult assessment form.
- Examination of the oral mucosa and recording of extraoral conditions and their location using standardized coding are included. Most common oral lesions occurring in human immunodeficiency virus (HIV) infection and acquired immunodeficiency syndrome (AIDS) are also recorded.
- The section on intervention urgency specifies the recommended level of treatment in response to acute oral problems and the need for immediate referral to special care. This may also include preventive care or routine dental care required for large carious lesions with or without accompanying pain or evident infection. Urgent intervention may also be needed in cases of reported pain and obvious signs of severe infection.

CONCLUSION

Surveying has far-reaching impact on the population, much more than collection of facts. It involves key people in the community who later become aware of their oral health status and needs. This information can empower them to demand and lobby for better health services. Thus surveying can be an eye opener for the community as well as policy makers to strive for better quality of life.

REVIEW QUESTIONS

1. Define survey. Discuss steps in survey.
2. Define the following:
   a. Sampling
   b. Types of examination
   c. Pathfinders
   d. Index age groups
   e. Calibration

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17 Indices

Hiremath SS and Archana Krishnamurthy

CHAPTER OUTLINE

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INTRODUCTION

The good clinician thinks in qualitative terms. During the diagnostic examination, the dental practitioner not only goes for existing disease, but also tries to look ahead for the possibility of future disease. Measuring oral disease in a population however requires a more standardized and objective approach. Specific diagnostic criteria, written explicitly for clinical, microbiologic, radiographic and pathologic examination, has replaced the judgement of the practitioner. These criteria, meaning objective standards on which diagnostic judgement can be based, are applied to judge the condition of the oral tissues as they are at examination time, not on how they might be in the future. This objective application of diagnostic criteria is the most important philosophical difference between the epidemiological examination and that carried out for treatment planning.

An index is a representation of clinical observations of numbers. It is used usually to describe the relative status of the individual or the population with respect to a particular condition/disease being measured. Indices using various criteria have been developed to compare the extent and severity of the diseases. These measurements aid in the overall assessment of the oral health status.

Thus dental index or indices can be considered as the main tool of epidemiological studies in dental diseases to find out incidence, prevalence and severity of the diseases, based on which preventive programmes are adopted for their control and prevention.

DEFINITION OF INDEX

An index has been defined as a numerical value describing the relative status of a population on a graduated scale with definite upper and lower limits, which is designed to permit and facilitate comparison with other populations classified by the same criteria and methods (Russell AL).

OBJECTIVE OF AN INDEX

The main purpose or objective of using indices in dental epidemiology is to increase understanding of the disease process along with measurement of the disease prevalence and incidence, thereby leading to methods of control and prevention. In addition, it attempts to discover populations at high and low risk, and to define the specific problem under investigation.

The simplest form of measuring any disease is by a count of the number of cases, but going one step ahead and making more meaningful results by expressing it in terms of proportion or rate will be a much more useful measure, as the results of different populations can be compared.

PROPERTIES OF AN IDEAL INDEX

Validity

If the index measures what it was supposed to measure, it is said to be valid. The scores should correspond with the clinical condition.

Reliability

The index that gives the same measurement at different occasions is said to be reliable. The term *reliability is also called as reproducibility, repeatability* and *consistency,* meaning the ability of the examiners to interpret and use the index in the same way under different conditions.

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Clarity, Simplicity and Objectivity

The criteria should be clear and unambiguous, with mutually exclusive categories. Ideally, it should be readily memorized by an examiner after some practice.

Quantifiability

The index must be suitable to undergo statistical analysis, so that the outcomes can be expressed by a distribution, mean, median or other statistical measure.

Sensitivity

The index should be able to detect clinically relevant but small changes in the status of the condition, in either direction.

Acceptability

The use of the index should not be unnecessarily painful or demeaning to the subject.

PURPOSE AND USES OF AN INDEX

For Individual Patients

An index can:

1. Provide individual assessment to help a patient recognize an oral problem.
2. Reveal the degree of effectiveness of present oral hygiene practices.
3. Motivate the person in preventive and professional care for elimination and control of oral disease.
4. Evaluate the success of individual and professional treatment over a period of time by comparing index scores.
5. Provide a means for personal assessment by the dental hygienist of abilities to educate and motivate individual patients.

In Research

An index is used to:

1. Determine baseline data before experimental factors are introduced.
2. Measure the effectiveness of specific agents for the prevention, control or treatment of oral conditions.
3. Measure the effectiveness of mechanical devices for personal care, such as toothbrushes, interdental cleaning devices or water irrigators.

In Community Health

An index can:

1. Show the prevalence and trends of incidence of a particular condition occurring within a given population.
2. Provide baseline data to show existing dental health practices.
3. Assess the needs of a community.
4. Compare the effects of a community programme and evaluate the results.

SELECTION OF AN INDEX

To select an index to evaluate studies, the following criteria should be used:

1. Studies conducted with different indices should be compared for general findings rather than specific details.
2. Indices should be selected according to their potential to best evaluate the variable or condition being assessed, e.g. it is difficult to accurately determine plaque severity scores on proximal tooth surfaces. On these surfaces, scoring on presence or absence of plaque is probably more precise.
3. In general, indices should be used without modification of methodology or criteria. In those rare instances where the criteria are modified, interpretation of the results should be modified in a like manner.
4. While indices measuring severity are extremely useful in conducting epidemiologic survey and clinical trials, indices measuring only the presence or absence of an entity are probably more amenable to patient's motivation efforts.
5. When evaluating the individual patient or when conducting studies with small samples, it is best to use a full mouth index. Simplified indexes are most useful in epidemiologic surveys and clinical trials in which sample sizes are large.
6. Examiners should establish their reliability with an index prior to using it in any research project. Additionally, throughout the course of an investigation both inter-examiner and intra-examiner reliability must be re-evaluated repeatedly.

TYPES OF INDICES

1. Plaque index
2. Oral hygiene index
3. Gingival index
4. Periodontal index
   - Periodontal disease index (PDI)
   - Russell's periodontal index
   - Community periodontal index and treatment needs (CPITN)
   - Community periodontal index (CPI)
5. Dental caries indices
   - DMFT
   - DMFS
   - deft
   - defs
   - Root caries index (RCI)
   - Significant caries index (SiC)
6. Dental fluorosis index
7. Dental aesthetic index.

Plaque Index

Turesky–Gilmore–Glickman modification of the Quigley–Hein plaque index. Quigley G and Hein J in 1962 reported a plaque measurement index that focused on the gingival third of the tooth surface. They examined only the facial surfaces

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of the anterior teeth, using a basic fuchsine mouthwash as a disclosing agent. A numerical scoring system of '0' to '5' was used.

Turesky S, Gilmore ND, and Glickman I modified the Quigley–Hein plaque index in 1970.

This modification of the Quigley–Hein plaque index was done by strengthening the objectivity of Quigley plaque index criteria by redefining the scores of the gingival third area. This modification of the index is a reliable index to measure plaque by measuring the area covered by plaque.

Plaque was assessed on the labial, buccal and lingual surfaces of all the teeth after using a disclosing agent. This system of scoring plaque is relatively easy to use because of the objective definitions of each numerical score (Table 17.1).

This technique with the modification of scoring plaque on 3 surfaces, namely the labial, buccal and lingual surfaces gives a complete method for evaluating antiplaque procedures such as tooth brushing and flossing, and also the chemical antiplaque agents. This index gives more importance to the collection of plaque in the gingival third of the tooth.

Scoring method. Dental plaque is assessed by scoring on labial, buccal and lingual surfaces of all the teeth after using disclosing agent (Fig. 17.1).

Silness–Löe plaque index (Silness and Löe, 1964). Similar to the gingival index, the plaque index also has its basis from the principle of measuring the severity and location of the soft debris collection. The purpose of this index (Silness and Löe 1964) was also to complement the gingival index completely.

The quantity of soft debris and mineralized deposits on the few selected teeth as indicated below is recorded by Silness–Löe plaque index (Fig. 17.2).

There is no substitution of missing teeth. For each of these teeth, four surfaces, namely, buccal, lingual, mesial and distal surfaces are examined and scored from 0 to 3. The scores from the 4 areas of the tooth are summed and averaged to indicate the plaque index for the tooth with the following scores and criteria (Table 17.2).

Scoring method. This is depicted in Figure 17.3.

Table 17.1 Turesky–Gilmore–Glickman modification of the Quigley–Hein plaque index: scoring system

Code	Criteria
0	No plaque
1	Separate flecks of plaque at the cervical margin of the tooth
2	A thin continuous band of plaque (up to 1 mm) at the cervical margin
3	A band of plaque wider than 1 mm but covering less than 1/3rd of the crown of the tooth
4	Plaque covering at least 1/3rd but less than 2/3 of the crown
5	Plaque covering 2/3rd or more of the crown

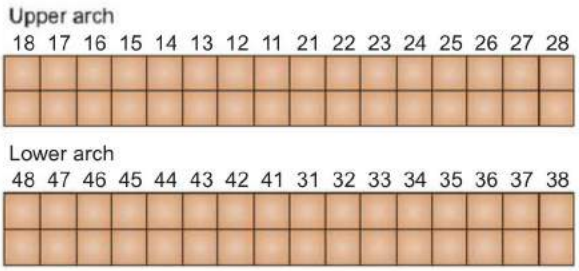


Figure 17.1 Scoring method in Turesky–Gilmore–Glickman modification of the Quigley–Hein plaque index.

Oral Hygiene Index

Many investigators have developed and used a variety of methods for estimating the status of oral hygiene in population and groups. However, those methods have not proved to be simple, objective tools for assessing oral hygiene status quantitatively since they appear to be based

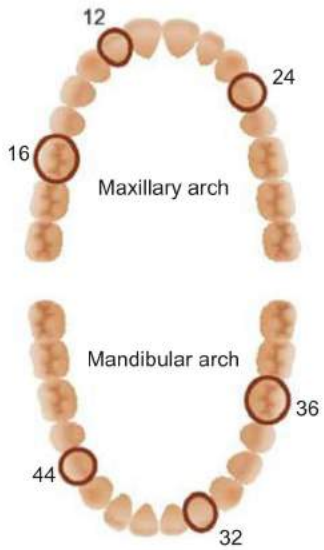


Figure 17.2 Silness–Löe plaque index scoring system.

Table 17.2 Scoring criteria for plaque index

Scores	Criteria
0	No plaque
1	A film of plaque adhering to the free gingival margin and adjacent area of the tooth The plaque may be seen in situ only after application of disclosing solution or by using the probe on the tooth surface
2	Moderate accumulation of soft deposits within the gingival pocket, or the tooth and gingival margin which can be seen with the naked eye
3	Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin

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Figure 17.3 Components of oral hygiene index.

on fairly subjective criteria, therefore sizeable inter and intra-examiner differences were there. A simple quantitative expression of oral cleanliness which is based on clearly defined criteria and which reduces examiner's variations to a minimum has been needed for many years. Such a tool would be useful in studying the epidemiology of periodontal disease and oral deposits in assessing tooth-brushing efficiency evaluation of dental health practices of the community and long-term effects of dental health procedures.

Therefore, there was a need to develop a simple qualitative expression of oral cleanliness. With this in mind, a method for quantifying individual and group oral hygiene status was developed over a period of four years by **John C Greene and Jack R Vermillion in 1960**.

Oral hygiene index is composed of two components (Fig. 17.3).

Mouth is divided into 6 segments (Fig. 17.4).

Segment 1—Upper right 2nd molar to 1st premolar
Segment 2—Upper right canine to upper left canine
Segment 3—Upper left 1st premolar to upper 2nd molar

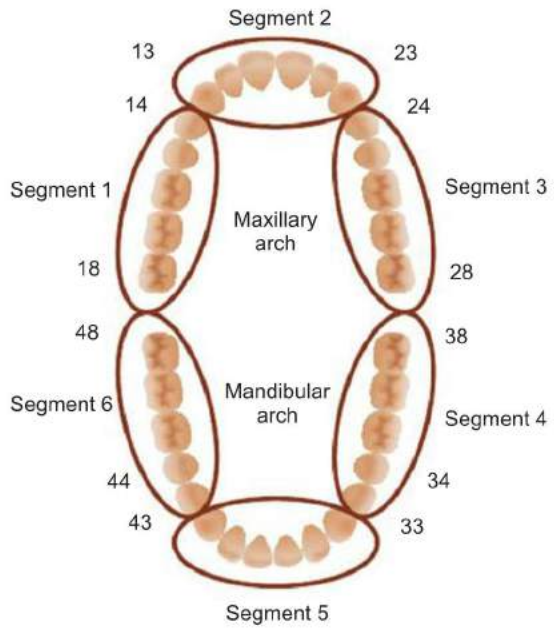


Figure 17.4 Segment wise division of the mouth.

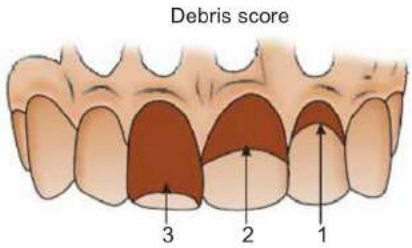


Figure 17.5 Scoring method for the debris.

Segment 4—Lower left 2nd molar to lower left 1st premolar
Segment 5—Lower left canine to lower right canine
Segment 6—Lower right 1st premolar to lower right 2nd molar.

Method of Examination

The separate recording for both oral debris and calculus is recorded in each segment. In each segment, two surfaces are recorded namely, facial and lingual/palatal surfaces of each tooth. Debris and calculus score assigned to a segment is based on the buccal-lingual surfaces having the greatest scores.

Calculation of Index Scores

The scores for debris and calculus should be tabulated separately and indices for each calculated independently but in the same manner, and added together for calculating oral hygiene index (Fig. 17.5).

Debris	Score
0	No debris or stain present.
1	Soft debris covering not more than 1/3rd of the tooth surface or the presence of extrinsic stains without the debris regardless of surface are covered.
2	Soft debris covering more than 1/3rd but not more than 2/3rd of the exposed tooth surface.
3	Soft debris covering more than 2/3rds of the exposed tooth surface.

$$1.\ \text{Debris Index (DI)} = \frac{\text{Total debris score recorded}}{\text{No. of segments scored}}$$

Range of Debris Index

Minimum – 0
Maximum – 6

Whenever in doubt, score the lower value for particular criteria.

$$2.\ \text{Calculus Index (CI)} = \frac{\text{Total calculus score recorded}}{\text{No. of segments scored}}$$

Range of Calculus Index

Minimum – 0
Maximum – 6

$$\text{Oral Hygiene Index} = \text{Debris Index (DI)} + \text{Calculus Index (CI)}$$

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Range of Oral Hygiene Index is 0–12.

Calculus	Score
0	No calculus present.
1	Supragingival calculus covering not more than 1/3rd of the exposed tooth surface.
2	Supragingival covering more than 1/3rd, but not more than 2/3rd of the exposed tooth surface or the presence of individual flecks of subgingival calculus around the cervical portion of the tooth or both.
3	Supragingival calculus covering more than 2/3rd of the exposed tooth surface or a continuation of heavy band of subgingival calculus around the cervical portion of the tooth.

Advantages

1. Sensitive enough to reflect the cleansing efficiency of the tooth brushing and the expected relationships between oral cleanliness and periodontal disease.
2. Simple, useful method for assessing a group of individual oral hygiene status quantitatively.
3. Useful tool in programme evaluation in monitoring oral hygiene maintenance programmes.
4. Can assess individual's attitude and effectiveness of tooth brushing in oral hygiene practices.

Limitations

1. Examination of all surfaces of all teeth present in the mouth (though only 12 surfaces are scored), hence requires more time.
2. Since it is time-consuming, it cannot be used in epidemiological surveys.
3. Cannot be used for mixed dentition.
4. Inter- and intra-examiner differences are more.

Oral Hygiene Index-Simplified

The oral hygiene index (OHI) was depicted as a sensitive simple method for assessing group, individual oral hygiene quantitatively. Though sensitive, simple and useful, the oral hygiene index, nevertheless, demands the evaluator to make more number of decisions and spend significant amount of time to arrive at his evaluation.

The oral hygiene index, the method for classifying oral hygiene status of population or groups, has been simplified. Although the simplified oral hygiene index does not pose as great a degree of sensitivity as the original index, it offers a more rapid method of evaluating the oral cleanliness of population groups. With this background, efforts were made to develop an index that was sensitive but also less time-consuming by reducing the number of decisions to be taken. This index was named as Oral Hygiene Index-Simplified (OHI-S) by John C Greene and Jack R Vermillion in 1964.

Oral hygiene index-simplified differs from oral hygiene index in:

- The number of tooth surfaces and type of tooth surface scored.

Greene and Vermillion selected 6 index teeth with selected surfaces that is buccal surfaces of 16, 26 and labial surface of 11, 31 whereas lingual surfaces of 36 and 46 which represent all anterior and posterior teeth in each segment of the mouth are examined.

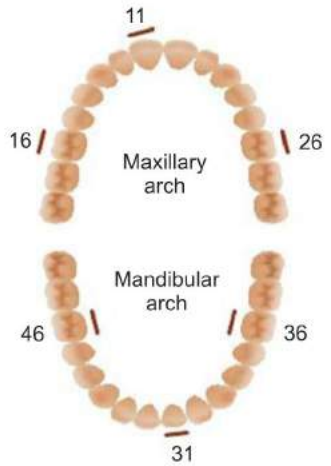


Figure 17.6 Examination and scoring of different tooth surfaces.

Oral Hygiene Index-S = Debris Index-S + Calculus Index-S

Tooth surfaces to be examined *(Fig. 17.6)*

The fully erupted tooth distal to second bicuspid, usually first molars, are examined on each side of the arch:

Upper molars – buccal surfaces
Lower molars – lingual surfaces

Labial surfaces of the upper right and lower left central incisors are examined. If these teeth are absent, the central incisor on the opposite side of the midline is substituted.

- Permanent teeth that are fully erupted are eligible for scoring.
- Teeth with full crowns and crowns with decreased height due to caries or trauma are not indicated for scoring.

The debris index-s and calculus index-s values range from 0 to 3.

The oral hygiene index-s values range from 0 to 6.

Interpretation of the oral hygiene index-s values at a community level:

For the DI-S and CI-S score,
Good: 0.0 to 0.6
Fair: 0.7 to 1.8
Poor: 1.9 to 3.0
For the OHI-S score,
Good: 0.0 to 1.2
Fair: 1.3 to 3.0
Poor: 3.1 to 6.0

Advantages

1. It is easy to use.
2. Requires less time and hence can be used in field studies, sometimes in selected clinical trials and programme evaluation.
3. It may be used as an adjunct in epidemiological studies of periodontal disease.
4. It determines the status of oral hygiene cleanliness in groups.

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5. Useful in the evaluation of dental health education procedures (immediate and long-term effects).
6. Inter- and intra-examiner errors are less.

Limitations

1. Lacks the degree of sensitivity as much as the original version.
2. Underestimation or overestimation of debris and calculus may occur.
3. Not appropriate for individual oral hygiene status evaluation.
4. Not appropriate for certain types of clinical studies (clinical trials and research) including detailed investigation of plaque or calculus formation.

Gingival Index

The main purpose of developing the gingival index (GI) is for assessment of the gingival condition by differentiating between the quality of gingiva (the severity of the lesion), and the location (quantity) in relation to four surfaces (buccal, mesial, distal, lingual) making up the total circumference of the free gingiva (Löe and Silness 1963).

The GI does not consider periodontal pocket depth, degree of bone loss or any other quantitative change in the periodontium.

Since gingival area constitutes the unit, the GI may be scored for all surfaces of all or the selected teeth. It may be applied at a population as well as individual level to estimate the prevalence and severity of gingivitis.

Gingival index—Löe and Silness. Gingival index (GI) was developed by Löe and Silness to describe the severity of gingivitis and its location (Table 17.3).

Table 17.3 Gingival index—Löe–Silness

Appearance	Bleeding	Inflammation	Score
Normal	No bleeding	None	0
Slight change in colour and mild oedema with slight change in texture	No bleeding	Mild	1
Redness, hypertrophy, oedema and glazing	Bleeding on probing/ pressure	Moderate	2
Marked redness, hypertrophy, oedema, ulceration	Spontaneous bleeding	Severe	3

Teeth Examined	Surfaces Examined on Each Tooth
1. Maxillary right first molar	1. Buccal
2. Maxillary right lateral incisor	2. Lingual
3. Maxillary left first bicuspid	3. Mesial
4. Mandibular left first molar	4. Distal
5. Mandibular left lateral incisor	
6. Mandibular right first bicuspid	

Table 17.4 Gingival index: interpretation

Average Gingival Index	Interpretation
2.1–3.0	Severe inflammation
1.1–2.0	Moderate inflammation
0.1–1.0	Mild inflammation
< 0.1	No inflammation

Calculation

Gingival index for a specific tooth

= AVERAGE (points for the 4 surfaces)

The averaging of score of 4 surfaces and divided by 4.

Gingival index for patient

= AVERAGE (gingival indices for all 6 teeth)

Totalling of all of this score per tooth and dividing by the number of teeth examined.

Based on this method, using the average score, the value of index score can be interpreted for a group (Table 17.4).

Limitations

Subsequent to gingival index, many modifications have been made which are highly sensitive to mild gingivitis and few have eliminated the need to probe for assessment.

Periodontal Index

Periodontal disease index (PDI). The periodontal disease index (PDI) was developed in 1959 by Sigurd P Ramfjord.

The PDI is a clinical application of Russell's periodontal index (PI) for epidemiological studies of periodontal disease. The PDI gives a precise assessment of the periodontal status of the individual. Level of attachment in relation to cementoenamel junction is the primary focus of assessment. Hence, this index can be used in the follow-up of longitudinal studies of periodontal disease and clinical trials.

Objectives of PDI

The following objectives are incorporated into the design of the index:

1. To assess prevalence and severity of gingivitis and periodontitis within the individual dentitions and in population groups.
2. To provide an accurate basis for incidence and longitudinal studies of periodontal disease.
3. To provide a meaningful basis for estimation of need for periodontal therapy in selected population groups.
4. To provide accurate recordings for clinical trials of preventive and therapeutic procedures in periodontics.
5. To provide measurable reference data for assessment of correlations with factors of potential significance in the aetiology of periodontal disease.

Assessment of degree of periodontal disease includes a subjective assessment of colour, form, density and bleeding tendency of the gingival tissues with emphasis on the

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level of the periodontal attachment related to the cementoenamel junction of the teeth.

Scoring Methods

Only six selected teeth are scored for assessment of the periodontal status of the mouth; however, for short-term clinical trials and where a limited number of patients are available, one may consider all of the teeth in the mouth. The six selected index teeth are:

16—Maxillary right first molar
21—Maxillary left central incisor
24—Maxillary left first premolar
36—Mandibular left first molar
41—Mandibular right central incisor
44—Mandibular right first premolar

The gingival status is scored first. The gingivae around the teeth to be scored are first dried superficially by gently touching with absorbing cotton.

Scoring Criteria

The scoring criteria for the periodontal disease index are depicted in Table 17.5.

Calculation of PDI Scores

The PDI score for the individual is obtained by totalling the scores for each tooth examined and then, dividing by the number of teeth examined. The PDI score ranges from 0 to 6.

The PDI score for a group is obtained by totalling the individual PDI scores and then, dividing by the number of people examined. The average PDI score for a group ranges from 0 to 6.

Russell's periodontal index—1956

Russell's periodontal index measures both reversible and irreversible aspects of periodontal disease. It is an epidemiologic index with a true biological quotient. The instruments used are mouth mirror and periodontal probe.

Table 17.5 Periodontal disease index: scoring criteria

0	Absence of inflammation
1	Mild to moderate inflammatory gingival changes not extending all around the tooth.
2	Mild to moderately severe gingivitis extending all around the tooth.
3	Severe gingivitis, characterized by marked redness, tendency to bleed and ulceration.
4	Gingival crevice in any of the four measured areas (mesial, distal, buccal, lingual), **extending atypically to the cementoenamel junction but not more than 3 mm.**
5	Gingival crevice in any of the four measured areas extending apically to the cementoenamel junction 3–6 mm.
6	Gingival crevice in any of the four measured areas extending apically more than 6 mm from the cementoenamel junction.

Examination Procedure

- Every tooth present is scored.
- Root stumps are not examined.

Scoring Criteria and Pattern

Score 0—*Negative* (Fig. 17.7)

(Neither overt inflammation in the investing tissues nor loss of function due to destruction of supporting tissues.)

Score 1—Mild gingivitis (Fig. 17.8) (An overt inflammation of free gingiva that does not circumscribe the tooth.)

Score 2—Gingivitis (Fig. 17.9A, B) (Inflammation completely circumscribing the tooth, but there is no apparent break in the epithelial attachment.)

Score 4—Onset of periodontitis—Used when radiographs are available—shows notch like resorption of crystal bone.

Score 6—Gingivitis with pocket formation (Figs 17.10A, B) (The epithelial attachment is broken, and there is a pocket. There is no interference with normal masticatory function, the tooth is firm in its socket, and has not drifted, no mobility and pathological migration.)

Score 8—Advanced destruction with loss of masticatory function (Figs 17.11A, B).

(Tooth may be loose; tooth may have drifted; tooth may sound dull on percussion with a metallic instrument; the tooth may be depressible in its socket.)

Rule: When in doubt, assign lesser score.

The scores of each tooth present are added together and divided by the total teeth scored, and then rounded off to one place beyond the decimal point (Table 17.6).



Figure 17.7 Normal gingiva.



Figure 17.8 Mild gingivitis.

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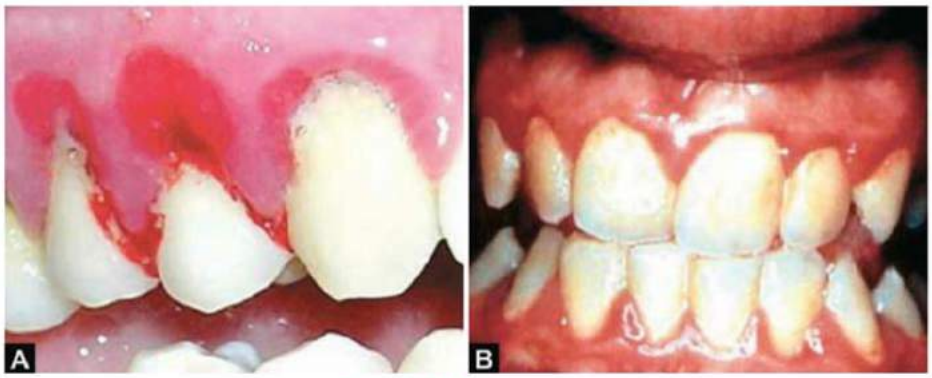


Figure 17.9 Gingivitis.

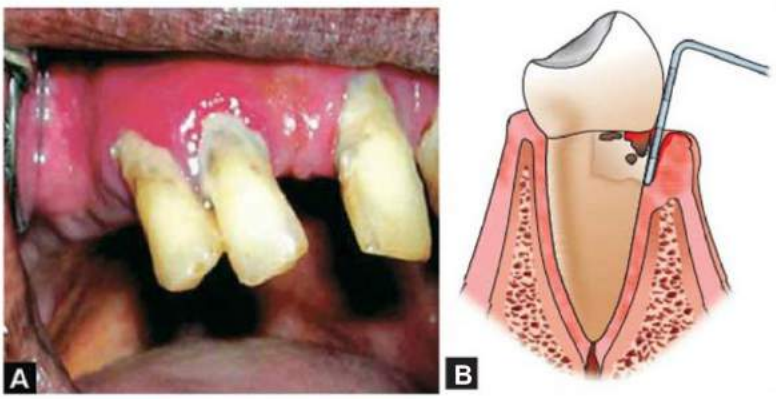


Figure 17.10 Gingivitis with pocket formation.

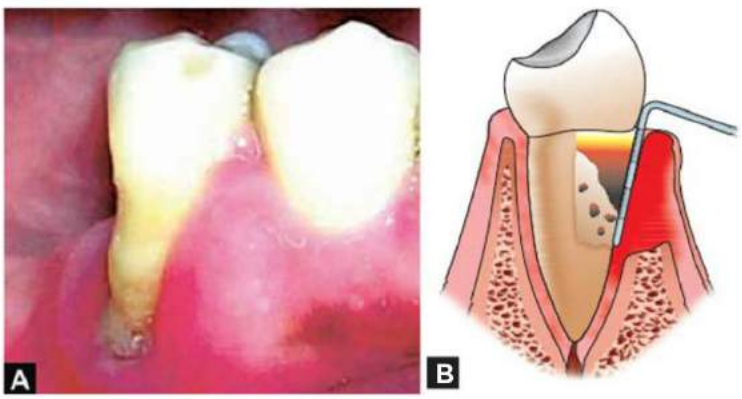


Figure 17.11 Advanced periodontitis with destruction.

Uses

- Epidemiological studies
- Most useful when it is necessary to distinguish between population with mild, moderate and advanced chronic destructive disease.

Advantages

1. Easy and quickly learned, and is reproducible.
2. Index is simple enough to be practicable under a wide variety of field conditions.
3. This index measures both reversible and irreversible aspects of periodontal disease, hence it is known as an epidemiologic index with significance.
4. Significance of periodontal index is that more data has been assembled using this index than any other index of periodontal disease.
5. The application and uses of Russell's periodontal index in the past have led to the development of better understanding of periodontal health status including research in the present era.
6. Criteria are clear and most of the time in epidemiological studies, results obtained are comparable.

Limitations

1. In field surveys, carrying radiographic facilities is impracticable and hence score 4 cannot be used.
2. Index scores from 2 onwards, jump to 4, 6 and 8 only to signify the severity and nature of destruction of periodontium, which are not recordable, and most of them are irreversible.
3. More time-consuming.

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Table 17.6 Russell's periodontal index: scoring criteria

Criteria for Field Studies	Additional X-Ray Criteria	Score
Negative (neither overt inflammation in the investing tissues nor loss of function due to the destruction of supporting tissues). Mild gingivitis (overt area of inflammation in the free gingivae, but this area does not circumscribe the tooth) Gingivitis (inflammation completely circumscribes the tooth, but there is no apparent break in the epithelial attachment)	Radiographic appearance normal	0 1 2
(Not used in field study) Gingivitis with pocket formation (the epithelial attachment is broken, and there is a pocket. There is no interference with normal masticatory function, the tooth is firm in its socket, and has not drifted	Early, notch-like resorption of the alveolar crest Horizontal bone loss involving the entire alveolar crest, up to half of the length of the tooth root (distance from apex to cementoenamel junction)	4 6
Advanced destruction with loss of masticatory function (tooth may be loose; tooth may have drifted; tooth may sound dull on percussion with a metallic instrument; the tooth may be depressible in its socket)	Advanced bone loss, involving more than half of the length of the tooth root, or a definite intra-bony pocket with definite widening of the periodontal membranes. There may be root resorption or rarefaction at the apex	8

4. This index is not sensitive to minor changes in periodontium.
5. No standardized probes are used.
6. It does not give past periodontal disease experience.

Interpretation of scores: (applicable only at community level)

Clinical Condition	Individual PI Score
Clinically normal supportive tissues	0–0.2
Simple gingivitis	0.3–0.9
Beginning destructive periodontal disease	1.0–1.9
Established destructive periodontal disease	2.0–4.9
Terminal disease	5.0–8.0

Community Periodontal Index of Treatment Needs (CPITNs)

This index was advocated by J Ainamo, Cutress, Barmes, Sardo-Infirri in 1980. The joint FDI/WHO working group was established in 1979 to develop and test survey method for assessing periodontal conditions, suggested in a WHO technical report (WHO 1978).

Following extensive discussions and testing, the CPITN was finalized and described in 1983. Over the past few years, the CPITN has been increasingly adapted as a procedure for classifying periodontal conditions with respect to the complexity of the care and oral health personnel required to restore periodontal tissues to a healthy condition.

Although originally intended as a screening procedure for epidemiological purposes, the index has been adapted and adopted for other purposes in a promotional role in developing periodontal health awareness programmes, for initial screening and for monitoring changes in periodontal needs of individuals in clinical practice.

Development of CPITN Methodology

1. In 1977, WHO organized a workshop in Moscow inviting experts from 14 countries to examine and advice on the epidemiology, aetiology and prevention of periodontal disease.
2. To develop CPITN, the criteria are agreed upon by the group and published in 1978 (the clinical examination proposed by Ainamo and Ainamo). Later minor modifications were made in 1982 and have been in use for more than 20 years.
3. a. The original CPITN divided the mouth into 6 sextants (teeth numbers 17–14, 13–23, 24–27, 37–34, 33–43 and 44–47).
   b. The clinical findings and observation were categorized into 5 codes (0–4).
   c. The periodontal treatment need indicators into 4 different treatment need categories (0–3).
   d. Treatment need is assessed using specially designed WHO colour-coded periodontal probe for assessment of probing pocket depths around either all teeth or all the WHO designated index teeth (the probe developed by WHO and described in detail by Emslie in 1980 (Figs 17.12A, B). Based on the graduations on the probe, 2 types of CPITN probes were developed; CPITN – E probe and CPITN – C probe.
   e. For each sextant only the highest treatment need indicator is recorded.
   f. In CPITN methodology, probing force is between 0–20 g.

Method of Examination

The dentition is divided into six sextants (Fig. 17.13) consisting of teeth 17–14, 13–23, 24–27, 37–34, 33–43, 44–47.

Highest score in each sextant is identified after examining all teeth.

- A sextant is examined only if there are two or more functional teeth present and not indicated for extraction.
- When only one tooth remains in a sextant it is included in the adjacent sextant.
- In epidemiological surveys, the scores are recorded by examination of specified index teeth.

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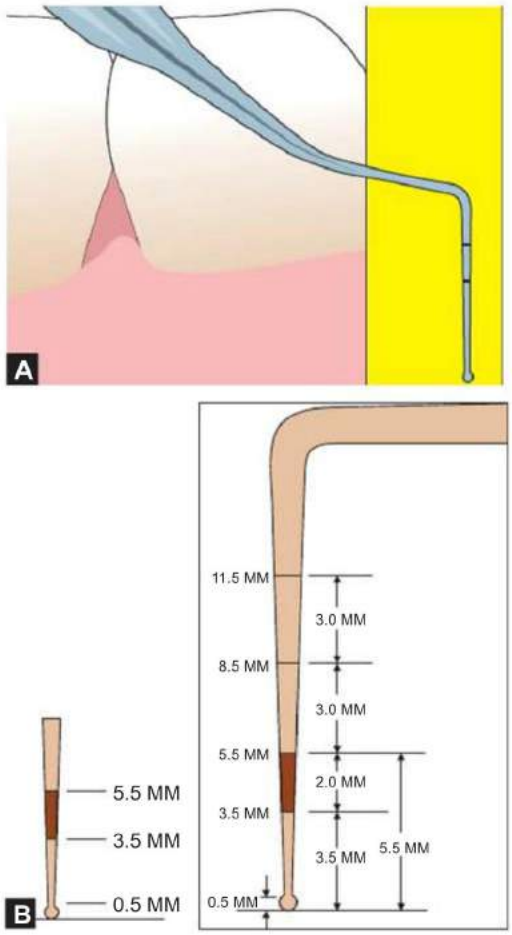


Figure 17.12 CPITN probe.

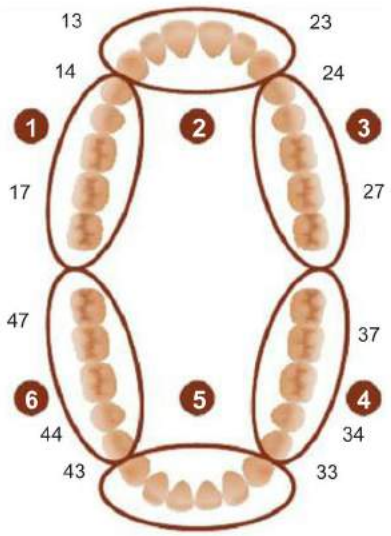


Figure 17.13 Sextant wise distribution of the mouth.

Index Teeth

- For adults aged 20 years or more only 10 index teeth are examined. Ten specified teeth are:
  17 16 11 26 27
  47 46 31 36 47
- These teeth have been identified as the best estimators of the worst periodontal condition of the mouth.
- For young people up to 19 years only six index teeth are examined:
  16 11 26 46 31 36
- Second molars are excluded as index teeth at these ages because of high frequency of false pockets.
- When examining children less than 15 years, pockets are not recorded.

Scoring Criteria

Code X—When only one tooth or no functional teeth are present in a sextant.

Code 1—Bleeding observed during or after probing (Figs 17.14A, B).

Code 2—Supra- or subgingival calculus seen or felt during probing (Figs 17.15A, B).

Code 3—Pathological pocket of 4 or 5 mm, i.e. the black area of the CPITN probe is at the gingival margin (Figs 17.16A, B).

Code 4—Pathological pocket of 6 mm or more, i.e. the black area of the CPITN probe is not visible (Figs 17.17A, B).

For Treatment Needs

TN 0—A recording of code 0 (healthy)—no treatment.

TN I—A code of 1 indicates a need for improving the personal oral hygiene of that individual—I.

TN II—A code of 2 and 3 indicates need for professional cleaning, root planning and removal of plaque retentive factors. In addition, patient obviously requires oral hygiene instructions—II + I.

TN III—Code of 4 requires complex treatment which involves deep scaling, root planning and more complex surgical procedures—III + II + I.

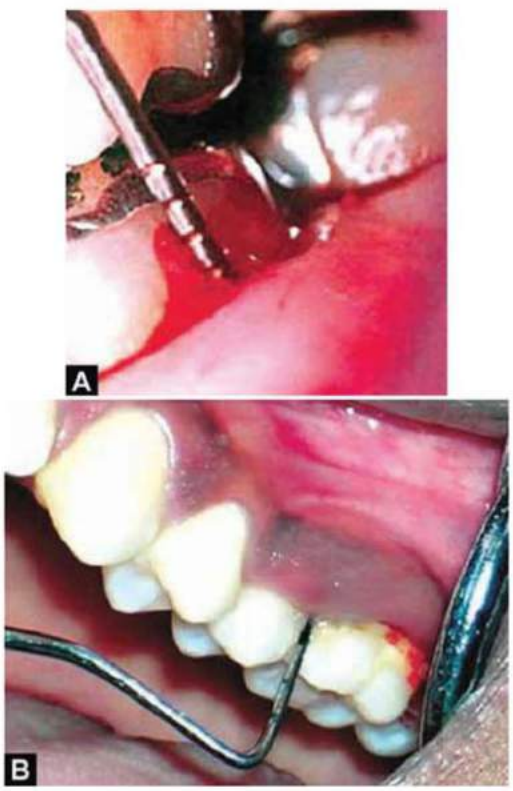


Figure 17.14 Gingival bleeding after probing.

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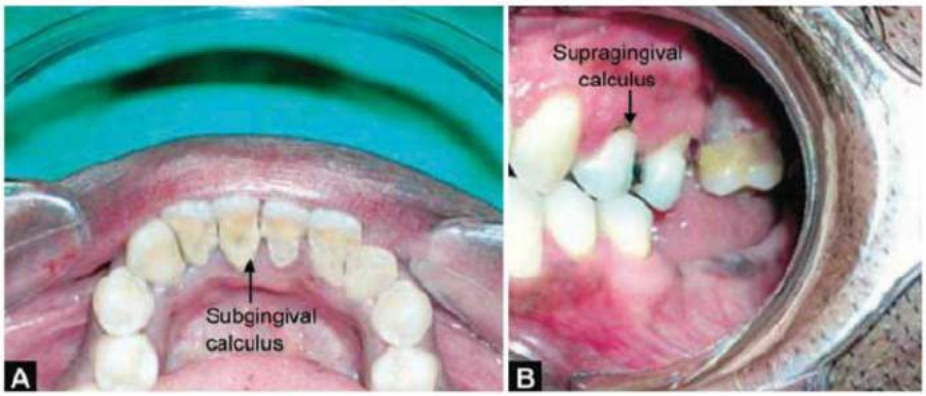


Figure 17.15 Sub- and supragingival calculus.

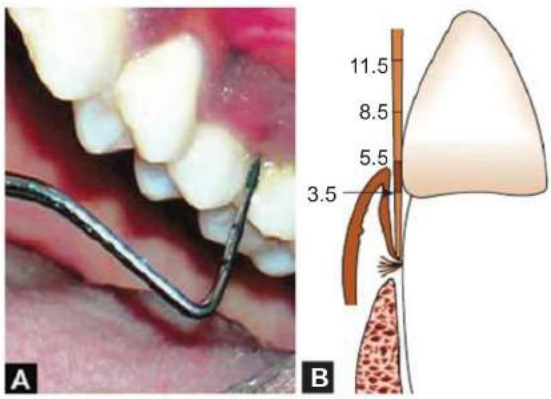


Figure 17.16 Pathological pocket of 4–5 mm.

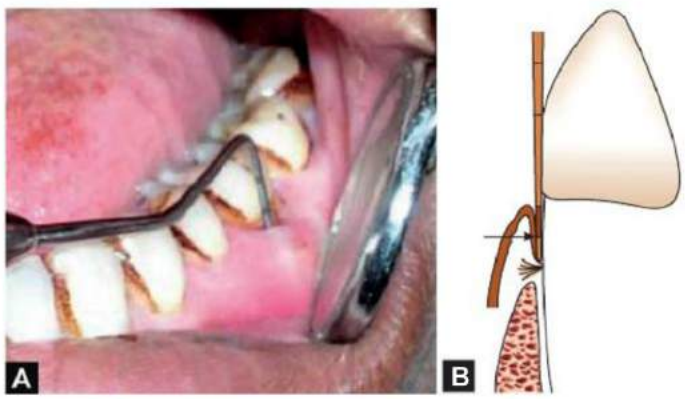


Figure 17.17 Pathological pocket of 6 mm or more.

Advantages

1. When compared to other epidemiological indices for periodontal health, the CPITN is simple and more objective in the method of application.
2. The data offers quick assessment of the periodontal condition of a population, their treatment needs and manpower required.
3. International uniformity.
4. Treatment needs provide an indication of the level of complexity of care needed if the periodontal conditions are to improve.

Limitations

1. Does not provide assessment of past periodontal disease experience
2. Does not record the position of gingival margin, i.e. the degree of recession, level of alveolar bone
3. Past periodontal experiences like attachment loss, and tooth mobility cannot be assessed using this index.
4. Any markers of disease activity or susceptibility are not included.
5. Underestimation of number of pockets greater than 6 mm in older age groups
6. No difference between supra- and subgingival calculus
7. No distinction is made between the presence of calculus with or without bleeding
8. Validity of CPITN index as a measure of the amount of periodontal care needed has not been demonstrated
9. The validity of CPITN—it appears that index underestimates in some areas and overestimates in others
10. It must be remembered that CPITN is not a research tool but rather a measure of treatment need
11. It should not be used as a measure of periodontitis in research studies
12. CPITN has been criticized for its measurement of pockets rather than loss of periodontal attachment.

Community periodontal index (CPI). This was introduced in 1994 by WHO.

Indicators: The three indicators used by its index to estimate periodontal status are: (i) gingival bleeding, (ii) calculus and (iii) periodontal pockets.

CPI index uses a specially designed lightweight probe called CPI probe which has a 0.5 mm ball at the tip, black band between 3.5 and 5.5 mm graduations and rings at 8.5 and 11.5 mm from the ball tip.

Sextants: The dentition is divided into 6 sextants: 18–14, 13–23, 24–28, 38–34, 33–43 and 44–48. A sextant qualifies for examination only if two or more teeth are present and are not indicated for extraction. The single remaining tooth should not be included in the adjacent sextant in contrast to CPITN.

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Index teeth: For adults aged 20 years and over, the teeth to be examined are:

Teeth to be examined

17	16	11	26	27
47	46	31	36	37

The two molars in each posterior sextant are paired for recording, and if one is missing, there is no replacement. If no index tooth or teeth is present in a sextant qualifying for examination, all the remaining teeth in that sextant are examined, and the highest score is recorded as the score for the sextant. In this case, distal surfaces of third molars should not be scored.

For subjects under the age of 20 years, only six teeth—16, 11, 26, 36, 31 and 46—are examined. This modification is made in order to avoid scoring the deepened sulcus associated with eruption as periodontal pockets. For the same reason, when examining children under the age of 15, pockets should not be recorded, i.e. only bleeding and calculus should be considered.

Sensing gingival pockets and calculus: An index tooth should be probed, using the probe as a "sensing" instrument to determine pocket depth and to detect subgingival calculus and bleeding response. The sensing force used should be no more than 20 g. A practical test for establishing this force is to place the probe point under the thumbnail and press until blanching occurs. For sensing subgingival calculus, the lightest possible force that allows movement of the probe ball tip along the tooth surface should be used.

When the probe is inserted, the ball tip should follow the anatomical configuration of the surface of the tooth root. If the patient feels pain during probing, this is indicative of the use of too much force.

The probe tip should be inserted gently into the gingival sulcus or pocket and the total extent of the sulcus or pocket is explored. For example, the probe is placed in the pocket at the distobuccal surface of the second molar, as close as possible to the contact point with the third molar, keeping the probe parallel to the long axis of the tooth. The probe is then moved gently, with short upward and downward movements, along the buccal sulcus or pocket to the mesial surface of the second molar, and from the distobuccal surface of the first molar towards the contact area with the premolar. A similar procedure is carried out for the lingual surfaces, starting distolingually to the second molar.

Examination and Recording

The index teeth, all remaining teeth in a sextant where there is no index tooth, should be probed and the highest score recorded in the appropriate box. The codes are as depicted in Table 17.7.

Loss of Attachment

In order to have more comprehensive assessment of the periodontal status of the population, WHO introduced loss of attachment criteria in CPI:

- **Score 0**—loss of attachment: 0–3 mm (Fig. 17.18) (CEJ not visible and CPI score 0–3 mm)
- **Score 1**—loss of attachment: 4–5 mm (Fig. 17.19) (CEJ within the black band)

Table 17.7 Community periodontal index: scoring criteria

0	Healthy
1	Bleeding observed, directly or by using mouth mirror, after probing
2	Calculus detected during probing, but all the black band on the probe visible
3	Pocket 4–5 mm (gingival margin within the black band on the probe)
4	Pocket 6 mm or more (black band on the probe not visible)
X	Excluded sextant (less than two teeth present)
9	Not recorded

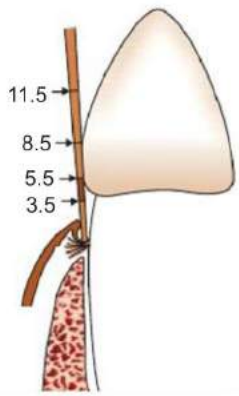


Figure 17.18 Loss of attachment, 0–3 mm—score 0.

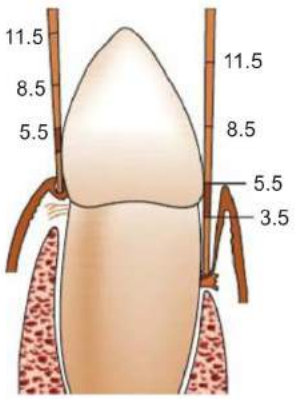


Figure 17.19 Loss of attachment, 4–5 mm—score 1.

- **Score 2**—loss of attachment: 6–8 mm (Fig. 17.20) (CEJ between the upper limit of the black band and 8.5 mm)
- **Score 3**—loss of attachment: 9–11 mm (Fig. 17.21) (CEJ between the 8.5 mm and 11.5 mm)
- **Score 4**—loss of attachment:12 mm or more (Fig. 17.22) (CEJ beyond the 11.5 mm)
- **Score X**—excluded sextant
- **Score 9**—not recorded (CEJ neither visible nor detectable).

Advantages

- Comprehensive measurement of periodontal diseases
- Severity of the disease can be measured
- Treatment need can be recorded.

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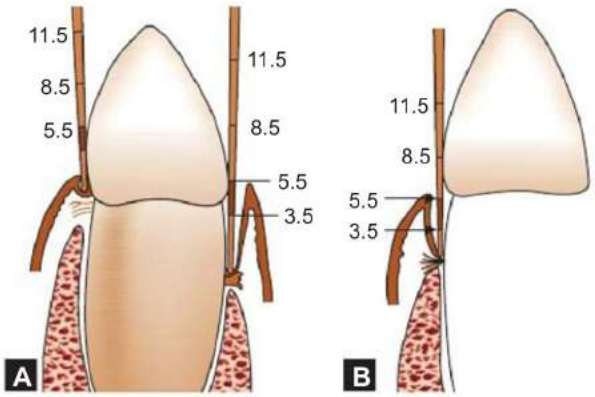


Figure 17.20 Loss of attachment, 6–8 mm—score 2.

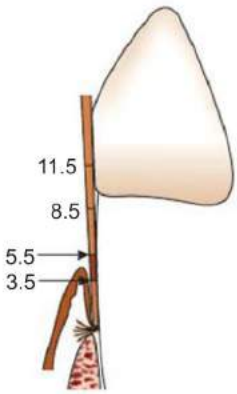


Figure 17.21 Loss of attachment, 9–11 mm—score 3.

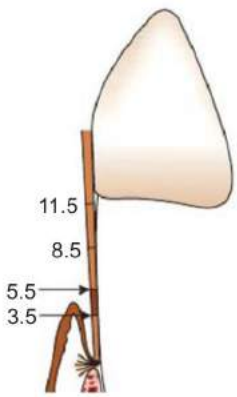


Figure 17.22 Loss of attachment, 12 mm or more score 4.

Limitations
- Time consuming
- Calibration will be difficult as CPI involves many criteria.

Dental Caries Indices

DMF index for permanent teeth (DMFT). Dental caries has become a significant oral health problem globally. It is clinically defined as a lesion that extends beyond the surface of enamel or cementum. It is identified by being penetrable with a dental explorer or by discolouration ranging from white to deep brown, although caries diagnosis threshold varies significantly between different types of research, as well as between traditional epidemiological survey and clinical practice. However, values for caries prevalence and incidence are expressed using the DMF index.

Indices for dental caries have been formulated by many investigators. The measurements of the intensity of dental caries, such as the proportion of tooth lost through caries and percentage of teeth affected by caries, have been in use since the early years of the twentieth century. This index was advocated by Henry Klein, Carrole E Palmer and Knutson JW in 1938.

- This index is most universally accepted. Dental caries after the level of cavitation is not self-healing and hence leaves a scar. Hence the carious tooth either shows a cavity, or a filling or will be extracted. Therefore the DMFT index is an irreversible index indicating the total lifetime caries experience.
- Irreversible index
- Gives total lifetime caries experience of an individual and group of individuals.

D – *Refers to decayed tooth* (Fig. 17.23)

Criteria for Scoring Decayed:
1. Discolouration (Figs 17.24A–C)
2. Definite catch
3. Discontinuity of enamel surface (Figs 17.25A–C)
4. Definite cavitation (Fig. 17.26)
5. Softness of base.

Component: M
M – refers to tooth missing due to caries only

Component: F
F – Tooth that has been filled due to caries (permanent restoration only, Figs 17.27A, B)

Method of Examination
- All 28 teeth are examined.
- Third molars are excluded, because of the difference in their status like congenitally missing, impacted or unerrupted.
- The instruments used are mouth mirror and standard No. 23 explorer.



Figure 17.23 Decayed teeth.

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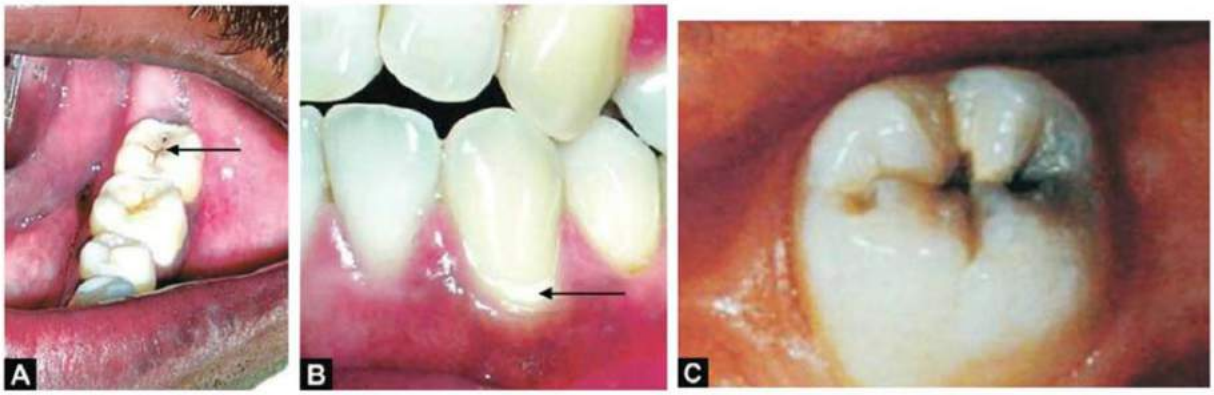


Figure 17.24 Discolouration of initial carious lesion.



Figure 17.25 Discontinuity of enamel surface—carious lesion.



Figure 17.26 Definite cavitation.

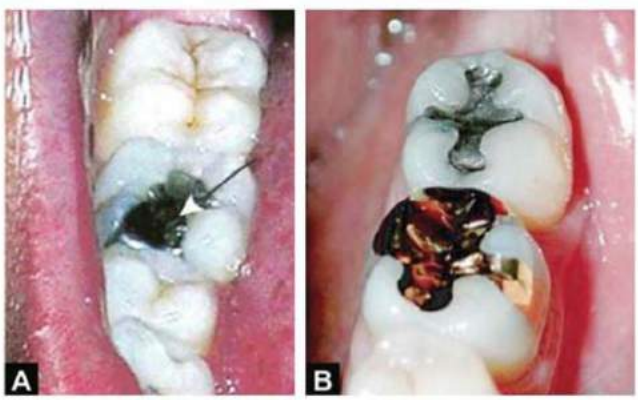


Figure 17.27 Filled teeth due to caries.

The teeth are examined visually. Explore only when necessary. Ask the patient and determine the reason for absent teeth. Teeth surface should be cleaned if obscured by debris and calculus.

Rules for Scoring

1. A tooth is considered to be erupted when the occlusal surface or incisal edge is totally exposed.
2. No tooth should be counted more than once.
3. Decayed, missing and filled teeth should be recorded separately.
4. Tooth lost or filled due to causes other than caries are not included.

Calculation of Index

(A) *Individual DMFT:* Total each component: D, M, and F separately, then total

D + M + F = DMF

(B) *Group average:* Total the D, M and F for each individual. Then, divide the total 'DMF' by the number of individuals in the group.

i.e. Average DMF = (Total DMF)/(Total number of the subjects examined)

(C) *Percentage needing care:* To calculate the percentage of teeth needing restorations, divide the total 'D' component by the total number examined.

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Percentage needing care = (Total number of decayed tooth × 100)/(Total number examined)

(D) *Percentage of teeth lost:* To calculate the percentage of tooth lost, divide the total 'M' component by the total number examined.

Percentage of teeth lost = (Total number of missing teeth × 100)/(Total number examined)

(E) *Percentage of filled teeth (care provided):* To calculate the percentage of filled teeth, divide the total 'F' component by the total 'DMFT'

Percentage of filled teeth = (Total number of filled teeth × 100)/(Total 'DMFT')

(F) *Missing permanent teeth per 100 children:* To calculate the missing permanent teeth per 100 children (MPT/100); divide the total number of missing teeth by the total number examined and then multiply by 100.

MPT/100 = (Total number of missing teeth × 100)/Total number examined

The maximum possible DMFT score is 32 (if third molars are included), and DMFT score is 28 (if third molars are excluded).

Advantages

1. Both the past and present caries experience of the individual or the community can be estimated.
2. Oral health status can be estimated indirectly by using caries experience.
3. It gives a broad overview of caries experience in a population over a period of time.
4. D—Component gives tooth status affected by dental caries (caries morbidity).
5. M—Component gives tooth lost (caries mortality).
6. F—Component gives the account of treatment done (fillings done) among the population.

Limitations

1. DMF values do not correlate with the number of teeth at risk. So, it does not directly give an indication of the intensity of attack of caries.
2. DMF index is invalid in older adults, as teeth can be lost for reasons other than caries like periodontitis.
3. A saturation level is reached at a particular point of time when all the teeth are involved and prevents further registration of caries attack even when caries activity is continuing.
4. Not indicated for root caries.
5. Extreme conditions are assigned the same score.
6. The index does not estimate the rate of progression of the caries.
7. Does not give the account for treatment needs.

DMF(S) index When the DMF index is employed to assess individual surface, that is when the unit of measurement is surface rather than a tooth, it is termed as "decayed missing filled-surface index" (DMFS index).

While the principles, rules and criteria for DMFS index are the same as that for DMFT index, in the DMFS index, individual surfaces are examined and the status noted.

Surfaces Examined

1. Posterior teeth: Each tooth having five surfaces namely facial, lingual, mesial, distal and occlusal are examined and recorded.
2. Anterior teeth: Each tooth having four surfaces namely facial, lingual, mesial and distal are examined.

Total surface count for a DMF(s) = D(s) + M(s) + F(s)

For missing tooth—**M component:** 4 surfaces.
For root stumps—**D component:** Posterior—5 surfaces, anterior—4 surfaces.

Total surface count for a DMFS index: Total number of surfaces examined, if only 28 teeth are examined (i.e., third molars are excluded)

16 posterior teeth (16 × 5) = 80 surfaces
12 anterior teeth (12 × 4) = 48 surfaces
Total = 128 surfaces

Calculation of Index

Individual DMFS:

Total number of decayed surfaces = D
Total number of missing surfaces = M
Total number of filled surfaces = F
DMFS score = D(s) + M(s) + F(s)

Advantages

- More sensitive
- More precise
- Gives true status of the caries attack.

Limitations

- Takes a longer time.
- May require radiographs.
- When the caries is low the prevalence of dental caries is expressed as percentage of population showing any evidence of caries.
- DMFT index gives a quantification of caries experience in large surveys.
- Two statistical concepts are "experience and incidence". The sum total of all decayed, missing and filled teeth or surfaces seen in an individual nowadays represents dental caries experience. It is impossible to tell from this single figure how fast the caries has occurred or is occurring. Caries incidence, on the other hand, is a rate and must always be expressed in terms of time. It involves repeated examinations at regular intervals such as 1 year and is usually expressed in terms of new findings per unit of time.
- Dental caries experience is all one can find from the cross-sectional survey of a group on a single occasion.
- Incidence is the finding par excellence in a longitudinal survey of the same individuals at different times. Estimates of incidence can be made however from cross-sectional surveys for noting how much more of the observed condition is found in one age group than in another.

WHO criteria for caries index—1986

1. Third molars are included.
2. In persons below 30 years, teeth lost only due to caries are considered as missing. In persons above

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30 years, teeth lost for any reason are considered as missing.
3. Initial caries are not considered as decayed.

Caries index for primary dentition (def index). This is the caries index for deciduous teeth given by Gruebbel in 1944 for measuring dental caries experience in primary dentition. Caries indices used for primary dentition deft index and defs index equivalent to DMFT and DMFS indices used for permanent dentition.

d—decayed primary teeth
e—primary teeth indicated for extraction/extracted due to caries only
f—primary teeth with permanent restoration due to caries.

Modifications
1. def index—for children before the age of exfoliation (5–6 years).
2. def index is applied only to primary molars after 9 years.
3. det index after 9 years.

The basic principles and rules for def index are the same as that for DMF index.

Calculation of Def Index
For primary teeth, the maximum deft score for an individual could be 20 (primary dentition consisting of 20 teeth). The maximum score for DMFS should be 88.

Total def score = d + e + f

Total defs score = ds + es + fs (decayed surfaces + extracted surfaces + filled surfaces)

Mixed Dentition
In a child with mixed dentition, both DMFT for permanent teeth and deft for deciduous teeth have to be applied and should not be added together.

Root caries index (RCI). The RCI developed by Ralph Katz in 1979 intended to make the simple prevalence measures for root caries more specific by including the concept of teeth at risk for root caries. This index is designed especially for analytical epidemiological studies in which risk factors and causes of disease are studied and analyzed. A tooth or teeth is being considered at risk if enough gingival recession has occurred, to expose part of the cemental surface to the oral environment and to the cariogenic challenge. Root caries index can be computed for an individual, for particular tooth types, or for population at large. Generally, RCI is derived from the maxillary and mandibular subtotals. RCI is based on the requirement that gingival recession should occur before root surface lesion begins. Teeth with gingival recession represent true unit at risk, thus preventing an underestimation of attack rate of root caries.

Root caries index is an index that can report root caries data in both descriptive and analytical studies and in trials that assess preventive and treatment agents. The index represents the true attack rate for supragingival root caries lesions. This will help in making comparisons among populations, estimate risk factors and assess preventive and therapeutic agents.

Procedure
To obtain RCI, each of the 4 surfaces (mesial, distal, buccal, lingual) of the root are examined for a single tooth. All teeth are examined in both lower and upper arch. For teeth with multiple roots and extreme recession, it is suggested rule that when multiple types of root surface are exposed, the most severely affected root surface of the tooth should be recorded.

This index expresses the proportion of carious and filled root surfaces among the exposed root surfaces to the buccal environment, i.e. with gingival recession, and can be calculated by the following formula:

RCI = (No. of surfaces with root caries lesions × 100)/ (No. of surfaces with gingival recession)

The condition of each root surface is analyzed according to the following criteria:

a. A root surface is considered to have gingival recession when the apical surface of the cementoenamel junction is visible
b. A root surface is considered carious when it present an area with a darkened appearance, discoloured, well-defined, allowing easy penetration of the exploratory probe
c. A root surface is registered as filled when it had a restoration, without being judged whether it is an abrasion, erosion or caries result
d. Conventions for diagnosis are adopted.

Root surfaces are characterized as M—Missing
Showing no association with gingival recession—NR
Recession present surface decayed—R-D
Recession present surface filled—R-F
Recession present surface normal—R-N

	M	D	B	L
R-N				
R-F				
R-D				
NR				

RCI score = (R-D + R-F) × 100)/(R-D + R-F + R-N)

Diagnostic Convention Approach for RCI
- **Convention no. 1:** If the diagnosis of caries or filled is uncertain, score the surface as sound.
- **Convention no. 2:** All caries detected on root surface near CEJ shall be scored as decayed, regardless of the adjacent enamel condition.
- **Convention no. 3:** For any coronal filling which extends to the root surface, the filling material must extend more than 3 mm, beyond the CEJ in order to score that root surface as filled (except crowns).
- **Convention no. 4:** In order to score a filling as involving multiple surfaces, the filling must extend across at least 1/3rd of each additional surface.
- **Convention no. 5a:** Recurrent decay associated with root filling should be recorded as an independent disease category called recurrent root decay.

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- **Convention no. 5b:** Recurrent decay associated with coronal filling or crown should be recorded as an independent disease category called root decay contiguous with coronal filling.
- **Convention no. 6:** For any root surface that is decayed, the events of an additional but separate root lesion is recorded as an independent disease category called additional root caries lesion.
- **Convention no. 7:** Any root surface that appears sound but has more than 20% of its area inaccessible to clinical examination due to calculus, or heavy plaque deposits will be regarded as unreadable.

Significant Caries Index (SiC)

The significant caries index was proposed by D Bratthall in the year 2000. The SiC Index attempts to focus attention on the individuals in the population who have the highest caries scores. The calculation of the index is as follows: individuals are arranged in an ascending order based on their DMFT values. The one-third part of the population that has the highest caries score is identified and selected. The mean DMFT for this group with highest caries levels is calculated and this value constitutes the SiC Index.

Uses

1. Helps in identifying the neglected and needy groups in the population.
2. Focusing strategies on this population will bring about a reduction on caries levels through 'targeted' or 'high- risk' approach.

Dental Fluorosis Index

Dean's fluorosis index. When the developing tooth is exposed to excessive amounts of fluoride, it can result in defective mineralization called as fluorosis. Bilateral opaque white areas in the enamel characterize the clinical appearance of dental fluorosis. With higher levels of fluoride, the severity of fluorosis increases with enamel exhibiting striations, mottling and pitting and sometimes maybe stained yellow to dark brown.

Hence, dental fluorosis is a hypoplasia or hypomineralization of enamel or dentin produced by chronic ingestion of excessive amounts of fluoride during the period when the teeth are developing.

One of the earliest reports of a condition like mottled enamel where teeth having brown stains among the people living in the area of Colorado Springs in Colorado was reported in 1901 by McKay. Eventually in 1917 the first aetiological findings were published about mottled enamel. Later the discovery of mottled enamel and fluorosis correlated with fluoride content of the water was made in 1931. Since then many systems are being used to describe dental fluorosis. However, the classification of mottled enamel developed by Dean in 1934 and later index of dental fluorosis in 1942 gained significant acceptance. Thus Dean's fluorosis index has been in use throughout the world and still being used in many epidemiological studies since 1942.

Objectives

To assess the prevalence of dental fluorosis (mottled enamel).

The criteria for dental fluorosis index/classification system developed by HD Dean in 1934 was based on 7-point ordinal scale (normal, questionable, very mild, mild, moderate, moderately severe and severe). However, 6-point ordinal scale consisting normal, questionable, very mild, mild, moderate and severe came into existence in 1942, and that is extensively used nowadays. The following classification is used:

0. Normal
1. Questionable fluorosis
2. Very mild fluorosis
3. Mild fluorosis
4. Moderate fluorosis
5. Severe fluorosis.

Limitations

- Classification questionable is often a baffling problem.
- Again in 1942 Dean modified his index by eliminating moderately severe fluorosis category.
- The scoring system ranged from 0 (normal enamel) to 5 (severe fluorosis).

Scoring Criteria Normal — (0)

The enamel represents usual translucent semi-vitriform type of structure (Fig. 17.28). The surface is smooth, glossy and usually of a pale creamy white colour.

Questionable Fluorosis — (1)

The enamel discloses a slight aberration from the translucency of normal enamel ranging from a few white flecks to occasional white spots. This classification is used in those instances where a definite diagnosis of the mildest form of fluorosis is not warranted and classification of 'normal' not justified.

Very Mild Fluorosis — (2)

Opaque, paper-white areas are scattered irregularly over the tooth but involving less than 25% of the labial tooth surface (Figs 17.29A, B).

Mild Fluorosis – (3)

The white *opacity* of the enamel of the teeth is more extensive than for code 3, but covers less than 50% of the tooth surface (Figs 17.30A, B).



Figure 17.28 Normal enamel.

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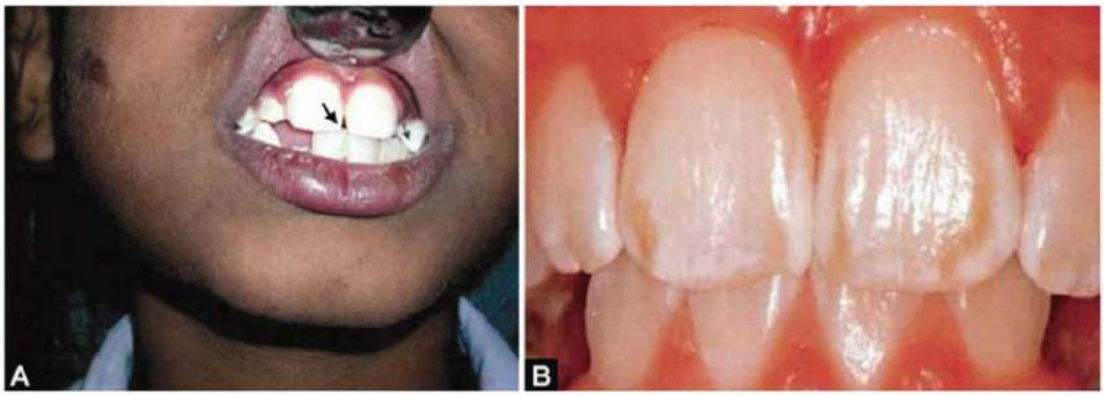


Figure 17.29 Very mild fluorosis—score 2.

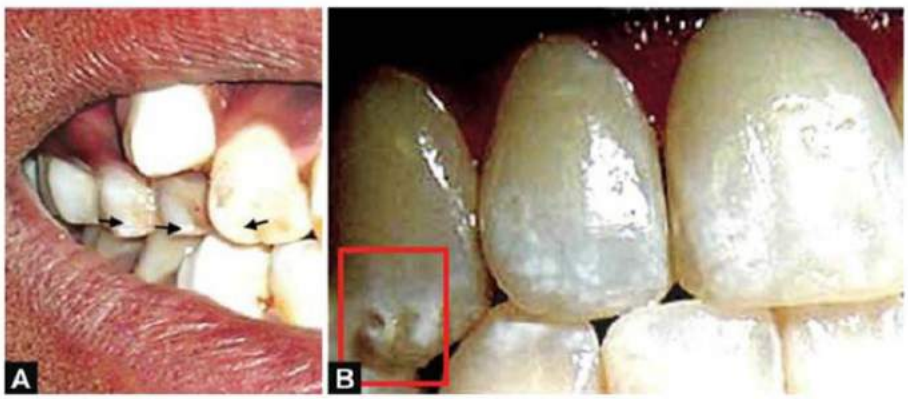


Figure 17.30 Mild fluorosis—score 3.

Moderate Fluorosis – (4)
The enamel surfaces of the teeth show marked wear, and brown stain is frequently a disfiguring feature (Figs 17.31A, B).

Severe Fluorosis – (5)
The enamel surfaces are badly affected and hypoplasia is so marked that the general form of the tooth maybe affected. There are pitted or worn areas, and brown stains are widespread; the teeth often have a corroded appearance (Fig. 17.32).

Excluded – (8) (e.g. a crowned tooth).
Not recorded – (9)

Community fluorosis index (CFI). To determine the severity of dental fluorosis as a public health concern and problem, Dean devised a method for calculating the severity of fluorosis in a community which is termed as "Community Fluorosis Index" (CFI).

The proportion in each category was multiplied by the weight given to derive a score for the community.

CFI = (n × w)/(N), where
N = no. of persons in each category
w = weight of the scale (average score)
N = the total population.

Scoring Criteria
Table 17.8 depicts community fluorosis index scoring criteria.



Figure 17.31 Moderate fluorosis—score 4.

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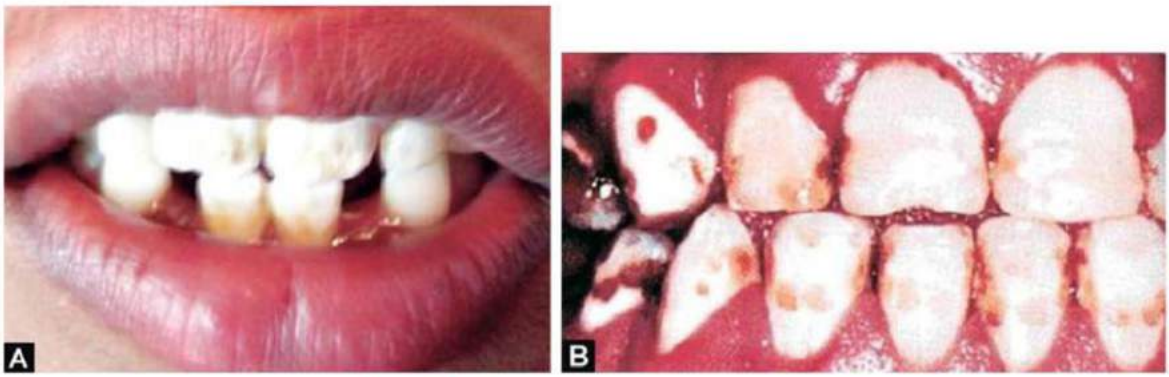


Figure 17.32 Severe fluorosis—score 5.

Table 17.8 Scoring criteria for CFI

CFI	Public Health Significance
0.0–0.4	Negative
0.4–0.6	Borderline
0.6–1.0	Slight
1.0–2.0	Medium
2.0–3.0	Marked
3.0–4.0	Very marked

Advantages

1. CFI is widely used in epidemiological studies worldwide.
2. It is of value while making comparisons between various studies.
3. It is used to assess the correlation between caries and fluorosis.
4. It is also used to assess the severity of fluorosis with level of fluoride in drinking water.

Limitations

1. It does not provide information on distribution of fluorosis within the dentition.
2. Questionable score has created confusion and continues to do so.
3. It is not sufficiently sensitive in its lower scores.
4. Definition of a pitting is necessary as the severe category is not clear in the 1942 diagnostic criteria.

Thylstrup and Fejerskov Index (TFI)

Another index for assessment of fluorosis was developed by Thylstrup and Fejerskov in order to refine, modify and extend the original concept and views described by Dean. The main aim was to develop a more sensitive classification system for recording enamel changes found in the regions with higher content of fluoride in the drinking water. This index appeals to epidemiologist and clinicians as the classification scale corresponds closely to the histological changes that might occur in dental fluorosis and in the concentration of fluoride found in enamel structure.

This index has 10-point ordinal scale to classify enamel changes associated with increasing level of fluoride exposure. Originally, when it was proposed only facial and occlusal surfaces were scored with different criteria used at various levels of severity. But many investigators and most studies have used only facial surfaces and later it became the recommended procedure by 1988.

Score 1 to 4 reflect involvement of the tooth surface with increasing level of opaque areas and loss of translucency. In keeping with one of the purposes of the index, Dean's category of severe is divided into 5 categories in order to record the various levels of clinical changes that can occur among the drinking water with higher fluoride levels. Assignment of the score representing one of these categories is based on the proportion of surface affected. Enamel stains are ignored while assigning the scores. The method used in examination of the teeth is different from the method used in Dean's index and the TSIF. Teeth are to be cleaned and dried before examination. The cleaning and the drying of the teeth accentuate the appearance of fluorosis, making diagnosis easier in questionable cases.

An important aspect of this index is that investigators are provided recommendations for summarizing the data. These methods provide both prevalence and severity of estimations, they include:

1. Percent distributions of scores for all teeth
2. Percent distributions of scores by tooth type and
3. Cumulative percent distributions of subjects by percent of teeth affected at given TFI score per subject.

Diagnostic Criteria and Scoring System for Modified Thylstrup and Fejerskov Index (TFI)

Score	Modified Criteria (Fejerskov et al, 1988)
0	The normal translucency of the glossy, creamy-white enamel remains after wiping and drying of the surface.
1	Thin white opaque lines are seen running across the tooth surface. The lines correspond to the position of the perikymata. In some cases, a slight "snow capping" of cusps/incisal edges may also be seen.
2	The opaque white lines are more pronounced and frequently merge to form small cloudy areas scattered over the whole surface. "Snow capping" of incisal edges and cusp tips is common.
3	Merging of the white lines occurs, and cloudy areas of opacity occurs spread over many parts of the surface. In between the cloudy areas, white lines, can also be seen.

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Score	Modified Criteria (Fejerskov et al, 1988)
4	The entire surface exhibits a marked opacity or appears chalky white. Parts of the surface exposed to attrition or wear may appear to be less affected.
5	The entire surface is opaque, and there are round pits (focal loss of the outermost enamel) that are less than 2 mm in diameter.
6	The small pits may frequently be seen merging in the opaque enamel to form bands that are less than 2 mm in vertical height. In this class are also included surfaces where the cuspal rim *of* farial enamel has been chipped off, and the vertical dimension of the resulting damage is less than 2 mm.
7	There is a loss of the outermost enamel in irregular areas, and less than half the surface is so involved. The remaining intact enamel is opaque.
8	The loss of the outermost enamel involves more than half the enamel. The remaining intact enamel is opaque.
9	The loss of the major part of the outer enamel results in a change of the anatomical shape of the surface/tooth. A cervical rim of opaque enamel is often noted.

Tooth Surface Index of Fluorosis (TSIF)

Tooth Surface Index of Fluorosis was developed in the beginning of 1980 by the investigators from the National Institute of Dental Research to estimate the prevalence of dental fluorosis in areas having differing concentration of natural fluoride in drinking water. In this index, each facial and lingual surface of anterior teeth and each buccal, occlusal and lingual surface of posterior teeth is given a separate score. The tooth surfaces are not dried before the examinations, the reason being primarily an aesthetic one and teeth should be assessed in their natural state. Those opacities that are visible, only after drying should not be counted or included in the definition of fluorosis.

In this index, 8-point scale is used in classifying the surfaces affected by fluorosis, whereas 4 points can be made concerning this criteria. First of all, as of the TFI, there is no questionable category and thus a positive score is assigned to the first signs of fluorosis. Secondly, TSIF scores 1, 2, 3 are based on the area of the tooth surface affected, assessed by visually all areas of fluorosis and relating that area to the total visible enamel to that particular surface. The area or surface affected can provide a useful indication of severity when exposure to fluoride is continuous during the development of teeth. With interrupted fluoride exposure, however only portion of a surface may be affected.

Third point concerns about the score of 4, given when staining is present in conjunction with any of the three conditions indicating of lower scores. The index is used mainly as an indicator of biological effect on account of fluoride exposure and hence the TSIF must be considered a nominal scale rather than an ordinal one. Since the staining of any portion of the surface is given precedence over the proportion of the surface affected with fluorosis, score of 4 may be given when an area equivalent to a TSIF score of 1. However, stains rarely occur before mild level of fluorosis is reached according to Dean's index, most likely corresponding to score of 3 in TSIF.

Fourth, the aesthetic orientation of this index is evident once again in the higher degrees of fluorosis wherein staining occurring in conjunction with discrete pitting is given a separate score. Finally, a distinction between discrete pitting and more advance confluent pitting is made, making the index more sensitive than Dean's index to the higher degree of fluorosis.

With the use of TSIF, examiner reliability may be of more concern than with Dean's index and of modified TFI because of the larger number of assessments to be made (72 surfaces *vs* the usual maximum of 28 teeth or buccal surfaces in children). the added lingual surfaces are more difficult to visualize than buccal surfaces, which also adds to the concern about examiners reliability.

The TSIF has two major advantages over Dean's index, namely criteria for scoring in the TSIF are clearer and consequently subjectivity should be reduced in its applications. The other advantage derives from scoring of surfaces rather than individual teeth.

Diagnostic Criteria and Scoring System for the Tooth Surface Index of Fluorosis (TSIF)

Score	Criteria
0	Enamel shows no evidence of fluorosis.
1	Enamel shows definite evidence of fluorosis, namely, areas with parchment-white colour that total less than one third of the visible enamel surface. This category includes fluorosis confined only to incisal edges of anterior teeth and cusp tips of posterior teeth ("snow capping").
2	Parchment-white fluorosis totals at least one-third of the visible surface, but less than two-thirds.
3	Parchment-white fluorosis totals at least two-thirds of the visible surface.
4	Enamel shows staining in conjunction with any of the preceding levels of fluorosis; Staining is defined as an area of definite discoloration that may range from light to very dark brown.
5	Discrete pitting of the enamel exists, unaccompanied by evidence of staining of intact enamel. A pit is defined as a definite physical defect in the enamel surface with a rough floor that is surrounded by a wall of intact enamel. The pitted area is usually stained or differs in colour from the surrounding enamel.
6	Both discrete pitting and staining of the intact enamel exists.
7	Confluent pitting of the enamel surface exists. Large areas of enamel may be missing and the anatomy tooth may be altered. Dark-brown stain is usually present.

Dental Aesthetic Index

Dental Aesthetic Index (DAI) was designed by Cons NC, Jenny J, Kohont FJ with the aim of specifically measuring dental aesthetics using objective physical measurements. Development of this index was based on measuring the relative social acceptability of dental appearance based on public's perception of dental aesthetics. Dental aesthetic index was initially based on dental records (study casts) from Caucasian adolescents in the United States. But because of the paucity of a valid measure for orthodontic treatment needs, the DAI scores that were designed to reflect North American Cultural Aesthetic and Psychosocial values without the perceived 'European

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bias' was introduced. Later the WHO adopted DAI as a cross-cultural index due to its simplicity and high examiner reliability. The index has great potential internationally. While DAI has been commonly used to determine orthodontic treatment need of populations, it can also be potentially used in smaller hospital-based groups.

The DAI has 10 physical measurements of occlusal traits by intraoral examination. These are:

1. Missing visible teeth: incisor, canine and premolar
2. Anterior crowding
3. Anterior spacing
4. Diastema
5. Largest anterior irregularity on the maxilla
6. Largest anterior irregularity on the mandible
7. Anterior maxillary over jet
8. Anterior mandibular over jet
9. Vertical anterior open bite in mm
10. Anteroposterior molar relation

These component scores are then put into a formula with their appropriate weights which have been calculated in index development process as a regression coefficient.

The DAI is considered to be a rapid and useful index for identifying unmet orthodontic treatment needs, and as a screening device for determining orthodontic treatment priority.

DAI Components	Rounded Weight
Number of missing visible teeth (Incisor, canine and premolar in maxillary and mandibular arches)	6
Crowding in the incisal segment (0 = no segment crowded, 1 = 1 segment crowded, 2 = 2 segment crowded)	1
Spacing in the incisal segment, 0 = no spacing, 1 = 1 segment spaced, 2 = 2 segment spaced	1
Midline diastema in millimeters	1
Largest anterior irregularity on the maxilla in mm	1
Largest anterior irregularity on the mandible in mm	1
Anterior maxillary over jet in mm	2
Anterior mandibular over jet in mm	4
Vertical anterior open bite in mm	4
Anteroposterior molar relation, largest deviation from normal either left or right 0 = normal, 1 = 1/2 cusps, either mesial or distal, 2 = one full cusp or more either mesial or distal	3
Constant	13
Total	DAI score

Procedure

Dental aesthetic index can be obtained from the study models or directly from the individual without using radiograph. The occlusal plates are scored and/or measured. These trait scores or measurements are multiplied by their actual or rounded weights provided within the parentheses and products are summed with the constant number 13.

DAI score = 6 (missing visible teeth) + 1 (crowding) + 1 (spacing) + 3 (diastema) + 1 (largest upper anterior irregularity) + 1 (largest lower anterior irregularity) + 2 (anterior maxillary over jet) + 4 (anterior mandibular over jet) + 4 (vertical anterior open bite) + 3 (anteroposterior molar relation) + 13.

DAI score can range from 13–52, with lower scores indicating the more aesthetic occlusal traits and higher scores the presence of less aesthetic traits. A score of 35 was selected as an arbitrary cut-off point for aesthetics. DAI scores above this cut-off point are considered to indicate less socially acceptable dental appearance.

CONCLUSION

Measurement, the quantifying of observation is the crux of science. In studies of oral disease, a true count of lesions in a population is almost never achieved. Any one count of disease in a group is, therefore, an estimate of conditions rather than absolute truth. So long as criteria applied consistently, however, values estimate will still result because diagnostic drifts in one direction will be balanced by drifting the other way. Hence, ideal index should possess certain characteristics such as simplicity, objectivity, validity, reliability and sensitivity.

There are several kinds of scale for measuring the intensity of the condition. The majority of the indices used in oral epidemiology are ordinal scales, which list conditions in order of severity without attempting to define any mathematical relation between the categories and although many are treated statistically as though they are interval or ratio scales. Other terms such as reversible and irreversible are used in the literature to describe indices. An irreversible index measures cumulative conditions that cannot be reversed, e.g. cavitated dental caries lesion, restored or tooth loss itself. Similarly, it also holds good in cases of advanced periodontitis using CPITN, CPI, and in case of dental fluorosis using Dean's fluorosis index. While measuring a disease level one should know what index should be used and how to interpret the data to assess the status of the various disease or condition. Gingivitis, however, is a reversible inflammatory condition so an index of gingivitis is considered reversible and also oral hygiene indices. Thus assessment of oral health is an important step in activities like describing normal biological process, understanding the natural history of the disease, testing hypotheses regarding preventive agents, and planning and evaluation of health services.

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REVIEW QUESTIONS

1. Define an index. What is the objective and properties of an ideal index?
2. Enumerate the difference between fluoride and non-fluoride opacities.
3. Write short notes on:
   a. Uses of an index
   b. CPITN
   c. Gingival index of Löe and Silness
   d. Russell's periodontal index
   e. DMFT index

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18 Dental Auxiliaries

Hiremath SS

CHAPTER OUTLINE

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INTRODUCTION

The main objective of the dental profession should be the attainment by all people, the highest level of dental health. This approach requires good planning on a nationwide basis and efficient utilization of resources in a rational way. Considering that both, the common major dental diseases, dental caries and periodontal diseases are preventable, provision of dental services should be developed primarily on the basis of preventive approach both for the individual and community. Unfortunately, majority of services are concerned with the curative and reparative aspects of dental diseases rather than prevention.

The heart of the dental public health programme is the manpower required to carry it out. The control of dental health services never takes place without the involvement of political, social and economic settings. Most of the countries differ widely in their political policies, economic standing and social structure, hence no two countries have an identical organization of health services.

A dental care delivery system is efficient when its structure, organization and performance satisfy the dental needs of the population it serves, in the best way possible. This requires efficiency in the production, distribution, consumption and financing of dental services, and also an ability to adapt to the changing needs of the population.

In a densely populated country like India, where more than 70% of the population lives in the rural areas, under such situation, the dental needs are also appalling.

This country is a perfect example of 'inverse care law', wherein the rural areas with the dentist:population ratio of 1:3,00,000 have the highest demand for dental care as compared to the urban areas with the dentist:population ratio of 1:20,000. Under the prevailing conditions, it is not feasible to train more dentists to cater to the dental needs of the community and moreover economically it is not affordable. Hence it is paramount consideration to train additional personnel to reach the unreached.

RATIONALE FOR TRAINING AND USE OF DENTAL AUXILIARY

Out of the total population, the percentage receiving professional care is about 25% only, with 30–35% in the urban area, and 12–15% in the rural area. Only 5–10% of children receive oral health care while the need for dental treatment is around 50–85% among them. Dental caries is increasing in school children and so is the backlog of untreated dental caries and other dental diseases.

An increased demand for dental treatment has been witnessed in the recent years, which might be attributable to:

- Better education
- Better health care facilities
- Increased income
- Better standard of living
- Demographic changes like increased population, and increase in life span.

Along with these problems, there can be other precipitating problems like increasing costs, shortage of equipment, material and manpower.

To meet the increasing demand for dental treatment and oral health care, more demand on dental treatment services will result. Hence, the need to train more and more dentists will be seen. But training dentists will be an expensive affair. Thus, there is an urgent need for the development of training and utilization of dental auxiliaries.

DEFINITION

Dental auxiliary is a person who is given responsibility by a dentist so that he or she can help the dentist in providing dental care, but who is not himself or herself qualified with a dental degree.

In the UK, the dental auxiliaries are termed as ancillary.

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CLASSIFICATION

Dental auxiliaries can be categorized into two:

I. Non-operating
II. Operating

I. Non-operating
1) Dental surgery assistant
2) Dental secretary/receptionist
3) Dental laboratory technician
4) Dental health educator.

II. Operating
1) School dental nurse
2) Dental therapist
3) Dental hygienist
4) Expanded function operating dental auxiliary.

I. Non-operating Auxiliaries

The non-operating type of dental auxiliary can also be classified as: (i) clinical and (ii) laboratory.

Clinical: Person who assists the professional dentist in his/her clinical work but does not carry out any independent procedures in the oral cavity of patient.

Laboratory: Person who assists the professional by carrying out certain technical laboratory procedures.

1. Dental surgery assistant (Dental assistant, chairside dental assistant). Dental surgery assistant is a person who assists the dentist with clinical work but does not independently carry out any procedures in the mouth. They help in smooth running of the clinical area and enable the dentist to spend more time providing actual dental care to patients.

With the increased use of dental surgery assistant, a new concept emerged in 1960s, called the 'four-handed dentistry' which is the art of seating both the dentist and the dental assistant in such a way that both have easy access to the patient's mouth who is in the supine position. The assistant helps the dentist by anticipating the instruments and materials that are required, and passing them to the dentist and also in maintaining a clear and well-isolated field of operation by performing retraction and aspiration. The dentist can thus keep his/her hands and eyes on the field and work with minimum fatigue and greater efficiency.

Duties

- Management of instruments, equipment and material
- Sterilization, cleansing and recycling of instruments
- Looks after the general well-being of the patient

2. Dental secretary/receptionist. Dental secretary or receptionist is a person who assists the dentist with his/her secretarial work and patient reception duties.

3. Dental laboratory technician (Dental mechanic). Dental laboratory technician works in a laboratory constructing dental appliances for the prescription of the dentist. His/her specific duties include: fabrication of dentures, splints, orthodontic appliances, inlays, crowns, etc.

Dental laboratory technicians receive their training through apprenticeship which is sometimes associated with formal training in academic and practical subjects at a dental school or technical college. They may be employed by dentists in private or public health practice, or self-employed and accept work from dentist in the area, or they may be employed by commercial laboratories established by other dental technicians.

4. Dental health educator. The health educator is a person who can take the responsibility of educating on simple and useful information of oral and dental health for the community.

II. Operating Auxiliaries

Operating auxiliary is a person who, in spite of not being a professional, is permitted to carry out certain treatment procedures in the patient's mouth under the direction and supervision of a dentist.

1. School dental nurse (New Zealand type). School dental nurse came into existence in New Zealand in 1923 to deal with the large amount of dental disease present among the school children.

Duties

- Examination, diagnosis and treatment for dental caries, and periodontal disease
- Prepares cavity, restoring with silver amalgam, silicate restoration, and temporary restorations
- Extraction of primary teeth
- Oral prophylaxis
- Application of topical fluorides
- Dental health education
- Use of infiltration anaesthesia
- Referral of complex cases to a nearby dentist.

Training of the dental nurse takes place over a 2-year period. Upon completion of training, each nurse is assigned to a school where she is employed to provide regular dental care to approximately 450 to 700 children. The lower figure (450) applies to areas without fluoridated water supplies and higher figure (700) to areas that have had fluoridation. Age group of the children attended to by the dental nurse is 2½–13 years.

The overall effect of the service has been dramatic. In 1923, 78.9 teeth were extracted for every 100 fillings placed. This ratio changed to just 2.9 extractions to every 100 fillings in 1969. Undoubtedly school dental nurse has played a major part in bringing about this success.

2. Dental therapist. Dental auxiliary began operating in UK in 1962. They are permitted to work to written treatment devised by supervising dentist. Though the operative procedures are similar to New Zealand school dental nurse, they are not permitted to diagnose and plan dental care. They have to work in public health service and are called 'New Cross Auxiliary'. They are trained for a period of 2 years. They operate under certain guidelines allowing them to provide some services both in schools and rural area.

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3. Dental hygienist. Dental hygienist was first employed in 1906 in a private dental practice in the USA, and in 1913, the first formal training course for hygienists was started. Mrs Irene Newmann was the first dental hygienist. The productivity of providing various oral health care can be enhanced or increased by appropriate utilization of dental hygienist.

Duties

- Scaling and polishing – Oral prophylaxis
- Topical application of fluoride, dental sealants
- Dental health education.

In some countries, they are permitted to take radiographs, make impressions, preparations of study models and polish restorations. In Denmark and the Netherlands, they are allowed to make a preliminary examination and charting of the teeth.

The training period for dental hygienist is 1–2 years. There are dental hygienists in many countries that with the largest number being in the USA where there are over 20,000 and most of them are employed in private practice.

4. Expanded function operating dental auxiliary. Dental surgery assistants or dental hygienists are normally trained as expanded function operating dental auxiliary (EFODA).

Duties

- Placing rubber dams
- Taking radiographs
- Placing amalgam restorations and plastic (reversible) fillings.

Depending on the type of work required, training period of EFODA is adjusted accordingly. He/she works in close co-ordination and supervision of dentist. As a result of this, it was found that the dentist's productivity increased by 61.5%.

The dental surgery assistants receive one year training. In Sweden, some dental surgery assistant receives 2 weeks of training, and they conduct fluoride mouth rinsing programme to school going children. These auxiliaries are 'dental health educators' (FDI, 1972). They are not, however, allowed to undertake any intra-oral procedures and therefore cannot be classified as operating auxiliary.

EFFECTS OF AUXILIARIES ON DENTAL EDUCATION

As dental auxiliaries came to be accepted more and more by the dental profession, their numbers increased, and individual dentists had to carry a greater responsibility for them. Accordingly it was realized in some countries that dental students should be trained to work with auxiliaries and begin to accept responsibility for them at an early stage in their undergraduate careers.

With this, in 1961, the US Public Health Service established the dental auxiliary utilization (DAU) programme, which initiated the training of dental students in modern methods of working with dental surgery assistants, and also the practice of **'four-handed dentistry'.**

Training in expanded auxiliary management (TEAM) programme. In the USA, the Public Health Service announced a plan to make funds available for teaching dental students to work with, manage and supervise dental health teams comprising both operating and non-operating auxiliaries. This is called TEAM programme. Facility for training the appropriate dental school supervisory staff in utilization of EFODA was included in the programme.

Some countries have an acute shortage of dentists and have no facilities for training the dentist. Under such situations, unusual measures must be taken to provide even the most rudimentary dental care for the population. The Expert committee on auxiliary dental personnel of WHO suggest two new types of dental auxiliary for such situation:

1. Dental licentiate
2. Dental aid

Dental licentiate: This type of dental auxiliary should be semi-independent operator trained for not less than 2 years. The dental licentiate might be responsible at the national level or at the regional level to a fully trained dentist in chief or local health service. Supervision and control would probably be remote as their services would probably occur in rural or frontier areas. Duties performed by them include:

- Prophylaxis
- Cavity preparation and fillings of both primary and permanent teeth
- Extractions under local anaesthesia
- Drainage of dental abscess
- Treatment of the periodontal disease
- Early recognition of more serious dental conditions.

Dental aids: This type of dental auxiliary is of even briefer training period who would perform functions somewhat similar to those of the medical corpsmen now seen in military services. Teaching of sterilization procedure to the dental aids is regarded as of great importance. Formal training period is between 4 and 6 months, and followed by field training under direct and constant supervision. Their duties include:

- Relief of pain
- Extraction under local anaesthesia
- Control of bleeding
- Helping in transportation of the patient to the higher centres or hospitals.

Four-Handed Dentistry

The dentist and the dental assistant sit closely, beside the supine positioned patient. The assistant anticipates the instruments and materials required and pass them to the dentist, in such a way that the dentist may not even have to take his eyes momentarily away from the field of operation while changing instruments.

Advantages

1. Less fatigue
2. Greater efficiency

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Functions of Dental Auxiliaries

- Office and chairside assistance
- Making radiographic exposures
- Taking impressions for study cases
- Removing sutures and dressings
- Applying topical anaesthetics
- Performing preliminary oral examinations
- Performing oral prophylaxis
- Providing oral health education and instructions
- Applying anticariogenic agents topically
- Placing and removing rubber dams
- Placing and removing matrices
- Placing and removing temporary restorations
- Placing and carving and finishing amalgam fillings
- Placing and finishing resin, composite and silicate restorations

Advantages

1. More oral health services to the community—more improvement.
2. More productivity of dental care services.
3. Better coverage of Preventive Services to individual patients and groups.
4. More section of society and different strata of population are served and benefited.
5. Better job satisfaction for the dentist and other dental personnel—better quality of life.
6. Training and utilization of dental auxiliaries is very economical—more work load is turned over, less time consumption, less fatigue, better quality and standard of work.
7. Encouragement for team work-specially designed team DAU (Dental Auxiliary Utilization Programme) Klein (1944)—USA. A study of dental surgery—assistant— showed that addition of 1 dental surgery assistant to a dental practice—there is an increase of 33% of the number of patients treated (increase in productivity).

INTERESTING TO KNOW

Degrees of supervision: The dental auxiliary can work only under the supervision of a licensed dentist and the degree of supervision varies as classified by ADA in 1975.

1. General supervision: The dentist diagnoses and plans the treatment of a patient and authorizes the auxiliary to carry out the treatment.
2. Indirect supervision: The dentist diagnoses and plans the treatment but he authorizes the auxiliary to carry out the treatment in the field (eg. school premises) while the dentist remains in the dental office.
3. Direct supervision: Similar to general supervision, the dentist diagnoses and plans the treatment of a patient and authorizes the auxiliary to carry out the treatment but before the dismissal of the patient, the dentist evaluates the procedure performed by the auxiliary.
4. Personal supervision: The dentist himself performs the treatment but authorizes the auxiliary to provide supportive assistance.

DENTAL MANPOWER PLANNING

Crux of the problem lies in the improper or defective planning of dental workforce without understanding the infrastructure and needs of the community and also without taking into consideration of the future problems arising out of the demographic profile and diseases load on the population. However, the following considerations require urgent attention to set right these anomalies and to facilitate for proper dental manpower planning:

1. **Dental education:** In the post-independence era, especially in the later half of the twentieth century, many dental colleges have come up across the country. Unfortunately, the type of training and the core of the curriculum of existing dental course are not relevant to the needs of the society. And also after the training of the young dental graduates, they do not get an appropriate platform to serve the society. Hence, the very training and utilization of dental graduates require drastic modification so as to meet the needs and demands of the oral health care of the community.
2. There is a drastic geographic imbalance in relation to distribution of dental colleges in the country. As of today, out of 220 colleges in our country, more than 70% of the colleges are situated in south India whereas, Karnataka state alone accounts for about 43 colleges. This maldistribution creates imbalance in catering to the oral health services to the whole society.
3. At the same time, there is acute maldistribution of dentists, wherein 70–80% of the dental graduates serving the 25% of the country's population, i.e. in urban area. Whereas in case of rural area, only 20–25% of the dentists are serving the 75% of the population. Thus the dentist:population ratio in India varies enormously between urban and rural population. Dentist: population ratio in Urban area is 1:20,000, whereas in rural areas it is 1:3,00,000.
4. The dental colleges are offering postgraduate courses in all specialties in dentistry. On the whole only 2% of the colleges offering postgraduation course in community dentistry. This results in acute shortage of public health dentists and, in turn, affecting the development of public health programmes.
5. All the dental colleges in India are not offering the courses pertaining to the dental auxiliaries. And also only few dental colleges are offering training of auxiliaries like dental hygienists and dental mechanics. No dental college is offering a full-fledged course in all disciplines of dental auxiliaries. This requires an urgent attention and top priority from the government side to set right this deficiency.
6. Unfortunately, the present dental curriculum does not provide or facilitate to train dental graduates along with dental auxiliaries, and also lack in combined utilization programme from the beginning of the training programme.

   The shear volume and load of the dental diseases, the shortage of trained dental manpower, the disappointing long-term results and conventional methods of dental health education and absence of effective

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preventive programmes together create a situation in which the prospect of promoting and planning the concept of positive dental health is remote.

The following informations are required for estimation of manpower (WHO, 1968): National and regional profile:

1. **Population**
   - Total
   - Demographic profile
   - Rate of growth
   - Distribution — Urban / Rural
   - School age population
2. **Economics**
   - Socioeconomic status
   - Source of fund for health care
3. **Political factors**
   - Government attitude towards and responsibilities of health services
   - Status of dentistry — Private / Government
4. **Communication—**
   - Transport
   - Distance between centres
5. **Demographic data**
   - Ethnic groups
   - Educational levels
   - Cultural aspects
   - Religions
   - Customs
6. **Dental disease patterns**
   - Estimation of various types of dental diseases and conditions
   - Collection of data with regard to dental diseases
   - Level of oral hygiene
   - Dietary pattern
7. **Present manpower**
   - Availability
   - Distribution
   - Training facility and capacity
8. **Desirable profiles**
9. **Attitude of dental personnel towards practice.**

With all these information, planning and decision can be made regarding the type of manpower to be used, when, and how. Sometimes priorities must be established, and estimation of the manpower required for achieving short, intermediate and long-term goals of the plan. The decision must be made whether to train single skilled or multiple skilled auxiliaries. This will be always in proportion to the cost of training of professional dentist, the number of trained graduates available, the type and prevalence of dental diseases, and basic demands of the community.

BENEFITS OF USING AUXILIARIES

While concentrating on treating the consequences of dental disease, provisions can be made to include prevention and educational activities in public dental health programmes. Dental services can be developed primarily on the basis of preventive approach, both for the community and the individual.

With rapid population growth and increasing demand for dental care, more and more dentists are required. But unfortunately, this is an expensive process, e.g. training of undergraduate costs around $ 44,300, training of dental hygienist costs $ 4,450 and training of dental assistant costs $ 1,600.

Hence, training an auxiliary is more economical, less time-consuming and fewer burdens to the society. In general, this results in definite benefits to dentists, patients, auxiliaries and to whole community, financially, psychologically and ethically. It is essential that those people who plan and organize dental care services should be aware of the problems that might exist and be able to relate to their own particular situations. Only with this can better utilization of dental auxiliary be made, and real dental care can be made available, eventually, to all communities in the world.

IMPACT OF AUXILIARIES IN INDIAN SCENARIO

There exists a serious maldistribution of the dental professionals with nearly 75% of the dentists practicing in the urban area catering to only 25% of the total population. Under such circumstances, services of dental auxiliary in meeting the dental needs of the deprived segments of the population will be significant.

Unfortunately, the only auxiliary personnel who exist in India are the dental surgery assistant, laboratory technician, and dental hygienists. The most suitable type of auxiliary for the Indian set-up will be the school going dental nurse and the EFODA. These auxiliaries will not only provide the basic dental care but also play an important role in prevention of the dental diseases both for school going children and general public (underprivileged population). School dental nurse will be extremely useful for taking care of oral and dental problems among school going children who constitute about 40% of the total population. Besides this, providing appropriate oral health care to school going children in younger age helps in preparing the children as better patients and development of positive attitude to oral health at a later part of the life. Thus such personnel will provide not only optimal dental care to the community but also enable to do so more economically and efficiently.

CONCLUSION

Based on the philosophy of division of labour, with the sum total of human knowledge, which is so much greater, has led to the development of not only professional specialties in the field of medicine and dentistry but also to various types of auxiliary personnel. Between these individuals and groups, there must be teamwork. Some tasks actually require more than two hands. Other tasks are more quickly or better performed if one worker confines himself to one part of the task leaving other part to other workers, which will, in turn, result in speed and accuracy.

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CONCLUSION—cont'd

Certain parts of the task require top-level skill and knowledge and, in dentistry, these are called professional services. Some other parts of the task require less skill and knowledge. These may safely and advantageously be delegated to auxiliary personnel. The community benefits from this sort of division of labour so that, training time for professional personnel can be conserved, thereby saving the cost and manpower to tackle the enormous untreated disease burden of the society. Those who do receive full training can make their best services available to a larger segment of population. Hence, the training of dental auxiliaries, not only helps in tackling the major problem of the common dental diseases of the developing countries in particular, but also the philosophy of preventive dentistry can be practised more efficiently especially in the countries suffering from financial crisis and lack of professional personnel. As advances are made in aspects of prevention and control of dental diseases, dental auxiliary utilization will have to change to keep pace with the developments. In order to deliver total dental care on a community scale, precise roles of each type of dental auxiliary has to be defined. They are likely to differ from country to country, and therefore need to be reorganized and reached within the social and cultural context of each individual society.

REVIEW QUESTIONS

1. Define dental auxiliary/ancillary. Classify them. Write a note on the rationale for training and use of such dental auxiliary in India.
2. Write notes on:
   a. School dental nurse
   b. Dental hygienist
   c. Dental therapist
   d. Denturist
   e. TEAM
   f. Dental aid and dental licentiate
   g. Dental auxiliary and dental manpower planning in India

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19 Financing Dental Care

Manjunath P Puranik

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INTRODUCTION

In most of the developed and developing countries, cost of the health care services are rising sharply. Dentists are often puzzled, when patients and public complain of high costs of dental care. In response to the barriers faced as a result of not being able to afford the cost of health care, various concepts and mechanisms of financing are born.

From time immemorial, health care has been provided on the basis of fee for service, wherein the patient pays the provider directly for services. This is a two-party system, where the contract exists between patient and the provider. Over a period of time, there has been the emergence of third parties in financing of health care. Dentistry's entry into the third party dental care is now a major and still evolving part of dental practice.

Hence, it is not surprising to see a continuous stream of proposals and mechanisms being conceptualized to make health care amenable to the public.

STRUCTURE OF DENTAL PRACTICE

Primary goal of dental practice is to promote oral health of the public, at the same time preserving the autonomy and economic well-being of the profession. This goal can be achieved by the co-ordination between three basic elements of a delivery system such as:

- The structure of the system, i.e. the organizational arrangement by which patients and provider meet
- The means by which the care is paid for
- The supply of various types of health care personnel.

The structure of dental care provision systems in the US and elsewhere are as under:

Private Dental Practice

Traditionally dental care is delivered by independent private practitioners. Adaptability in a rapidly changing world is a major strength of private practice, an attribute that ensures private practice will endure the challenges of changing times.

There are many *advantages* in private practice. One advantage to both provider and patient is flexibility in terms of duration of work, fees and so on, thereby increasing the productivity. Private practice provides free choice for the practitioner as well as for the patient. On the other hand, there are certain overhead costs such as utilities, rent, equipment, supplies, staff payroll and various forms of insurance. These expenses must be met whether patients come or not, or whether or not bills are collected.

Private practice can be solo practice or group practice. *Solo practice* refers to work in a practice with no other dentists. *Group practice* often refers to practice with at least one other dentist, according to IDA. Some of these dentists may be employed by the owner dentist in the practice. Solo practice is the most common while group practices are generally small, consisting of two dentists. The long-term pattern suggests that the dominance of solo and small group practice will continue with a general shift toward small group practice.

Open and Closed Panels

American Dental Association (ADA) defined closed panels as existing "when patients eligible to receive benefits can receive them only if services are provided by the dentists who have signed an agreement with the benefit plan". Only a small number of practitioners are available in a given area to provide care under the plan. For instance, the practice is set up by an employer or union for the treatment of employees, and their dependents by salaried dentists. In an open panel, any licensed dentist may elect to work with the corresponding beneficiary. The dentist may accept or refuse any beneficiary. In an open panel any licensed dentist may elect to participate. The dentist may accept or refuse any beneficiary. Similarly patient chooses from among all licensed dentist.

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Managed Care

As per Health Insurance Associations America (HIAA), managed care is defined as:

"System that integrates the financing and delivery of appropriate services with selected providers to furnish a comprehensive set of health care services to members". Explicit criteria for the selection of health care providers include formal programmes for ongoing quality assurance and utilization review, significant financial incentives for members to use providers, and procedures associated with the plan.

Managed care has evolved out of a concern over the seemingly endless increase in medical treatment costs and hoped to control the costs of medical care. The most common forms of managed care are: health maintenance organizations (HMOs) and preferred provider organizations (PPOs).

Health maintenance organizations (HMOs). HMOs were intended to provide an acceptable alternative to private practice system and help restrain the costs of care. HMOs were defined in 1973 Act as, "A legal entity which provides a prescribed range of health services to each individual who has enrolled in the organization in return for a prepaid, fixed, and uniform payment".

HMOs having 5 essential elements are:

1. A managing organization
2. A delivery system
3. An enrolled population
4. A benefit package
5. A system of financing and prepayment.

Health management organizations use a prepaid capitation system of financing medical services. One of the main advantages of HMOs lies in their claim to reduce costs of care for those enrolled. The emphasis is on ambulatory care, and unnecessary hospitalization, e.g. for diagnostic tests or minor surgery is curtailed.

Dental care, limited to preventive services, was originally part of basic services and later become a supplementary service. In 1990, only small proportion of HMOs offered dental services where the care was financed through primary capitation premium, a separate premium, or on a fee-for-service basis.

Dental personnel in HMOs: The models are:

- Staff model: Dentists, dental hygienists and dental assistants are salaried employees of HMOs.
- Group model: The HMO contacts directly with a group practice, partnership or corporation for the provision of dental services. The group receives a regular capitation premium from the HMO.
- Independent practice association (IPA): IPA is an association of independent dentists that develops its own management and fiscal structure for the treatment of patients enrolled in HMO. IPA acts as a link between HMO and providers. IPA can also contract with insurers to provide dental services to groups on a capitation basis.
- Capitated network or direct contract model: The network is similar to the IPA, except that the HMO contracts directly with the individual provider for the provision of services. This is the most common form of capitation arrangement in dentistry.
- Preferred provider organizations (PPOs): Preferred provider organization involves contracts between insurance companies and number of practitioners who agree to provide specific services for fees that are lower than average for that area. The mode of payment is fee-for-service unlike HMO. Competition, probably, is a driving force to that PPO patient.

Hospital Dentistry

Dentists have substantial role in hospitals although the amount of care provided is very small. Normally dental care is provided in the hospital for situations requiring general anaesthesia, oral surgery for removal of tumours/correction of cleft lip/palate, prosthetic treatment for victims of trauma or burns involving head and neck region, for patients with systemic diseases, and so on. The experience gained by residents by working in hospitals helps them to make use of hospital privileges later in their career.

INSURANCE AND DENTAL CARE

The use of insurance to help or spread the financial burden of attendant upon death or severe accident is of long standing. Of late, is the effort to apply the same principle to current medical and dental expenses. After World War II, when medical insurance was growing rapidly, dental care was considered uninsurable by carriers. It was felt that the nature of dental need violated the basic principles of insurance, which states that, to be insurable a risk must be:

- Precisely definable
- Of sufficient magnitude that if it occurs, it constitutes a major loss
- Infrequent
- Beyond the control of the individual

Without "moral hazard", which means the presence of insurance itself should not lead to addition claims.

Dental care has been perhaps the least of the health services to receive attention. The incidence of dental disease is more predictable than other diseases. The only category of dental care beyond the range of individually predictable is oral surgical procedures, and such restorative procedures that follow in the wake of an accident. Insurance schemes such as Blue shield policies included oral surgery benefits although a wide range of conditions are included later. Insurance helps in several ways to provide dental care such as:

- Having patients pay a share of the costs
- Limiting the range of services available offering coverage only to the groups
- Including waiting periods after enrollment before benefits become payable
- Using preauthorization and annual expenditure limits.

Having patients to pay a share of the costs is considered as an economic disincentive to overutilization. The portion of the cost of the service that the patient

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pays is either deductible or co-insurance. As per US public health services, a deductible amount is that portion of dental care expenses, which the insured must pay before the plan benefits begin. Many medical insurance, automobile insurance and so on use the principle of deduction. One great disadvantage in deductible clause is that they inhibit preventive measures unless special provision is made to accept these measures from the deductible arrangement. Catastrophe insurance policies are not very much concerned with preventive measures but prepayment policies defined are concerned.

Co-insurance is defined as an arrangement under which a carrier and the beneficiary are each liable for a share of the cost of dental services provided. For example, the dental plan may cover 80% of the cost of the policy holder interested, financially in the amount of care he/she receives. Co-insurance also helps keep premium down.

Limiting the range of services available is yet another way. Some services are available and some are not, as per the plan this is termed coverage, coverage charges or schedule of benefits. Services such as dental implants, cosmetic restorations and extensive temporomandibular joint disorders (TMDs), treatments are rarely covered.

Offering coverage only to groups was done initially because illness experienced is reasonably predictable in a group, although not for an individual. Mass predictability is of extreme importance to the insurance underwriter, since wide fluctuations in the frequency or unit cost of insurance conditions might easily saddle him with obligation that cannot be fulfilled. Although a group would likely include people with high levels of needs, still premiums would be paid. In fact, this is the essence of insurance. The size of the group varies from situation to situation.

Including waiting periods after enrollment, before benefits become payable, reduces the probability of adverse selections (inclusion of high-risk beneficiaries) so that people with existing diseases were not simply going to use the plan, have that disease treated and then drop out.

Using preauthorization, an additional cost-control mechanism, and fixing a limit on annual expenditure dental services are made insurable. Preauthorization means that treatment plans for more than a specific sum must be reviewed by the carrier's dental consultants to ensure that the proposed treatment is reasonable and that same quality of care could not be achieved at less expense.

Some plans distinguish between services-benefit members, who are not subjected to an additional charge by a participating dentist for the services as defined, and identity-benefit members, who are entitled to receive the scheduled amount as a credit toward doctor's customary charge, the difference, if any, being the member's personal responsibility. Service benefits to members are generally limited to low-income families. Both physicians and dentists generally prefer indemnity plans, because these plans permit additional charges to be made, while consumer groups usually resent such plans.

CLASSIFICATION OF PAYMENT PLANS

1. Private fee for service
2. Private third party payment plans
   a. Commercial insurance companies
   b. Non-profit health service corporation
   c. Prepaid group plans
3. Post-payment plans
4. Salary
5. Public programmes

Private Fee for Service

It is a two-party arrangement system and the traditional form of reimbursement for dental services in almost all countries. Although other forms of payment are growing rapidly, this mechanism still remains a major method by which dental patients pay for their care.

Advantages

1. It is culturally acceptable—the concept of an individual establishing a fee for the service rendered is inherent in the way of doing a business.
2. It is flexible—fees can be charged in accordance with the market conditions.
3. It is administratively simple.

Disadvantages

1. There is always a possibility that some potential patients cannot afford the dental care offered.
2. Hence these persons will be unable to receive dental care if private fee for service are the only financing mechanism for dental care.

Private Third Party Prepayment Plans

Third party payment. In this system, the patient and the dentist are the first and second parties, and the administrator of the finances is the third party. It is defined as the party to a dental prepayment contract that may collect premiums, assume financial risk, pay claims and provide administrative services. In contrast with two party systems, dentist receives payment by an agency rather than that by the patient. The third party is sometimes called the carrier, insurer, underwriter or administrative agent. The term public financing of care is used when the government acts as a third party.

In private third party plans, periodic premiums are collected to meet the costs of providing care, as well as the administrative costs of the third party. This arrangement should be called prepayment rather than insurance although dental prepayment and dental insurance are virtually synonymous. The main difference between dental and some other forms of insurance is that traditional insurance involves a group of people making small payments in order to cover the risk of suffering catastrophic loss. The expectation is that few will ever suffer from a loss and most of them will never collect any insurance payments. While dental prepayment is a mechanism to spread the financial load of dental care over a group and over time, virtually all of them can reasonably expect to make regular and somewhat predictable use of the benefits.

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Reimbursement of dentists in Third party plans. The major forms of third party reimbursement in use are: (i) usual, customary, and reasonable (UCR) fee, (ii) table of allowances, (iii) fee schedules and (iv) capitation.

i. *Usual, customary and reasonable (UCR) fee:* ADA has consistently supported the concept of UCR fee as a reimbursement method for dentists in prepayment plans. The ADA definitions of UCR fees are:
   - Usual fee: The fee that an individual dentist most frequently charges for a given dental service.
   - Customary fee: The fee level is determined by the administrator of a dental benefit plan from actual submitted fees for a specific dental procedure to establish the maximum benefit payable under a given plan for the specific procedure.
   - Reasonable fee: The fee charged by a dentist for a specific dental procedure that has been modified by the nature and severity of the condition being treated and by medical and dental complications or unusual circumstances, and therefore may differ from the dentist's "usual" fee or the benefit administrator's "customary" fee.

ii. *Table of allowances (or schedule):* This is defined as a list of covered services with an assigned amount that represents the total obligation of the plan with respect to payment for such service, but this does not represent the dentist's full fee for that service. This system requires dentists to carefully explain to patients the limited nature of the insurance payment.

iii. *A fee schedule:* This is defined as a list of charges established or agreed upon by dentist for specific dental services. It is usually taken to mean payment in full. Dentist's opposition to fee schedule is based on its potential inflexibility, fear that autonomy is threatened and the implicit assumption that dentist's treatment is of same quality and therefore worth the same.

iv. *Capitation:* A capitation fee is defined as affixed monthly or early payment paid by a carrier to a dentist in a closed panel, based on the number of patients assigned to the dentist for treatment. Capitation as per ADA, a dental benefit programme in which a dentist or dentists contract with the programme's sponsor or administrator to provide all or most of the dental services covered under the programme to subscribers in return for a payment on a per capita basis. While in capitation payment the risk is shifted to the providers previously accepted by the insurer.

Types

Commercial insurance companies. Commercial insurance companies operate for profit. They are competitive through a variety of mechanisms such as:

- They can be more selective about a group to which it selects to offer dental insurance.
- They present attractive total health package to potential purchasers.

Commercial insurance plans. These plans operate for profit unlike Delta plans. It is often designed as indemnity plan, meaning cash payments to the providers, rather than as a service benefit plan. This allows the commercial carriers to organize reimbursement differently from the way that Delta usually does. In this, the carrier develops fee profile based on the prevailing fees in the given area, and the dentists are paid at that rate. Fee audits, post-treatment evaluations are less likely while preauthorization, annual expenditure limits and monitoring of treatment pattern are conducted.

Advantages
- The companies pay the dentist directly for the provision of covered services and payment is quicker and hassle free.
- Fee audits and post-treatment dental examinations are not conducted to assess the quality of dental care delivered.

Disadvantages
- They do not encourage utilization of professional services.
- In order to allow for profit margin, they need to charge higher premiums.

Non-profit health service corporation
- Delta dental plans
- Blue cross and Blue shield.

Delta dental plans: Dental Service Corporation was born with the purpose of providing comprehensive dental care programme for children up to 14 years age. A dental service corporation is a legally constituted not-for-profit organization, incorporated on a state-by-state basis that negotiates and administers contracts for dental care. It is not only a full-fledged financial mechanism for administration of prepaid care, but goes further to express the concern of the dental profession for the quality of care. The original dental service corporations, now known as Delta Dental Plans, are sponsored by the constituent dental societies in each state. Characteristics of a dental service corporation as per Mitchell and Hoggard are:

1. Professional sponsorship
2. Non-profit operation
3. Participation permitted by all licensed dentists with the state
4. Benefits provided on a service basis
5. Freedom of choice is allowed for both patient and dentist.

Dental service corporations are subjected to the insurance laws of the state in which they operate. As the number of corporations increased, the need for a national organization was felt, thus leading to the formation of National Association of Dental Services Plans in 1966, supported and funded by ADA. The name became Delta Dental Plans Association (DDPA) in 1969, and most of the members were known as Delta Dental Plan members for that particular state. Delta plans cover about 20 million people in US and account for about 25% of total claims paid annually by all dental care givers.

Delta Dental Plans help the dental practitioners to adapt their traditional patterns of practice to meet the group purchase demand care. Delta also pioneered specific approaches to ensure the quality of care provided and to keep a programme's cost under control.

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Reimbursement of dentists in Delta plans: Reimbursement of dentists, under the fee-for-service programme, depends on whether a dentist is participating (par dentists) or not participating (non-par dentists) with Delta. A participating dentist is one who has entered into a contractual agreement to provide care to eligible persons.

The conditions to be fulfilled by the participating dentist are:

1. Filing of their usual and customary fees with Delta: The accumulated fee of all participating dentists forms the basis of UCR fee system. When a dentist decides to raise his/her fees, he/she must refile the new fees. As long as the new fees are charged to all patients they will become the fees that Delta use for reimbursement purposes.
2. Acceptance of payment for their services at an agreed on percentile as payment in full: This means they will not assess the patient for any further charges, other than co-payments as specified by the particular contract.
3. Fee audits by auditors from Delta check the office records from time to time. The purpose of this audit is to ensure that the dentists are indeed charging their Delta patients the same fees as they charge their other patients, and that co-payments are being properly billed to the patient.
4. Post-treatment inspection of randomly chosen patients is done whom they have treated, by other dentists. The participating dentists agree to abide by decisions regarding quality of care rendered.
5. The withholding by Delta of a small amount of each payment, usually to build-up insurance reserves. Adequate reserves are required by state insurance commissioners in most states.

Initially, the amount withheld was approximately 5%. As the reserves built up sufficiently, the withheld amount has been reduced to as little as 0.5% in some states of the US.

Non-participating dentists need not follow these conditions. However they are paid at 50th percentile of fees, rather than at 80th or 90th percentile usually paid to participating dentists.

Percentile fees: The percentiles of a dataset divide the total frequency into hundredths, so that the 90th percentile is that value below which 90% of the observations lie. When the payment is made at the 90th percentile, 90% of the participating dentists will receive their full fee for the service, and only 10% will be paid at less than their usual fee. This method helps to control payment at the top end of the scale while paying the majority their full fee. In a similar way, non-participating dentists are paid at 50th percentile.

Blue cross and Blue shields: These plans have offered limited dental coverage (hospital based) for many years as a part of hospital surgical-medical polices as they felt dental care was a poor insurable risk. Once dental prepayment was shown to be viable, Blue cross and Blue shield dental plans adopted many of the cost control features and mode of reimbursement of Delta plans. These plans are also active in offering alternative reimbursement methods such as capitation, including Independent Practice Associations (IPAs) and Preferred Provider Organization (PPO) to meet the demand of cost control from purchasers.

Prepaid group plans. These are essentially a budgeting type of arrangement in which predictable expenditures are planned where groups are large enough.

Range of choices

1. Fee for service (FFS): Open panel
2. Fee to service: Participating provider (no provider restriction)
3. Fee-for-service: IPA/PPO model (selected provider participation)
4. Capitation: Staff model groups
5. Capitation: Independent practice association (IPA) model.

Fee for Service: Open panel

- Indemnity commercial insurance plan
- Basic contractual agreement is between insurance company and the insured, wherein the insurance company indemnifies for losses from dental claims as outlined in the policy's list of coverage.
- Patients are free to select the dentist of their choice, can pay directly to the dentist and get reimbursed from the company, or assign payment directly to the dentist.
- Reimbursement is based on table of allowances or UCR fee system upto 90th percentile.
- Dentists are free to collect any difference between their fee and that allowed under the terms of insurance from the patient.

Fee for Service: Participating Provider (no provider restriction)

- Professionally sponsored plans such as blue cross, blue shield and Delta plans.
- Contact is between insurer and the providers (dentist)
- Service benefits cannot charge the patient more than agreed-upon fees.

Fee for Service: Independent Practice Association (IPA)/Preferred Provider Organization (PPO) Model (selected provider participation)

- Provides service benefit by insurance arrangements, but with the clear intention of negotiating a reduced fee with the providers.
- Closed panel—only few offices will be selected to participate in any geographical area, thereby guaranteeing each office a greater volume of patients than would otherwise be obtained.

Capitation: Staff Model Groups

- Health Maintenance Organization concept as applied to delivery of dental services
- In one setting, patient can receive all required dental services
- The economic incentive is to improve oral health status of the enrolled population while the patient gets the advantage of one-stop shopping for dental care.

Capitation: IPA Model

- Advantage of fixing the risk sharing of capitation with the dental care delivery system, as it presently exists.

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Post-payment. This is one of the oldest systems of financing of dental care. Post-payment involves spreading lump sum of indebtedness over a period of time. Use of bank loans to pay their dental bills without ever involving dentist in the transaction is a mode of post-payment. Dentists who permit installments in payment of bills tend to lose interest on the credit as well as run a risk of default in payment.

The first dental personal loan plans were instituted by National City Bank of New York in January 1929, followed by the Bank of America. In 1935, the first dental society plan was established in recognition of the profession's interest in promoting and helping control personal loans for dental care. Later District Dental Society, State Dental Association made arrangements with banks to provide loans. This business has now been taken over by agencies such as Visa and Master Card, where loans are available.

Salary

A defined amount is paid to the dentist whatever the treatment assigned to him, regardless of whether the patient utilizes or not.

Current concepts in payment for dental care

Direct reimbursement: Direct reimbursement involves an agreement between the employer and the employees in which the employer agrees to reimburse the employees for some part of their expense for dental care. Reimbursement is usually on a percentage basis and annual limits are customary.

The ADA promotes this system because it keeps third parties out of decisions on which services to be provided, how frequently they can be provided, what the fee will be, or who will provide the care. This system also minimizes administrative costs.

Administrative services only: In a conventional insurance, the insurer is "at risk" for the costs of care. While in administrative services only (ASO) contract the purchaser of the contract, who is at risk for the costs of care rather than the insurer. The purchaser pays a periodic fee that covers all of the normal administrative services such as actuarial services, claims processing, preauthorization, post-treatment reviews and the processing of payment to provider. ASO contracts are popular with large purchasers because they need not hand over the large sum of money needed for payment to insurance company. Of late, companies called third party administrators (TPAs) have emerged, who handle only the administrative aspects of insurance leaving the risk in the hands of purchasers.

Medical savings accounts (MSAs): This concept is to allow a person to establish and add to a special savings account, protected from taxes, to be used when required to cover medical expenses. If not used, it becomes a part of personal retirement fund. It can be used in combination with high-deductible insurance policy that would cover most expensive and infrequent expenses.

Public Financing of Health Care

Efforts in the direction of public financing of health care can be traced to establishment of Marine Hospital Fund in 1798. Later groups such as coast guard personnel, American Indians, Alaska Native and inmates of federal pensioners were provided with health care.

The year 1935 in the US saw the passage of first Social Security Act in the midst of mass unemployment and widespread destination. Later various insurance acts were passed for the benefit of elderly, survivors and disabled. Inability to purchase health care was considered as a major social problem. The system of grants-in-aid ($1 from state: $2 from federal) was developed as a method of using federal finances for needed health care services for specific categories of needy individuals such as blind, dependent children, permanently and totally disabled, and the aged. Later, vendor payments (payment directly to the provider) were introduced to ensure that allocated funds could be used for health care only.

Growing awareness of the problems of poverty and ill health led to landmark amendments of Social Security Act in 1965, Title XVIII-Medicare, provided for the receipt of health care services by all persons aged 65 and over, regardless of their ability to pay and Title XIX known as Medicaid, intended to bring access to health care to the indigent and medically indigent sections of the population. In 1997, Social Security Act was further amended through Title XXI-State children's Health Insurance Programme.

Public Financing of Dental Care

North Carolina established the first state dental divisions in 1918 and many states followed the suit. Many programmes were instituted, financed and administered by state and local communities. Many state programmes focused on other and child health populations.

Medicare (Title XVIII of social security amendments of 1965). It removed financial barriers for hospital and physician services for persons aged 65 and over, regardless of their financial means. Medicare also covers disabled as well as people with permanent kidney failure.
Medicare has two parts:

Part A: Hospital insurance.
Part B: Voluntary supplemental medical insurance.

Both parts contain a highly complex series of service benefits, and require some payment by the individual.

Medicare addresses the problems of old age, which have high health care needs and low income. It was brought into action because voluntary health insurance system was unable to provide adequate coverage above the age of 65 years.

The dental segment of Medicare is limited to those services hospitalization for their treatment, usually surgical treatment for fractures and oral cancer.

Medicaid. Medicaid was established in the year 1965 by Title XIX of the Social Security Act (SSA), jointly funded by the federal and state governments. It provides medical and health-related services to America's poorest people under the category of parents and children, the disabled, and the elderly. In terms of expenditure, the vast majority of all Medicaid spending is utilized for the services of the disabled (42%) and the elderly (30%), while only 17% of the expenditure goes for their children's services.

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The following services can be availed provided they are considered to be medically necessary:

- Hospital services (inpatient and outpatient)
- Physician services
- Nursing home care
- Nurse midwife and nurse practitioner services
- Laboratory and X-ray services
- Early and periodic screening, diagnostic, and treatment (EPSDT) services (including dental services) for individuals under aged 21
- Federally qualified health centre (FQHC) and rural health clinic (RHC) services
- Family planning services.

According to the federal law, the amount, duration and scope of each service provided must be "sufficient to reasonably achieve its purpose".

Early and Periodic Screening, Diagnostic and Treatment Services: The EPSDT service was enacted in the year 1967 and amended in 1989 provides for periodic screening, vision, dental, hearing and necessary and follow-up services for Medicaid recipients under age 21.

Screening services: The EPSDT screening services must include:

- Comprehensive health and developmental history, including assessment of both physical and mental health development.
- Comprehensive unclothed physical examination (dental screening services are not required for Medicaid children but generally have been considered to be part of general health screening for young children).
- Appropriate immunizations according to the schedule established by the advisory committee on immunization practices (ACIPs) for paediatric vaccines.
- Laboratory tests—the minimum laboratory tests or analyses to be performed by medical providers for particular age or population groups.
- Lead toxicity screening—all children are considered at risk and must be screened for lead poisoning.
- Health education—counseling to both parents (or guardians) and children is required to assist in understanding what to expect in terms of the child's development and to provide information about the benefits of healthy lifestyles and practices, as well as accident and discuss prevention.

When screening indicates the need for further diagnostic or treatment services, children are to be referred to appropriate, qualified health care provides for all necessary services.

The EPSDT hearing and vision services must include diagnosis and treatment of defects in hearing and vision, including hearing aids and eye glasses, and are subject to separate periodicity schedules.

The EPSDT dental services include diagnostic, preventive and therapeutic or treatment services needed for relief of pain and infection, restoration of teeth and maintenance of dental health, starting at an early age deemed necessary in accordance with current standards of dental practice.

Dental Services in Medicaid

Medicaid EPSDT coverage includes all dental services deemed "medically necessary" meaning services that in the opinion of a qualified provider are required to relieve pain and infections, restore teeth and maintain dental health; or correct or ameliorate defects, illness and conditions discovered by screening services. Orthodontic services are generally limited to cases to which the malocclusion is deemed to be "handicapping "or more severe using various classifying indices.

Federal statutes do not require Medicaid coverage for adult dental service, states that do choose to cover adult dental services as a part of Medicaid programme have flexibility to determine eligibility criteria and the type of service screening they will provide.

STATE CHILDREN'S HEALTH INSURANCE PROGRAMME (SCHIP)

This programme (Title XXI of SSA in 1997) was developed in the US to provide coverage for children in low to moderate income families who do not qualify for Medicaid. The overwhelming majority of newly covered children are from "working poor" families in which one or both parents are employed but earn little to afford health insurance.

Dental coverage is not a requirement under Title XXI, But 49 out of 50 states in the US have chosen to offer dental coverage as part of their SCHI programmes and to provide relatively comprehensive benefits. It includes preventive, diagnostic and restorative services, although the coverage is not as broad as Medicaid's EPSDT programme.

The relative success of dental service delivery through SCHIP, supported by higher payment rates and improved provider participation, may provide a model for Medicaid programmes to consider in their efforts to improve access.

Other Programmes of Public Financing of Dental Care

- The Indian Health Service (IHS) is responsible for medical and dental care for American Indians and Alaska Natives.
- US coast guard personnel and inmates of federal prisons are provided with dental care by dentists of US Public Health Service.
- Community and migrant health centres for the benefit of rural and high poverty urban areas. MCH Service block grants for dental care.
- Head start for pre-kindergarten and kindergarten children from deprived backgrounds; those are otherwise not eligible for Medicaid.
- Health care services for homeless.
- Haemophilia projects for haemophiliacs.
- Rehabilitative care for children born with cleft lip and palate.
- The Dept of Veteran Affairs provides some dental care to eligible veterans.
- Various schemes for military personnel in service and after treatment.

INDIAN SCENARIO

More than three fourth of the Indian population reside in rural areas, predominantly depending on agriculture

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for their livelihood. Unfortunately most of them are poor, have no fixed income, and are at the receiving end due to unpredictable monsoons. Hence, purchasing insurance for health care, paying regular premiums become out of question.

Some parts of the urban areas consist of population residing in the slums (urban poor) who have migrated to cities in search of manual jobs and working poor class people who are unable to purchase health care.

In this situation, the proportion of population eligible for insurance is about 2% which is very low. Also when it comes to purchase of care/general health, receives the first priority and as always, oral health is neglected. Thus, a collective organized effort is required to bring about a sea change, not only in the attitudes of the recipients of care but also in the administrators, policy makers and like-minded people such as NGOs in the private sector.

Funds to set up an Insurance corpus should be raised in the local areas, supported by *Gram panchayats* and NGOs. Government can provide a boost for such an endeavour by adding the matching amount to the premium collected every month. Coverage should be provided to the households rather than individuals. When the resources are scarce, priority should be given to school going children, expectant mothers, handicapped and the aged.

Government has been making all efforts in the provision of health care on the basis of the principle of primary health care. Organized efforts are needed to achieve this goal in the true sense.

There is no universal health scheme in India. It is at present limited to some industrial workers or specified group of employees. The central government employees are also covered by health insurance under the Central Government Health Scheme (CGHS).

Employees State Insurance Scheme (ESI)

It was introduced by an act of Parliament in 1948 amended in 1975, 1984 and 1989. It provides benefits for sickness, maternity, employment injury and death due to employment injury.

Scope of ESI

1. Small power using factories employing 10 to 19 persons, and non-power using factories employing 20 or more persons
2. Shops
3. Hotels and restaurants
4. Cinemas and theatres
5. Road motor transport establishments
6. Newspaper establishments.

Finance. The scheme is run by employee's contribution and grants from central governments. The employer contributes 4.75% of the total wage bill, the employee contributes 1.75% of the wages. Employees getting wages below 15 rupees are exempted from the payment contribution. State government shares 1/8th of the total cost of the medical expenditure and ESI corporation's share 7/8th of the medical expenditure.

Benefits to the employees

1. Medical benefit
2. Sickness benefit
3. Maternity benefit
4. Disablement benefit
5. Dependant's benefit
6. Funeral's expenses
7. Rehabilitation allowance.

Central Government Health Scheme (CGHS)

Central Government Health Scheme was introduced in 1954 for comprehensive medical care of central government employees.

The dental health aspect is covered through the dental welfare facilities available in dispensaries.

Defence Medical Services

Defence services have their own organization for medical care to their personnel under the banner "Armed Medical and Dental Service".

Health Care of Railway Employees

The railways provide comprehensive health services including dental treatment through the agency of railway hospitals, health units and clinics.

Dental Insurance Schemes in India

- The first of its kind dental insurance scheme in India was launched through **oral care brand, Pepsodent** in 2002.
- The scheme, launched through a partnership with the New India Assurance offered a dental insurance of Rs 1,000 on purchase of any pack of Pepsodent.
- Insurance cover against expenses for the extraction of teeth due to caries and periodontitis was provided.
- Dental rehabilitation was not covered.
- But this plan was time bound and also did not cover other aspects of dental rehabilitation.

The dental insurance plan provided by **ICICI Lombard** and **Bajaj Allianz** are not comprehensive plans and are clubbed with the general health insurance scheme.

- "Health Advantage Plus" by ICICI Lombard is the **first health insurance product to cover OPD and Dental expenses** while optimizing on tax benefits under Section 80D. The age limit for health check is also the highest at 56 years.

Metlife dental insurance plan

- Is currently offering its members a preferred dental programme.
- This is considered as a preferred provider organization (PPD) with a nationwide network of 90,000 dentists locations.

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- Fee for this particular plan is 10–35%.
- The plan covers essential care arrangements, endodontic treatment, implants and dentures and other procedures.
- **Indian Dental Association** has also been striving to bring out a new all-inclusive dental health care insurance scheme.
- However, it has been unable to achieve anything substantial on this front.

On the whole, very limited percentage of population in India is having the facilities either getting treatment postpaid or to make payment in any other way. Unfortunately within this category payment for dental treatment or provisions for payment through any other means is very negligible, hence the concept and utilization of financing for dental care in Indian scenario is far from the reality and it is not possible to practice.

CONCLUSION

Health care services traditionally have been provided on a fee-for-service basis, whereby the patient receives various types of services and makes the payment to the provider. There are various methods of payment for the services provided by the health care personnel. Private fee for service will likely to remain the predominant method of financing the dental care in the foreseeable future. Developing countries like India are in a transition period during which alternative feasible modes of financing and delivery of services will evolve. Dental personnel and health care service organization can be certain that financing of dental care is a very important dynamic area, and there could be further expansion and evolution with new concepts that might emerge.

REVIEW QUESTIONS

1. Define the following:
   a. Payment in dental care
   b. Dental insurance
   c. Post-payment plans
   d. Delta dental plans
   e. 90th percentile
   f. Group practice
   g. Medicare and Medicaid
   h. Public financing of dental care

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20 Dental Needs and Resources

Manjunath P Puranik

CHAPTER OUTLINE

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INTRODUCTION

Before embarking on dental public health programme careful studies of dental diseases and the facilities for dental care are needed in order to answer a number of leading questions about the function of public dental health programme.

Dunning points out important questions such as:

1. What are the dental needs of the community or population?
2. To what extent will prevention of the disease obviate the need for treatment?
3. How large is the demand for dental treatment in the population at current or at different prices?
4. What dental manpower is available to serve the population and how efficiently is it used?
5. What is the prevailing philosophy of the people regarding the extent of health care they expect to receive from government?
6. What scope of service shall be offered in the public programme?
7. Who shall receive the service?
8. How can the service if new be adjusted to the customs and culture of the population?

It requires broad and extensive thinking, great deal of hard work and support and cooperation of the community to answer these questions. Careful preparation will pay rich dividends in the long run.

Concepts of Need

Normative need: Need that is defined by experts. Normative needs are not absolute and there may be different standards laid down by different experts.

Felt need (want): Need perceived by an individual. Felt needs are limited by individual perceptions and knowledge of services.

Expressed need (demand): Felt needs turned into action. Help seeking.

Comparative need: Needs are identified by making comparisons with other areas or services.

DENTAL NEEDS

Before assessing the dental needs in terms of resources required it is essential to examine health situation existing globally and appropriate care required.

Primary Dental Care

Dental care of this type is based on the model of primary health care wherein physicians are located in primary health centres (PHCs), but actual care is rendered in outlying areas by auxiliaries under general (not direct) supervision. "Bare foot doctors" of China are trained and equipped for relief of dental pain. Similarly "lay persons", in some parts of the world are trained to provide dental first aid, place temporary fillings, repair dentures and make intelligent referrals to urban dentists. In many developing countries where this situation prevails, instruction on oral hygiene and nutrition can be given.

Blood and Vulcanite

It is found among low income or uneducated groups or where there is lack of dental manpower. These groups neither prevent disease nor conserve the affected teeth, the consequence being extraction of teeth (blood) followed by dentures (vulcanite). Such areas need more care than primitive and underdeveloped areas. Dental education should be provided, with emphasis on prevention and early control of dental disease for a new generation.

Systemic Infection of Dental Origin

The fact that mouth acts as a portal of entry for agents of disease have made it clear that dental infection could not be dissociated from systemic disease. Dunning opines

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that even an intelligent public will often become impressed with the need for dental health only when a role of a healthy mouth in the control of systemic disease is property demonstrated.

Dental Need in Terms of Comprehensive Dental Care

Comprehensive dental care besides elimination of pain and infection provides restoration of serviceable teeth to good functional form, the replacement of missing teeth, maintenance care for the control of early lesions of dental disease, and most important of all, preventive measures, educational and otherwise so that a population may experience a low prevalence of disease. Good quality work using the best of the modern restorative techniques is advised.

As per studies conducted by Douglas et al in the United States using life tables and estimates of population growth, the need for operative dentistry will be higher for ages of 30 and 40 (40 million hours) whereas other studies indicate a net increase of 24 million hours in developing countries where increase in caries incidence has occurred.

As the pattern of dental caries changes and the growing ranks of elderly keep more and more of their natural teeth, the problem of periodontal disease will assume a larger part of sum total of comprehensive dental care.

Dental Needs by Sex and Race, Frequency of Treatment, Income and Region

Women are more considerate to their oral health and are more concerned to prevent cosmetic defects than are men. Hence they may demand more care in comparison to men. The need for extraction and dentures are lower in women than men while need for periodontal care is equivocal.

There are accumulated needs among blacks than whites for fillings while need for periodontal care, extraction and prosthesis was more in whites than blacks. Periodontal care need in India and China appear to exceed those in the United States while need for treatment of caries is smaller.

American Dental Association study showed that the patients who had seen their dentists for more than 3 years are in far greater need of care than those who have seen the dentist more frequently.

Dental needs are generally lower among patients with high income probably due to better preventive measures, education and frequency of visit. More fillings are seen in high income while higher count of decay in low-income group.

Marked downward trend in childhood caries is seen in developed countries whereas upward trend is seen in developing countries.

As per National Oral Health survey and fluoride mapping 2002–2003 India, the findings are:

- The caries experience was high in all age groups and increased as age advanced. The decayed tooth component was dominant in the younger age group, while missing teeth component was dominant in the older age group. There were virtually no filled teeth across age groups in the country, indicating a high proportion of untreated caries. The prevalence was higher in rural than urban residents.
- The periodontal disease marked by calculus and bleeding was widely prevalent in all age groups. Shallow pockets (4–5 mm) and less severe forms of loss of attachment were most common in 35–44 and 65–74-year-old adults. Rural residents were more affected than their urban counterparts.
- Nearly 30% subjects in 65–74-age group were completely edentulous while only 0.55% subjects were edentulous in the 35–44-year-age group. Survey indicates that teeth are rapidly lost in middle and old age due to dental caries and periodontal disease.
- Malocclusion, as per dental aesthetics index, was reported in 23.6% and 23.9% of 12 and 15 years respectively. However, these figures only include the definite, severe and more severe types of malocclusion.
- Only a few cases of oral cancers and precancerous lesions were detected in this survey. One impression from this study is that prevalence of oral cancer is about 15 per thousand in the country while that of precancer is high.
- Moderate and severe forms of fluorosis which may be associated with skeletal fluorosis appeared to be infrequent and had a low prevalence in the country. Fluorosis was prevalent in 10.2% and 9.9% in 12 and 15 years respectively.

Factors Affecting Dental Health

A correlation is established between selected clinical variables and findings on the socioeconomic and cultural background such as:

- The regular and irregular cleaning by the individual is associated with either increased or decreased prevalence of periodontal disease.
- A strong correlation exists between consumption of sugar and its frequency and the prevalence of dental caries.
- There is a strong association between the prevalence of oral mucosal conditions, especially leucoplakia and tobacco smoking.

DEMAND FOR TREATMENT

Demand for dental care can be influenced by a number of factors and can vary as a result of manipulation. So it is essential to calculate approximately the portion of the population that will demand these services as well as the kind of services that will be demanded.

As per Pelton, there are five automatic factors such as gross increase in population, urbanization, education, occupational changes and income per capita can increase the demand for dental care.

Expensive dental care, cost of travel and time lost from work and cost of child care in families with more than one child tend to depress the demand for dental care.

The reasons why individuals may elect not to ask for needed dental treatment are often a subject of psychological rather than economical analysis. Effective education for

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dental health can create awareness thereby demand for treatment. In this regard, interdisciplinary approach is required to start educational activities in state departments so as to take dentistry to a common man.

MANPOWER

The supply of dental care available in a given area and to a certain extent also the demand for dental care are linked with the number of people in the dental profession, and the way they make use of them. The dentists, auxiliaries and the total output are considered.

Dentists

Most of them in India are in private practice while the rest are employed in government/private service, teaching or research. Practice is part-time or full-time. Among practitioners there are more general practitioners than specialists. Practice is concentrated in cities and bigger towns while many rural areas are devoid of services.

Auxiliary Dental Personnel

A comparison between medical and dental profession shows that the dentists still have a long way to go to match their medical counterparts in the utilization of auxiliary personnel. A few institutions offer a course on dentist/ hygienist/laboratory technician programme. The supply of auxiliary personnel is inadequate and has a remarkable effect on the total output in the delivery of oral health care. Recruitment of new type of dental manpower like dental licentiate and dental aides can improve the oral health situation.

SCOPE OF SERVICE

Comprehensive Dental Care

Comprehensive dental care refers to the meeting of accumulated dental needs at the time, a population group is taken into the initial care programme (initial care), and detection and correction of new increments of dental disease on a semi-annual or other periodic basis (maintenance care). It is obvious that dental manpower is inadequate as well as maldistributed to provide comprehensive dental care. Only few receive comprehensive dental care whereas most of them receive some care or no care at all.

Incremental Care

Incremental care may be defined as periodic care so spaced that increments of dental disease are treated at the earliest time consistent with proper diagnosis and operating efficiency, in such a way that there is no accumulation of dental needs beyond the minimum. In public health programme, the interval is 1 year while it is biannual in private practice.

This represents the ideal pattern for care from the point of treatment, interception or prevention of oral disease and also bills for dental service are equalized and regularly spaced.

This system has certain disadvantages like operative dentistry is more time consuming on a piecemeal basis than upon a wholesale basis. Secondly this targets the youngest available group and the funds get exhausted even before the elementary school population has been cared for, and the high school child receives no care at all.

Prevention Versus Treatment

Only prevention can bridge the gap between dental care and dental disease. No complete preventive measure has been discovered either for dental caries or periodontal disease. The best strategy lies in a combined use of water fluoridation, dietary improvements, oral hygiene, early correction of dental defects, control of concomitant disease, etc. than providing comprehensive dental care.

Dental Care for Children

Children form the most important subgroup from the point of control of physical/mental defects, control of communicable disease, and value of health education is great in this group. However seldom does dental care reach an entire child population.

Chronically Ill Elderly

Chronically ill elderly deserves attention in part because it is often confined in public institutions and in part because the chronic nature of illness involved creates acute financial problems even for people normally in the middle-income brackets (medical indigence). Special problems of disease, access to care and psychological attitude toward care occur among the elderly; geriatric dentistry should be able to cater to their needs. Dental hygienists have a greater role where there are problems of access and home care.

Industrial and Consumer Groups

There are many voluntary agencies that advantageously maintain public health dental programme such as consumer groups, industrial employers, labour unions, fraternal organizations, service clubs, etc. These programmes may be of preventive type or as straight efforts to purchase dental care on a group basis.

MATCHING PROGRAMMES TO NEED AND DEMAND

Fitting of dental health programmes to need and demand is far easily said than done. Different levels of dental care should be designed for varying degree of development of a nation's existing manpower. Mere increase in manpower may not be adequate unless long-term actions on number of issues such as recruitment, geographical distribution, auxiliary utilization are taken in the field of prevention of dental disease. The need for

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increased understanding and action is to be clear and strong.

Dunning suggests few principles for type, scope and availability of services:

1. *Search for real stress groups* in the population, where the need for education or for care clearly exceeds ability to obtain it.
2. *Do not be afraid to educate* for fear that demand will exceed manpower supply.
3. *Be attentive to public demand,* particularly in the field of group care.
4. *Learn team leadership* for the more efficient use of auxiliary personnel.
5. *Concentrate on the public programme* on those services where prevention of disease can best be obtained and where teamwork is of greatest value.
6. *Blend financial aid* from private and government sources, making more efficient use of the principles of insurance, prepayment and postpayment.

CONCLUSION

It is essential to study various factors related to oral diseases and the facilities for dental care in order to plan an appropriate public dental health programme. Dental needs do exist in populations but type of care to be rendered should be based on resources available and the demand for care. Dental needs vary with sex and race, frequency of treatment, income and region. A correlation is established between selected clinical variables and findings on the socioeconomic and cultural background. Demand for dental care can be influenced by a number of factors and can vary as a result of manipulation. Scope for service includes incremental dental care, comprehensive dental care but the emphasis is on prevention rather than treatment in any public health programme catering to the needs of children, elderly and the other needy groups. Matching programmes to need and demand is critical for the success of the programme.

REVIEW QUESTIONS

1. Write notes on:
   a. Primary dental care
   b. Comprehensive care
   c. Dental needs
   d. Dental manpower
   e. Dentist-population ratio
   f. Incremental dental care
   g. Dental public health programmes

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21 Planning and Evaluation in Oral Health

Manjunath P Puranik

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INTRODUCTION

Planning is an integral part of health care provision. At the most basic level, planning aims to guide choices so that decisions are made in the best manner to reach the desired outcome. Planning provides a guide and structure to the process of decision making to maximize results within the limited resources available.

Planning is a process of preparing a set of decisions for action in the future, and must precede development and change in any organization. Planning provides an opportunity to be proactive in decision making rather than constantly reacting to pressure and demands. It enables priorities to be set and identifies where resources can be directed to have the greatest impact.

As per Banfield, "A plan is a decision about course of action." In other words, a plan is a systematic approach to defining the problem, setting priorities, developing specific goals and objectives and determining alternative strategies, and a method of implementation.

TYPES OF HEALTH PLANNING

As per Spiegel and associates, health planning is of various types. It may be *problem solving planning* such as Colorado stain problem or school based *programme planning* to reduce dental caries. *Coordination of efforts and activities planning* is done to improve the efficiency and effectiveness of health systems. *Planning for allocation of resources* becomes vital when the resources are limited. A state health plan is an example of *creation of a plan* while *design of standard operating procedures* provides a set of standards of practice or criteria for operation and evaluation.

This chapter describes various types of health planning but concentrates specifically on planning of dental health services and community dental programme planning process.

PLANNING OF DENTAL HEALTH SERVICES

Six main stages of planning of dental health services have been described (WHO, 1976): (i) situation analysis, (ii) problem identification and formulation of objectives, (iii) formulation and analysis of alternative strategies, (iv) identification of special efforts, (v) strategy selection and (vi) programme formulation (Fig. 21.1).

Situation Analysis

In the first stage, a review of the existing services is done and information is collected about the population to be served and the resources available. Account must be taken of national and local policies and the steps which are required to obtain approval of any changes.

The types of information relevant to the planner include data about the needs of the population, the resources available and performance of the service.

To begin with description of a population by age group with projections of the expected changes is done. Demographic information is required on the population density, distribution and mobility and the social class composition of the area. Transport and communications may be important in determining what services should be provided. In addition to that existing service provision, and disease levels information should be collected.

Information is also required about the knowledge, expectations, attitudes and dental health related behaviour of the public including the use of preventive measures such as fluoride supplements and dentifrice.

A report should be prepared on existing services, including manpower and facilities, and their distribution. The level of performance should be analyzed and the possibility of change investigated. Similarly any constraints imposed by professional values and attitudes should be identified (Fig. 21.2).

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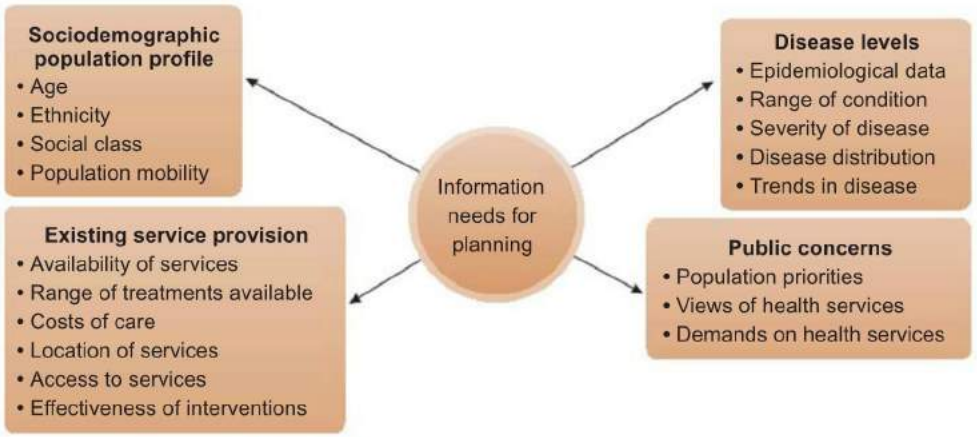


Figure 21.1 Information needed for planning.

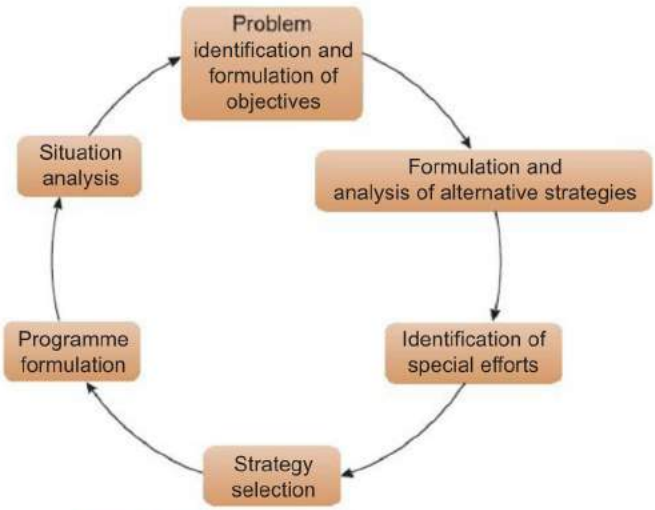


Figure 21.2 Planning of dental health services.

Problem Identification and Formulation of Objectives

The overall aim is to meet the dental health needs of the population. A need for health care exists when an individual has an illness or disability for which there is an effective and acceptable treatment or cure.

Selection of the concept of need is crucial in the identification of problems and setting of objectives. Traditionally oral health services have been planned on the basis of information collected in normative assessment of need, although it has certain fundamental shortcomings.

The recognition of a relevant problem apt for intervention is done being aware of the way in which professional and political values intrude into this type of decisions.

The type of objective selected should be determined by the nature of the problem identified. The objectives must be realistic, achievable and measurable. They should include a definition of target population, statement of priorities, and expressed in terms of dental indices (DMF or so on) or non-dental indicators (availability/acceptability).

Formulation and Analysis of Alternative Strategies

Various combinations of preventive measures, different ways of providing treatment services in rural areas (mobile unit/fixed clinics) may be considered. Each alternative strategy needs to be examined carefully as regards to its technical, social, political and financial feasibility. Logistic constraints will narrow the choice, and remaining options should be subjected to critical analysis of their costs in relation to the benefits which are likely to increase.

Identification of Special Efforts

Any planned change involves making choices based upon predictions coupled with an element of risk. The extent of risk can be reduced by testing the proposals on a small scale before widespread implementation. This needs collection of special data, field trials or pilot studies, recruitment and training programmes to ensure that the results are valid and forms a sound basis for judging the value of the project.

Strategy Selection

Selection of the most desirable strategy is made after considering all the feasible alternatives and their advantages and disadvantages. To gain cooperation and support for future implementation, steps should be taken to involve not only technical experts and administrators but also the providers and consumers of the services.

It may be necessary to revise the objectives based on the feasibility and acceptability of the proposals, even at this juncture. Provisional agreement from the relevant authorities should be obtained before proceeding to the next step.

Programme Formulation

It is necessary to plan the detailed implementation once the strategy is selected. It consists of the preparation of schedules of sub-objectives covering methods, manpower, facilities and finance. It describes the techniques to be employed, the intended coverage of the target

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population and how the programme will be managed and controlled. The plan should indicate precisely what should be done by whom, when and at what cost.

The plan should include a description of the method of evaluation and the arrangements for the collection of necessary data. The nature of the information and criteria used should be relevant to the objectives so that the degree of success in achieving them can be assessed.

PLANNING FOR COMMUNITY DENTAL PROGRAMMES

The process of programme planning uses a systematic approach and should be used as a guide to solving a particular problem. The process of planning is dynamic. Within a fluctuating and ever changing system, the process itself must remain fluid and flexible, responsive to the presentation of new factors and issues (Fig. 21.3).

Needs Assessment

The first step in the planning process is to carry out a needs assessment. The main reason is to define the problem and to identify its extent and severity. Also it is used to obtain the profile of the community to ascertain the causes of the problem. This information helps in developing appropriate goals and objectives. It also involves identifying potential health problems and health promotion needs. A needs assessment evaluates the effectiveness of the programme.

Conducting a needs assessment for a community can be a costly endeavour. One has to coordinate with the research activities of other agencies with similar interest or find out if similar surveys are done in the past by other organizations.

It is important to consider what type of information is needed and how it should be obtained. Data can be obtained by various techniques such as survey, questionnaire or clinical examinations or more informally through personal communication based on the population to be examined.

Data for needs assessment should essentially include:

1. Population profile, general information on a population.
2. Epidemiological data on patterns and distribution of dental disease.
3. History and current status of dental programmes in the community.
4. Mode of development of policies and decisions.
5. Types of resources available to the community (funds, facilities and labour).

When planning a preventive dental programme for a community or institution, the planner should determine sources of water, fluoride status of water, efforts to provide fluoridation and attitudes, laws regarding fluoridation and type of fluoride being administered to individuals in private offices, the schools and the health centres.

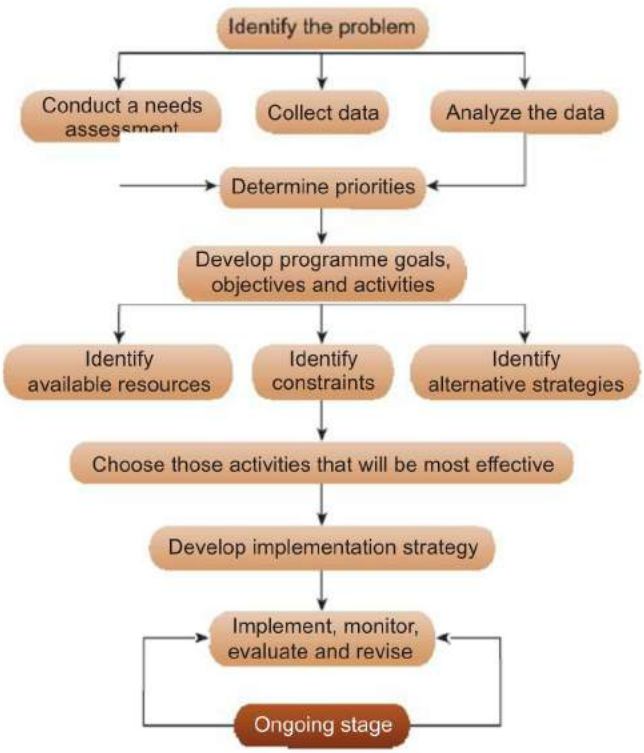


Figure 21.3 Planning cycle.

Collection of Data

Data can be collected by conducting a survey with various techniques discussed and also from local, state and central agencies and private organizations. Other sources for obtaining such data are research studies and investigative reports.

Analysis of Data

Once the data are obtained, the information must be analyzed before it can be put into a plan of action:

- It is important to first look into the socioeconomic structure of the community and determine the type of employment that exists. This information is important because it indicates whether or not they might be able to afford dental care through their jobs.
- Population breakdown reflects the possible cultural and language issues which should be considered.
- The age distribution tells what the target groups are, and thus sets up priority for planning.
- The educational status of a community provides two perspectives for planning: (i) it tells the educational level (years of schooling) obtained by majority of community members, and (ii) it may give an understanding about the community's values towards obtaining an education.
- Knowing the median income of the community helps in determining the population's ability to purchase health services.
- A look into the community's public transport system provides the information regarding the population's access to health care services. This is especially true for rural communities where roads are unpaved and public transportation is scarce.
- Health care facilities indicate types of services being provided, the amount of services and the cost of receiving those services.

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- The labour data (health resources) give information about the number of dentists providing care. More than the dentist:population ratio it is important to know types of services provided, the cost and the availability of services.
- Knowing the fluoride status of a community is also essential for dental planning.
- In most cases the political affairs of the community will determine the direction the programme takes. Each local government's policies may vary in its methods of instituting new programmes, allocating funds, hiring personnel or setting priorities. In addition, the politics of the state government will also shape the overall direction taken by the communities within the state.
- Educational system provides an insight into number of schools, and enrolment and distribution of children among schools within the community. This information can assist in developing school-based programme for the community.
- If the planner is designing a dental treatment programme for specific population, the survey data can be converted into specific resource requirements (time, labour and facility) for treating the population.

Determining Priorities

As per Spiegel "Priority determination is a method of imposing people's values and judgement of what is important onto the raw data."

When resources are limited, it becomes necessary to establish priorities to allow the most efficient allocation of resources. If priorities are not determined, the programme may not serve those individuals or groups who need the care most.

A health task force or advisory committee formed by consumers, community leaders and providers should be established to aid in the development of policies and priorities. Planning with community representation helps in the programme's implementation and acceptance.

Priorities should be determined based on extent and severity of the disease as well as groups with high-risk dental needs. Among population groups preschool and school children, mentally or physically disabled, chronically ill or medically compromised, elderly, expectant mothers, low-income minority groups (urban and rural) have high-risk dental needs. Once the target group has been identified (based on the dental problem), the type of programme should be established.

Development of Programme Goals, Objectives and Activities

Programme goals are broad statements on the overall purpose of a programme to meet a defined problem such as "to improve the oral health of the school-aged children in community," while programme objectives are more specific and describe in a measurable way the desired end result of programme activities.

The objectives should specify the nature and extent of the situation or condition to be attained, the target group or portion of the environment and the geographical areas of the programme and also the time by which the desired situation or condition is intended to exist.

Programme objectives may be outcome objectives or process objectives based on the way they are started. Outcome objectives provide a means of measuring quantitatively the outcome of the specific objective whereas process objective states a specific process by which a public health problem can be reduced and prevented.

Subsequently a statement is made about programme activities which include type of activities, personnel to be involved and the schedule with due considerations to the type of resources available as well as the programme constraints.

Resource Identification

Commonly used criteria to determine what resources should be used are appropriateness, adequacy, effectiveness and efficiency of resources in completing the job.

Identifying Constraints

Constraints may result from organizational policies, resource limitations or characteristics of the community. By identifying these constraints early in the planning stages, one can modify the design of the programme and thereby create a more practical and realistic plan.

One of the best ways to identify constraints is to bring together a group of concerned citizens who might be involved in or affected by the project. As a group that is familiar with the local politics and community structures, these individuals not only can identify the constraints but also can offer alternative solutions to and strategies for meeting the goals.

Alternative Strategies

It is important to generate a sufficient number of alternatives so that at least one may be considered acceptable. With limited resources, the planner needs to consider the anticipated costs and effectiveness of each alternative.

If the preventive measures were considered to be cost effective, as well as practical to implement, then select that measure as the best of the alternatives.

Implementation, Supervision, Evaluation and Revision

The process of putting the plan into operation is referred to as the implementation phase. This phase is ongoing in situations where close supervision and evaluation of the programme ensure effective operations.

Integrating all the external variables to achieve comprehensive planning and implementation requires an ecological approach (Bruhn, 1972). Only through teamwork between the individual and the environment can the implementation be successful.

Developing and Implementation Strategy

An implementation strategy for each activity involves addressing various aspects related to the programme such as the effect of the objective to be achieved, the activities required to achieve the objective, individuals responsible

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for each activity, chronological sequence of activities, materials, media, methods and techniques to be used and the cost estimate of materials and time.

To develop an implementation strategy the planner must know what specific activities they want to do. Once stated the planner may specify what activities must be undertaken to implement the activity.

Phase of Implementation

Health programmes can be divided into four phases of implementation, which should occur in sequence:

1. Pilot phase
2. Controlled phase
3. Actualization phase
4. Operational phase.

In the pilot phase the programme proceeds on trial and error basis, while in controlled phase the programme runs under regulated conditions to judge its effectiveness. In actualization phase the programme is subjected to realistic operating conditions whereas, in the operational phase the programme becomes an ongoing part of the structure. Each phase has different objectives to be met.

Monitoring

Once it has been implemented, the programme requires continuous surveillance of all activities. The programme's success is determined by monitoring, in terms of programme objectives met, individual's job efficiency, equipment functioning and appropriateness and adequacy of facilities only so as to avoid problems, and adjustments are made as and when necessary.

RATIONAL PLANNING MODEL

Within the community and hospital dental services the rational planning model is used to a certain extent. In general dental service, the dental practitioners need to plan how best to provide a good level of dental care, and make a reasonable income. One should know type of dental problems, attitudes, beliefs and economic factors in the area of practice and the approach one will adopt to best cope with the problems (Fig. 21.4).

The rational planning model provides a basic guide to the planning process (McCarthy, 1982) and involves the following steps:

1. Assessment of need: identification of oral health problems and concerns of the population.
2. Identifying priorities: agreeing the target areas for action.
3. Developing aims and objectives: aim is the overall goal to be achieved, whereas objectives are the steps needed to reach the aim.
4. Assessing resources: identifying the range of resources available to facilitate implementation of the plan, for example personnel, materials and equipment.
5. Implementation: turning the plans into action.
6. Evaluation: measuring the changes resulting from a plan.

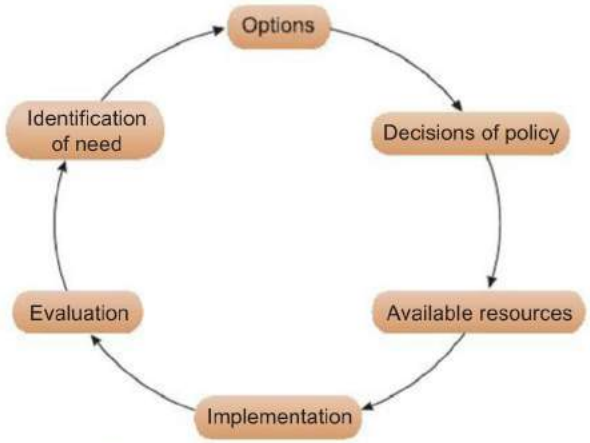


Figure 21.4 Rational planning model.

EVALUATION

Evaluation is intended to determine the value of the programme to see if it has been carried out as prescribed and to discover whether the required performance and objectives have been achieved. It should demonstrate the extent of the contribution to oral health in the target population and whether each part of the programme is relevant and appropriate.

Measurements of the results may be direct or indirect. Direct measures assess changes in oral health, due to the programme being evaluated using dental indices. Indirect measures are used when results of the programme may not appear for a long time such as health education aimed at reduction of tooth loss due to periodontal disease.

In this situation, knowledge and attitudes, oral hygiene status or level of gingivitis are assessed. Indirect measures make assumptions about the relevance of the characteristics being measured and should be treated with caution.

Four main criteria have been accepted for use in the evaluation of dental services (WHO, 1972) such as *effectiveness* in terms of stated objectives being achieved; *efficiency* relating to cost in manpower and finance regarding the output of the programme; *appropriateness* concerning to programme's acceptability to both consumers and providers and priorities reflecting a proper interpretation of the needs of the population and *adequacy* in relation to coverage of the target population and the readily available services.

Evaluation is an integral part of the planning process. The results are the starting point for further examination of the need for change and the basis for the selection of future objective and strategies.

Evaluation, both formal and informal is a necessary and very important aspect of programme. It helps to measure the progress and effectiveness of each activity, identify problems in carrying out the activities and plan revision and modification. Besides it helps to justify cost of administering the programme, and if necessary justify seeking additional funds.

Evaluation should address the quality of what is being done. The attitudes of recipients should be examined to determine whether the programme is acceptable to them.

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Elements of Evaluation

Evaluation is the most important as well as hard task in the area of health services. The components of evaluation process are:

1. Relevance: relates to the appropriateness of service. (Is it needed at all?) If the need does not exist, the service is of hardly any value. Vaccination against smallpox is now irrelevant because the disease no longer exists.
2. Adequacy: If adequate it means relates to allocation of resources (money, men, material and time) according to workload or demand.
3. Accessibility: refers to proportion of population that can be expected to utilize specified facility or service, etc. There can be physical barriers (e.g. distance, travel, time); economic barriers (e.g. travel cost, fee charged); social and cultural barriers (e.g. caste and language barrier).
4. Acceptability: refers to the services provided that may be satisfactory or suitable to all, for example male sterilization, screening for rectal cancer.
5. Effectiveness: relates to the degree to which underlying problem is prevented or lessened. Hence it measures the extent of accomplishment of predetermined goals, objectives and targets of programme, service or institution-expressed, if possible, in terms of health benefits, problem reduction or an improvement of an unsatisfactory health situation. In health services the eventual measure of effectiveness will be decline in mortality and morbidity rates.
6. Efficiency: It evaluates how well resources are utilized to be given accomplish the objectives (effectiveness). The number of immunization provided in an year as compared with an expected norm; the percentage of bed occupancy, cost per day in hospital, cost per patient treated, etc. are some examples.
7. Impact: refers to overall effect of a programme, services or institution on health status and socioeconomic development. For instance, due to malaria control in India, not only the incidence of malaria dropped down, but all aspects of life such as agricultural, industrial and social sectors showed a marked development. If the target of immunizations is reached say 100%, it may also lead to reduction in the incidence or elimination of vaccine preventable diseases.

Planning and evaluating is a continuous interactive process, with frequent modification of both objectives and plans. Successful evaluation may also depend upon whether evaluation was built into the design of the programme before it was implemented.

Types of Evaluation

- Formative evaluation
- Summative evaluation.

Formative evaluation. Formative evaluation refers to the internal evaluation of the programme. It is an examination of the process or activities of a programme as they are taking place. It is usually carried out to aid in the development of a programme in its early phase. Formative evaluation is used primarily by programme developers and programme staff members concerned with whether various components of a programme are workable or whether changes should be made to improve programme activities. It plays an important role in pilot phase and controlled phase of programme implementation.

Summative evaluation. Summative evaluation judges the merit or worth of a programme after it has been in operation. It is an attempt to determine whether a fully operational programme is meeting the goals for which it was developed. Summative evaluation is aimed at programme decision makers, who will decide whether to continue or terminate a programme, and also at decision makers from other programmes who might be considering adoption of the programme. This type of evaluation is done for actualization and final operational phase of the programme.

Evaluation of Health Services

There has been a growing concern about the functioning of health services in both in the developed and developing countries. Questions are raised about the quality of medical and dental care, access, utilization and coverage of health services, benefits to in terms of reduction in morbidity and mortality rates, and overall improvement in the health status of the recipients of care.

General Steps of Evaluation

The basic steps involved are:

1. Determine *what* is to be evaluated
2. Establish *standards* and *criteria*
3. Plan the *methodology* to be applied
4. Gather *information*
5. Analyse the *results*
6. Take *action*
7. *Re-evaluate.*

1. Determine what is to be evaluated

There are three types of evaluation:
As per Donabedian model

a. Evaluation of "structure": whether facilities, equipment, manpower and organization meet a standard accepted by experts as good.
b. Evaluation of "process": various activities of the programme that is carried out is evaluated by comparing with a predetermined standard. An objective and systematic way of evaluating the physician (or nurse) performance is known as "medical or nursing audit."
c. Evaluation of "outcome": whether persons using health services experience measurable benefits such as improved survival or reduced disability (end results). The traditional outcome components are the "5 Ds" of ill health, viz. disease, discomfort, dissatisfaction, disability and death.

2. Establishment of standards and criteria

Standards and criteria must be established to decide how well, the desired objectives have been achieved.

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Standards and criteria must be developed according to the focus of *evaluation* (Donabedian model)-*structural criteria*, for example facilities and equipment; *process criteria* for example every prenatal mother must receive 6 check-ups, etc; *outcome criteria* for example alterations in patient's health status or behaviour resulting from health care or the educational process, etc.

3. Planning the methodology

A proforma for evaluation must be prepared for gathering information desired. Standards and criteria must be included at the planning stage.

4. Gathering information

Information required may include political, cultural, economic, environmental and administrative factors influencing the health situation as well as mortality and morbidity statistics. It may also concern health and related socioeconomic policies, plans and programmes as well as the extent, scope and use of health systems, services and institutions. The quantity of data required will depend on the purpose and use of the evaluation.

5. Analysis of results

The analysis and interpretation of data and feedback to all individuals concerned should take place within the shortest time feasible, once information has been gathered. In addition, there should be scope for discussing the evaluation results.

6. Taking action

Emphasis should be placed on actions designed to support, strengthen or otherwise modify the services involved. This may demand for shifting priorities, revising objectives or development of new programmes or services to meet previously unidentified needs.

7. Re-evaluation

Evaluation is an ongoing process aimed mainly at rendering health activities more relevant, more efficient and more effective.

CONCLUSION

Planning helps in preparing a set of decisions for action in the future, enables priorities to be set, taking into account situations involved to reach the desired outcome within the limited resources available. It aids in decision making in a rational way rather than constantly reacting to pressure and demands and must precede development and change in any organization. Planning is meaningful only if change is seen to be necessary and if the plans are capable of being implemented in a given social and political environment.

Different types of planning exist and must be tailored according to the needs.

Evaluation helps to determine the worth of the programme to assess if it has been performed as prescribed and to discover whether the required performance and objectives have been achieved. It should demonstrate the extent of the contribution to oral health in the target population and whether each part of the programme is relevant and appropriate.

REVIEW QUESTIONS

1. Define plan. Discuss planning cycle.
2. How do you plan a programme for the improvement of oral health in community.
3. Define evaluation. Discuss steps in evaluation.
4. Discuss planning of dental health services.
5. Write notes on:
   a. Framework of evaluation
   b. Types of evaluation
   c. Types of planning

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22 School Dental Health Programmes

Hiremath SS

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INTRODUCTION

Although most oral diseases are preventable, not all individuals and communities benefit fully from the available preventive measures. The school children are not exception to this. Children are most frequently the main priority group. Expectant and nursing mothers and preschool children are other groups given priority in many public health programmes. Disparities in oral health are there between the rich and poor. However, this kind of disparity has to be minimized especially for school going children.

Activities in schools can reap returns to communities, nations, families and individuals in terms of socioeconomic advancements, increased productivity and enhanced quality of life. Inspite of continued commitment and hard work on the part of teachers and administrators, noticeable changes have not been witnessed in many developing countries.

Oral health is fundamental to general health and wellbeing. Schools can be an ideal environment to promote oral health through school policies, health education prevention risk factors like tobacco and excessive alcohol consumption.

In 1909, the first school health service in India was provided by conducting medical examination of school children in Baroda city. It was followed by the Bhore Committee in 1946, reporting that the school services are not existent in India and in 1953, the secondary education committee emphasizing the need for school nutrition programme.

In January 1982, the Task Force constituted by the Government of India to accomplish the school health survey project submitted its report. Only 14 states had done some progress with their own health department budget. However the school dental health programmes are not carrying out satisfactory programmes to promote oral health among the children.

HEALTH PROMOTING SCHOOL

The concept of Health Promoting School was introduced by the World Health Organization in 1998 in order to strengthen capacities to promote health with schools as the media. The concept of a Health promoting school is a school that strengthens its infrastructure and capacity to promote healthy living, learning and working. It has the following functions:

- Helps promote health and learning using health and education officials, teachers, students, parents and community leaders.
- Introduce measures for a healthy environment, school health education and school health services and also school community projects and outreach, nutrition and safety of food, facilities for physical education and recreation and also for counselling, social support and mental health promotion.
- Encourages laws, activities and other practices that promote an individual's self-esteem, likelihood of success and advancement in personal achievements.
- Promotes the health of school personnel, families and community members as well as students; and helps community leaders identify and control problems in the community. (Fig. 22.1).

IMPORTANCE OF ORAL HEALTH IN CHILDREN

Poor oral health can have a harmful effect on children's academic activities in school and also their achievements

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Figure 22.1 Screening of school children.

Table 22.1 Effects of poor oral health

• Poor oral health affects learning, general health and wellbeing
• Poor nutrition
• Speech impairments
• Psychological problems
• Cardiovascular disease
• Diabetes
• Cancer

in the future. (Table 22.1). Children who have oral ailments are 12 times more likely to have more affected activity like school absenteeism when compared to those who do not.

- More than 50 million hours are lost from school due to oral problems per year.
- While dental caries and gingivitis are the most common conditions in human populations, other conditions such as trauma of teeth and jaws, dental erosion, developmental enamel defects and oral cancer also need attention.
- Early loss of primary teeth may lead to malalignment of the permanent teeth, affecting an individual's aesthetics.
- Lastly, tooth-loss can affect children's nutritional intake thus impacting the growth and development.

IMPORTANCE OF SCHOOLS IN PROMOTING ORAL HEALTH

School is the best place to promote oral health as worldwide, nearly 80% of children attend primary schools and 60% complete at least four years of education.

- School years cover a period that runs from childhood to adolescence. These are influential stages in a person's life when lifelong permanent oral health related practices and attitude are developed.
- Children are highly capable of learning in this period and the learned habits last a long time.



Figure 22.2 School dental clinic.

- Moreover, health education can be repeated regularly throughout the school years. Children may also learn personal skills that enable them to take healthy decisions and promote health.
- The school environments can also encourage healthy habits and services like safe drinking water, toothbrushing drills, etc.
- School laws and regulations can promote healthy dietary habits particularly on sugar intake.
- Further, for some children especially in low socioeconomic strata, school may be the only place to access and utilize dental services. This is especially noticed in developing countries that have limited dental manpower (Fig. 22.2).
- Trained teachers can be used for numerous oral health activities.
- From the schools, the children can transmit health message to their parents and community at large.
- Early detection of oral diseases can prevent future detrimental effects, which can be avoided by providing timely dental health services.
- If left untreated, the oral disease can be financially overburdening to the parents or may lead to increased pain, disfigurement, more serious general health problems, school absenteeism, low self-esteem and poor quality of life.

PLANNING A SCHOOL DENTAL HEALTH PROGRAMME

- The steps involved in planning school dental health programmes are: (i) establishing or involving a school health team and a community advisory committee; (ii) conducting a situational analysis; (iii) obtaining source of data; (iv) establishing commitment and policies, (v) establishing supportive school policies/practices, (vi) obtaining parental support and commitment and (vii) setting goals and objectives.

Establishing School Health Team/ Community Advisory Committee

School health team. School health team is a group of 8 to 14 who are interested to work together to promote the health. Depending on prevailing conditions, the school health team should include representatives, including

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students, parents, school governors, teachers and school staff, members of teachers' representative organizations, Parent Teacher Association (PTA) representatives, administrators, food service providers and health care providers. The function of this team is to manage, coordinate and monitor health promotion action plans and implementation.

Community advisory committee. Community advisory committee consists of members from the general population who can advise and support the school. They need to identify the important issues regarding oral health at both the school and community levels. Committee members have cordial relationships between the school and the community.

Situation Analysis

Situation analysis is conducted to evaluate the needs, resources and conditions that are useful for planning a school health programme.

The information needed include:

- Current health and oral health status of children and adolescents.
- Behaviours and other key factors related to oral health and disease.
- Oral health beliefs, knowledge, attitudes and behaviours. Other socioenvironmental factors that have an impact on oral health.
- Existing programmes and activities in school and the local community, as well as those delivered by the health service providers.
- Available resources in school and the community.
- School's physical and psychosocial environment, curriculum, health-related policies and practice, school-home-community interaction, physical, cultural, social, political and economic factors that might support or hinder the development of good oral health practices.

Source of Data

- School records, observations, questionnaires to students, school staff, parents and local organizations
- Data from health authorities; a checklist of services available in the school, and the types and frequency of activities
- Sample survey of community members; focused group discussion with community leaders. Review of school records and timetable
- Observations, structured questionnaires or checklist, types and quality of food and drinks in the canteen/mobile snack shop and vending machines around the school premises.

Commitment and Policies

For the success of a school health programme, commitment from the school authorities, law makers and children and their parents. Responsibility must be shared among students, family, school, health professionals, government and the community.

Supportive School Policies/Practices

Supportive school policies are essential components of a health promoting school. Policies should be brief and simple documents that provide a supportive framework detailing the rationale, objectives and guidelines for the development, implementation and evaluation of oral health promotion activities in schools made available. If preferred, a single policy document that covers all elements, areas and activities of a health promoting school can be developed.

Parental Support and Commitment

Parents play an important role in the implementation of this programme. They play an important role in the implementation of this programme. They can influence children adapt healthy behaviours, and dietary habits. Parents and other family members should have knowledge about the importance of oral health, and encourage children adopt these habits. Parents can be accessed through PTA, school governors, etc.

Setting Goals and Objectives

- To provide a physical, organizational and psychosocial school environment that is conducive to oral health of students, teachers and school staff, as well as families and the community
- To reduce the risk factors associated with oral health
- To improve oral health knowledge and attitudes
- To develop skills and behaviours for good oral health. Comprehensive school programmes should include: (i) healthy school environment; (ii) school health education; (iii) school health services; (iv) nutrition and food services; (v) physical education and sports; (vi) mental health and wellbeing; (vii) health promotion for school staff and (viii) school and community relationships and collaboration.

Health school environment. School environment classified as physical and psychosocial have an impact on the success of the programme

Physical environment: Physical aspects like the location and surroundings of the school, school grounds, buildings, classrooms, cafeteria, etc. are included in the physical environment. Safety being the main concern, emphasis should be given to safe location away from busy roads, industries, polluting sanitary facilities. It is imperative to design a well-planned building and playground.

Psychosocial environment: The social and psychological conditions that determine the health and education potential of the school community is psychosocial environment. Stress control measures, ban on alcohol and tobacco sales near schools can help prevent oral diseases.

School health education. The primary goals of school oral health education are to help children develop life skills, increase health awareness and bring about a change in attitude and behaviour to promote health. School health education can be provided in school as a specific subject or as an integral part of other subjects. It can also be included in extracurricular activities.

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School health education focuses on:

- Important behaviours and conditions that promote oral health or that reduce risk of oral disease
- Skills needed to negotiate and practice those behaviours or to address those conditions both personally and collectively
- Knowledge, attitudes, beliefs and values related to those behaviours and conditions
- Learning experiences that allow students to model and practice skills
- Personal development
- Responsibility at home and in the society.

Examples of learning and teaching strategies for oral health education and methods to convey knowledge are:

- Lectures
- Stories
- Programmed instructions
- Computer-aided instructions
- Group work seminars
- Peer teaching (e.g. senior students to junior students, adolescents to primary school children)
- Symposia.

Methods to influence attitudes are:

- Open discussions
- Student-led seminars
- Student-based teaching
- Research and inquiries
- Field trip to community resources
- Role-play group work
- Problem-solving exercises
- Debates, games
- Experiments
- Interactive learning.

Methods to develop skills are:

- Practical exercises
- Demonstration
- Small group teaching
- Simulations
- Research and investigation
- Project work
- Role-play
- Computer-aided practices
- Behaviour modifications
- Making models
- Experimentation
- Case studies.

Training teachers and other personnel: Training can be provided to the teachers before their induction into the job while in the training college, or as a part of on the service training. Effective teacher training should aim to build commitment, understanding skills and attitudes in the teacher. A complete training programme should encompass four broad goals:

1. to develop positive attitudes towards and commitment to a comprehensive approach to school health
2. to increase the understanding of principles of behaviour change that are essential to health education
3. to improve teaching skills using a variety of learning and teaching methods
4. to equip teachers with skills to deal with sensitive issues and students with special needs.

ORAL HEALTH EDUCATION PROGRAMMES

"Learning about your Oral Health": A Prevention Oriented School Programme

Development. It was developed by ADA (American Dental Association) and its consultants in response to a request from the ADA House of Delegates in 1971. It was a comprehensive programme covering preschool, primary and secondary schools. The goal was to develop knowledge skills and attitudes needed for prevention of dental disease with a priority to develop effective plaque control knowledge and skills, and to increase knowledge regarding diet and dental health, with an emphasis on understanding the role of sugar and starch. In addition to this, significance of fluoride, oral safety, consumer health concepts, the role of dental professionals, oral health in relationship to total health and community dental programmes were also included.

Implementation. Programme was implemented in five levels with core material for teachers to adapt to needs of students at: preschool, level 1 (K–3), levels II (4–6), level III (7–9) and level IV (10–12). It included overhead transparencies and spirit masters and supplementary printed material, and films to corresponding levels were developed. The price of teaching packet for each level was US $ 8 per level in 1990s.

Evaluation. Evaluation of effectiveness is done with behavioural objectives using pre tests and post tests for all levels except I and II. Formal evaluation was done for level III (1974), level II (1974) and level IV (1980).

Results for level III indicate that ADA's programme favourably influenced attitudes and behaviour towards oral health care which in level II showed the need of teacher orientation to the programme to influence student's knowledge whereas in level IV, ADA programme was found to be effective in improving oral health knowledge of secondary school students.

Texas Statewide Preventive Dentistry Programme: Tattle Tooth II—A New Generation

Development. The Tattle Tooth programme was developed in 1974–76 as a cooperative effort between Texas oral health professional organizations, the Texas Education Agency and the Texas Department of Health through a grant from the department of health and human services to the Bureau of Dental Health. This programme covered about 900,00 children in Texas till 1989.

In 1989, the Bureau of Dental Health developed a mostly new programme, Tattle Tooth II—A new generation (K through 6th), a statewide preventive dentistry programme to cover more than 3 million school children, based on Texas legislation (1985) which mandated to incorporate essential elements identified in school

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health education evaluation (SHEE) project in school curriculum.

In 1993, a preschool programme titled "super brush" was completed, designed for use with personnel in head start programmes, public and private child care centres, public school programmes and family day care homes.

This programme focuses on dental health as a part of total health and tries to convince students that preventing dental caries is important and they can do it. The goal is to reduce dental disease and to develop positive dental habits to last a lifetime in participants.

Implementation. Dental hygienists and dental assistants are employed to implement this programme statewide. The hygienists provide instruction to teachers with videotapes designed for teachers, training and provide them with a copy of the curriculum. At times hygienists train teachers in their schools. Curriculum includes proper brushing and flossing techniques, information about safety, facts about dental diseases and their prevention. Each grade level has five core lessons and two enrichment lessons. Health promotion activities are encouraged and publicized within the school community. In 1990, cost of programme implementation was US $ 289.25 per workshop, and cost per child was estimated at US $ 0.60.

Evaluation. Formative evaluation was carried out in spring of 1988 and summative evaluation in 1989–90 using a questionnaire year using a questionnaire. The results were positive, indicating good interaction between teachers and students. Most of the teachers (94%) believed that teaching oral health can have a positive effect on children's oral health habits. About 90% of the teachers taught oral health once per year (average 4.2 hours).

The curriculum succeeded in providing dental information and creating awareness regarding oral hygiene practices. But majority of teachers did not provide students with the opportunity to practise the skills of brushing and flossing.

Parent programme. Texas department of health's dental hygienists coordinated a parent programme, "dental health is a family affair," a slide tape, for use with school parents groups, local health departments and clinics. The programme covers dental disease problems and their prevention, diet and characteristics of children's dental development ranging from prenatal to late adolescence.

Senior citizen programme. This programme consists of presentations aimed at non-institutionalized senior citizens regarding general oral health information, demonstration of brushing and flossing of natural teeth and proper method of cleaning partial and complete dentures. When possible, volunteer dentist examines the participants for oral cancer and answers their questions.

Prenatal and postnatal programme. There are three parts, taking about 15 minutes each plus demonstration time:

1. "Mom, it's up to you! Your health depends on you!" focuses on dental diseases and their causes, effective oral hygiene aids, drugs during pregnancy and proper nutrition. It is followed by demonstration of brushing.
2. "Mom, it's up to you! Your baby depends on you!" discusses fluoride, aids in relieving teething discomfort, nursing bottle syndrome and brushing and flossing the baby's teeth. It is followed by a demonstration of flossing.
3. "Mom, it's up to you! Your toddler depends on you!", the participant learns about primary and permanent teeth, dental accidents and thumb sucking.

Tattle Tooth II—A New Generation: "Super Brush" Preschool Curriculum

Preschool provides an important opportunity to build a foundation for healthy physical, mental and emotional development. The potential exists to instil in young children the importance and practice of oral healthy habits that will last a life time. This programme is developed for teachers and care givers who work with 3–4-year-old children in "head start programmes," pre kindergartens or public and private child care centres.

The main purpose is to teach basic tooth brushing skills and to establish tooth brushing as a daily routine in schools or day homes.

The curriculum consists of children-directed activities (done by children on their own) and teacher-directed activities (done by teachers for children in small or large groups). It includes songs, games, stories, art projects, a resource list and videotapes.

Evaluation showed that curriculum was well received by teachers and students. Teachers found it to be easy and could adapt according to the needs, and were satisfied with the training and technical support received.

North Carolina Statewide Dental Public Health Programme

Development. North Carolina has a long standing history since 1918 in dental public health and school oral health education. In 1970, the North Carolina Dental Society resolved to lobby a strong preventive programme comprising of school and community fluoridation, fluoride treatments for school children, continuing education on prevention for dental professionals and plaque control education in schools and communities. In 1993, a 10-year programme to reduce dental disease was initiated that is the first statewide programme of its kind in magnitude and most comprehensive so far in the US.

The programme's mission was to ensure conditions in which North Carolina citizens can achieve optimal oral health with a vision to make North Carolina the first state with the generation of cavity-free children. Oral health is considered an important part of general health and can be achieved through the coordinated efforts of individuals, professionals and community members.

They focused on young children because the potential for positively affecting the child's attitudes, values and behaviours is high. Programmes were based on education and prevention. Programme activities include educational components to modify the behaviour patterns of individuals and to improve their oral healthy habits

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through dietary change, tooth brushing and flossing. Fluoride was considered as the most effective public health measure for preventing dental caries.

The objectives to successful completion were correct use of fluorides, health education sessions and increased access to public health dental staff in all counties.

Implementation. Oral health surveys conducted by oral health section and University of North Carolina School of Public Health form a basis for planning, implementation and evaluation of programme in North Carolina. The programme is comprehensive in nature designed to reach young children, parents, teachers, dental professionals and community leaders, providing services, such as weekly fluoride mouth rinse for elementary children, screening and referral of targeted children, dental sealants application, oral health education and distribution of educational materials to children and adults and point of contact oral health education exhibits.

Elementary school teachers, health department staff and parents are provided with training and consultative services so that children are reached. Teachers receive pre-service, in-service and follow-up training to cover oral health concepts, practice oral hygiene skills and integrate oral health into the curriculum.

Besides screening, simple measurements of decayed and filled teeth were done to facilitate assessment of prevalence of dental disease countywide for better planning, funding requests, monitoring and comparison.

The oral health section in the Department of Health and Human Resources gave a theme "Seal the state in 98" in 1998 to prevent dental caries in children, especially for children at high risk.

The goal was to ensure every person in the state to have heard about dental sealants. The oral health section had three objectives such as sealant placement in children at risk for dental caries, sealant education to parents and providers and partnerships to strengthen dental public health partnerships, both state and local for better oral health.

This led to consciousness having about sealants resulting in awareness in children and adults and inclusion of sealants in dental practice.

Evaluation. Various measures undertaken in this programme have shown good results such as reduction in DMFT in children in school water fluoridation programme, high retention of sealants, effectiveness and efficiency of mouth rinses over school water fluoridation in caries reduction.

School health services. School oral health services help to identify, prevent, manage and monitor oral diseases and conditions. School oral health services can be provided in the schools either by the dental team (dentists and/or dental auxiliary staff) or the school health team and trained school nurses based on the quantum of resources available. If the resources are scarce, appropriately trained school teachers or the school staff can be utilized. However, the works of nurse health workers, teachers and community workers in relation to the school oral health programme must be carefully monitored and evaluated. Depending on the oral health status of the children and the demands of parents, community leaders and students, the level and types of services provided should be decided. School oral health services may include screening and diagnosis, preventive measures and treatment of oral disease, regular monitoring and, for more complicated conditions and/or referral to other dental or medical specialists and secondary care. In some developing countries, provision of emergency care, dental extraction and restorative treatment with a traumatic restorative technique may prove very important. Services provided are:

- Screening
- Dental examination, treatment and monitoring
- Referral
- Nutrition and food services—school lunch programme
- Physical exercise and leisure activities.

SCHOOL BASED PREVENTIVE PROGRAMMES

Classroom Toothbrushing

Mechanical plaque removal prevents and reverses gingivitis, and to some extent even the dental caries. Thus it is important for the children and adolescents to know effective plaque removal methods using toothbrush and dental floss without harming the oral tissues. For some children, daily toothbrushing in the classroom may be indicated. Schoolteachers can play an important part in teaching the correct brushing technique in classroom. hygienic and clean storage of brushes and replacement of frayed and damaged and lost brushes are to be followed-up by the teacher because success of the daily toothbrushing drill in the school is dependent on these factors.

Although little or no evidence supports toothbrushing as a means of preventing dental caries, evidence supports the fact that use of fluoridated toothpaste during toothbrushing is helpful. Thus, one of the objective of toothbrushing instruction is to encourage children to use fluoridated toothpaste while brushing. However, it will be difficult task for the children especially who are coming from low socioeconomic status wherein they cannot afford toothbrush and paste. Hence, school authorities have to make some provision to supply toothbrushes and paste to the children either at an affordable cost or free.

Fluoride Therapy

School water fluoridation. This is one of the methods of systemic administration of fluoride for school going children who are coming from non-fluoridated areas. There is a good evidence to show a reasonable reduction of dental caries prevalence among the school going children, if they are exposed to school water fluoridation programme from the earlier stage. In this method, sodium fluoride of 4–5 ppm is used in drinking water because children do not attend the school throughout the year; attend only 4–6 hours a day, and frequency of consumption of water in school is less. It requires a commitment and involvement of the school authorities to implement and monitor the programme.

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Children should be encouraged to participate actively in this programme to make it more effective and useful. In a similar way, the supervised fluoride tablet supplementation programme can be carried out for school going children depending on their age. This programme is also very effective in reducing caries prevalence among children if they are coming from non-fluoridated areas. However, these programmes should be taken up with caution and good monitoring. There are several methods of administering the fluoride systemically like community water fluoridation, school water fluoridation, milk fluoridation, salt fluoridation and fluoride supplements. Among these methods, any one of them can be recommended. Anyhow, supervised fluoride mouth rinsing programme, school water fluoridation and supervised fluoride supplements are quite effective in schools as they are monitored by the school teachers.

Fluoride mouth rinsing programme in schools. The fluoride mouth rinses have been found to be an effective tool in prevention of dental caries, especially where there is no fluoride in water. They are also recommended for those who are at high-risk for dental caries along with other preventive programmes. Fluoride rinses can be used as daily mouth rinse (0.05%) or weekly/fortnightly (0.2%). The latter is best suited for schools, even though the daily rinsing is more effective.

In schools, the teachers can prepare rinses by dissolving one packet of sodium fluoride (NaF) powder, that is 2 g in 1000 mL of water to make 0.2% solution. The children should be made to rinse once fortnightly using 5–10 mL of this solution under the supervision of class teacher. Students have to put the solution in their mouth and rinse vigorously for 60 seconds. This procedure is not recommended for children below 6 years of age as they may swallow the rinse, which might result in dental fluorosis.

For a school having around 1000 children, 0.5 kg of NaF powder would be sufficient for fortnightly rinses by all children for 1 year. Thus, it is very much feasible and economical in developing countries including India. The cost of 0.5 kg is Rs 54 only.

Many studies conducted have shown a marked reduction in dental caries prevalence. It was found about 45% reduction with weekly rinsing of 0.2% NaF. Ripa et al (1983) found 45% reduction of DMFS with weekly rinsing of 0.2% NaF. Horowitz in 1971 found a 44% reduction with weekly rinsing of 0.2% NaF. In fluoridated areas, mouth rinse gives a super added benefit, but a lower concentration of 0.025% would be sufficient.

Topical fluoride therapy. For those school going children who are at more risk of developing dental caries or having uncontrolled caries activity on account of unsatisfactory dietary habits and poor oral hygiene measures, the topical fluoride therapy is recommended. Among the various types of topical fluoride preparations, the most ideal one for school children is neutral sodium fluoride 2% (Knutson technique). This preparation is applied for school going children at the age of 3rd (including preschool age), 7th, 10th and 13th years. In each age group four applications are done at an interval of 1 week.

In some situations, fluoride varnishes are the choice of application, especially for uncooperative children wherein management of dental caries is difficult. Fluoride varnishes like Duraphat (2.26%) and Fluor protector (0.7%) are extremely effective in controlling caries activity and arresting active carious lesions.

School Based Sealant Programmes

Ninety per cent of all carious lesions in children occur on pits and fissures, and hence they need to be protected. Dental sealants are highly effective in protecting them. Use of sealants along with a fluoride regimen in the school can eliminate dental caries to a large extent (Ripa et al). Dental assistants or hygienists can be trained for pit and fissure sealant programme. The cost varies depending on who are involved in the pit and fissure sealant programme.

REFERRAL FOR DENTAL CARE

Schools should have a provision for identifying and treating the common dental diseases. To achieve this, annual screening is indicated for all children and semiannual screening for children who have been classified as high-risk group. This can be accomplished with the help of dental hygienist and school dental nurses. During routine prophylaxis and sealant programmes, dental hygienist can identify and refer the students for expeditious, definitive diagnosis and treatment for conditions, which cannot be treated at school. In areas where a government programme does not provide full dental care to all school children, referral of some or all of these children to private dentist or private hospital is an important part of the school dental health programme. In case of referral for further dental treatment, mere issuance of referral slips to children following dental screening will be of little value if steps are not taken for a good follow-up. The dental hygienist or school dental nurses are the logical persons to conduct a follow-up system if they are members of school health team. Sometimes classroom teachers can take up such kind of assignments. In some countries, the present method is that the teacher or school nurse sends home a note indicating a need for treatment. The parents then take the child to dentist. After the treatment is done, a postcard is returned to school hygienist or nurse indicating that the particular treatment has been carried out. Most commonly the children are referred to a public health clinic. Another option is involving/contracting with local practitioners for predetermined fees.

"Blanket" Referral

In this programme all children are given referral cards to take home followed by a dentist examination, treatment after which the dentist signs the letter. The signed cards have to be brought back to the school nurse or classroom teacher.

SCHOOL LUNCH PROGRAMME

Dietary guidelines are designed to maintain an adequate intake of nutrients and to protect against diet related

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diseases. There is a great deal of understanding about malnutrition and general health including oral health.

It is generally accepted that consumption of good amount of nutrients in appropriate quantity—"balanced diet," during the growth and development influences the development of good dentition, which, in turn, will be less susceptible to dental diseases. Specially, the relationship between the sugar consumption and caries has been demonstrated to a great extent and fortunately it has been changed by the widespread use of fluoride and improved oral hygiene. Hence, dentist should share with the nutritionist and others, the responsibility to see that a balanced meal, including four basic food groups, is served to children. And also intake of excessive refined carbohydrate should be minimized especially in between meals and also to see that vending machines are not supplying these types of snacks in the school premises.

School Lunch Box

The parents, teachers and children should be informed and instructed about the nutritional aspects of the lunch box, which are being brought from home. This can be reinforced from time to time through effective health education programmes. The mothers in particular should be informed about the content of lunch box from the point of nutritional and caloric value. As far as possible, lunch box should contain sandwiches (e.g. *chapathies, roti,* bread without jam, *idlies* etc.), fresh vegetables and seasonal fruits and avoiding ready-made snacks like biscuits, cake, etc. On the whole, school lunch box should contain those dietary items which are less harmful to oral health and are "tooth friendly."

INCREMENTAL DENTAL CARE

One method of delivering priority dental care to a group of school children is by the incremental care. George Cunningham in England proposed this system in 1907. Basically it consists of providing necessary dental care for the lowest age-group in the priority scale in one year, then adding a new age group to the group receiving care each year.

It may be defined as periodic care so spaced that increments of dental diseases are treated at the earliest time consisting of proper diagnosis and operating efficiency, in such a way that there is no accumulation of dental needs beyond minimum.

A programme with limited resources, if it is proposing to provide dental care to the 6–12-year old age-group, then the first year would see complete care for the 6-year old. The following year, this group, now aged 7, would receive necessary maintenance and the new group of 6-year old would receive complete care. The third year would see maintenance care for the first two groups, now 7- and 8-year old, plus complete care for the new 6-year old. By this system, all ages in the priority group will be reached within 7 years, and probably more efficiently than by haphazard treatment of the whole 6–12-year-old group initially. This system is currently used in the school health programmes of many countries.

It is beyond any doubt that the services scheduled in this way are ideal for prevention of new oral diseases and dental caries can be managed before complications like pulpitis. Periodontal diseases are intercepted at or near the beginning.

Topical and other preventive measures can be maintained on a regular basis. Incremental care, however, to be effective, must represent a real system of human behaviour, faithfully maintained.

Comprehensive Dental Care

It is defined as "the meeting of the accumulated dental needs at the time a population group is taken in to the programme (initial care) and the detection and correction of new increments of dental diseases on a semi-annual or other periodic basis" (maintenance care).

EVALUATION

Evaluation is a powerful tool that can be used to inform and strengthen school health programmes.

Types of Evaluation

For evaluating the success of a school oral health programme, process and outcome evaluations are the two main types of evaluations that can be conducted.

Process evaluation. This assesses what and how well the intervention planned or not planned has been developed and implemented, to which population and when. It provides information about progress towards programme objectives, identifies factors that facilitate or disrupt the implementation, and if necessary, informs the modifications required.

Outcome evaluation. This measures results of the programme, determining whether the objectives of the programme are achieved and to what extent. By ascertaining the outcomes of the services, future action plans can be formulated.

CONCLUSION

School dental health programmes are but one aspect of total dental public health programmes and should be allied to other programmes of prevention and education as far as possible. However, dental treatment programmes may be initiated in isolation. Most of these programmes are administered by government at some level, and they should ensure that all school going children have access to dental care as far as possible. There is a sound basis to argue that, with given limited resources for young children, the school based preventive programmes can be implemented effectively to large extent. Good oral health in childhood will pave way for good oral health in adulthood. So, regular

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CONCLUSION—cont'd

dental utilization and preventive action in early life will be continued after the school age.

It is time to take a closer look at all the possible actions and opportunities for providing proper dental care along with good oral health education. These things can be carried out with proper planning, execution, monitoring and a systematic evaluation through well-organized school dental health team. At times, there are limitations and also reasons for failures to implement such public health programmes effectively through school health activities, unless and until such programmes are taken up on priority basis keeping in mind financial constraints, shortage of manpower and administration problems. One of the first steps, therefore, in organizing a dental health programme at school level is the formation of school dental health council consisting of professionals, experts, school authorities, voluntary organizations like NGO, teachers and parents; thus, convincing the public and the community that oral health is an important part of their overall health, and it should be practised right from the school going age to be effective and meaningful.

REVIEW QUESTIONS

1. Write a note on health promoting school.
2. Plan a school dental health programme for a school in rural India.
3. Write a note on various school-based preventive programmes.
4. Describe steps in planning a school oral health programme.
5. Write notes on:
   a. School lunch programme
   b. Incremental dental care
   c. Criteria for evaluation

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23 Dental Practice Management

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CHAPTER OUTLINE

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Factors Associated with Successful Dental Practice 219

INTRODUCTION

Successful dental practice is a result of proper management of resources, professional skills, relationships with other health care providers and public in general. In India, commoners are largely dependent mainly on government health care delivery systems in which dental services are integrated with medical services while the affluent get private services for a fee. In recent years, policies of the government have allowed the participation of individual and multinational groups in private health care systems. Dental requirements of the public in India are vast, varying and largely unmet. An effort is made in this chapter to understand the concepts of "dental practice management" and its application in the Indian scenario.

Patients, most commonly, present themselves with painful tooth or bleeding gums to the dentist. The outcome is the relief provided, for which patient pays for the services, in full in private or partly in a government centre. The term "practice" means arrangement or an agreement to provide certain services under a roof by an authorized person. "Management" means the effective mode of provision of these services in a setting. Dental practice management is therefore the services provided by the dentist and auxiliaries in a clinical set-up.

FACTORS ASSOCIATED WITH SUCCESSFUL DENTAL PRACTICE

Positive impact on virtually all facets of practice is best related to a well-planned dental office which improves productivity. Several factors are responsible for a successful dental practice and are listed in the order of priority as: (i) location and designing of dental office, (ii) equipment and materials, (iii) financial resources, (iv) patients in practice, (v) fee for service, (vi) personal qualities required of the dentist, (vii) records and accounting, (viii) growth and expansion and (ix) measure of success in practice.

Location and Designing of Dental Practice (Fig. 23.1 a and b)

Locating a new dental practice either in a city or town is a serious dilemma for a new graduate. Ultimately, the dentist has to consider as to where he or she would like to settle down, get married and raise family. Consideration to children's future needs, social life, entertainment and community activity should be addressed. Established dental practice should not be shifted unless owing to unavoidable circumstances; relocation usually has severe repercussions financially and personally.

The location for opening up of the dental practice could be in: (i) business area, (ii) professional area or (iii) residential area.

Each area has distinct advantages and disadvantages. For example, starting practice in a *business area* in the city, one will encounter the difficulty in acquiring the ideal place, floor area and the easy access desirable for dental practice. The business area can be very expensive with high rental or building value, but being centrally located where most people can easily locate a dentist when they are in need. The returns in city practice are more lucrative. The town practice usually is quieter. *Professional area* is one where a number of medical practitioners, specialists and other professionals are concentrated and know each other by the practice of trade. This set-up has referral system for patients. In the *residential area*, this practice is confined to having patients within the locality where the dentist resides.

The floor plan of dental office is the most important step in the entire planning process which will focus on the functions performed in the clinic. It depends upon the type of practice and must include provision for patient waiting area, consulting chambers, private rooms, operatory, recovery, laboratory, utility room and rest rooms.

The most efficient shape for dental office is a squarish rectangle and to avoid long and narrow shapes, triangular or odd shapes. The clinic should be well ventilated with windows allowing the patients to have a view in to the landscaped area. The dental office interiors must fulfill a wide range of diverse needs and choose colours

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Figure 23.1 A and B Location and designing of dental practice.

for the walls which are blue, blue green, green and white which tend to be restful and soothing tones and these colours tend to give the patients a sense of calm and wellbeing and also lower the blood pressure and pulse.

Reception area should be well equipped with computers which will have patients information screen and daily appointment window. The dental office should always imitate or incorporate natural lighting in which patients will spend most of their time with the dentist. Patients waiting area should include a soft warning bell announcing the patients arrival and should be acknowledged immediately. It should be furnished with chairs that have arms and seat height to help in sitting and rising of the patients of all ages easily, upholstery should be of a texture that help to hide everyday wear and tear, sink in sofas are not recommended as is it is difficult for old patients to get up. The reception area should have a magazine rack and children's corner if possible. Soft background music will add to the ambience. Oral Health awareness videos should be played in the reception area to reinforce the oral health habits to the patients. The receptionist should be neat, tidy and appealing to the patients and the impression she creates is long lasting and reflects upon the doctor and the practice. The area in which patients make payments or discuss financial matters should be removed from the reception to a place of privacy. The furnishing of the individual rooms should be pleasant and pleasing if not lavish. Alterations in certain areas within the dental office to accommodate patients with special needs are often necessary.

Equipment and Materials

Although equipping the dental office is an individual choice, it should be done wisely. Equipment and the materials should be of superior quality and technology, but procurement should be based solely on necessity and demand, initially. A protocol of annual additions is amenable to practice depending upon the financial growth and requirement of the practice.

Personal protective equipment like gloves, surgical masks, protective eyewear, face shields and protective clothing should be used. All instruments and equipment used in the dental office should follow the protocol of disinfection and sterilization to prevent any cross infections to doctor as well as patients.

The waste generated in the dental clinic should not be mixed with the house hold or general waste as it is hazardous to health. Segregate waste according to the colour coding bins and waste should be collected by the concerned authority who will do the needful.

It is very important to reinvest part of the money earned in the dental office every year to include latest equipment every year to upgrade the practice with latest technologies.

Financial Resources

Financing new dental practice by dental graduate is in most cases difficult, unless one is financially well off. It is appropriate to identify sources of finances such as, banks, both nationalized and private, state financial corporations, private financiers or corporate houses. Applicant who is of good standing, having all documentation, and having a guarantee should be able to avail the grants or loans from such institutions. Care should be taken to be familiar with the rules, terms and conditions before availing financial assistance from sources.

Patients in Practice

Patients attending the dental office in a private set-up, irrespective of the city or town areas differ from their race, culture, religion, occupation, socioeconomic status, behaviours and personalities. The dentist should be discreet and polite while offering services to the patients. All patients pay for services, either in cash or in kind as in case of a rural practice. The dental office should be well equipped for other modes of payment options for patients like acceptance of credit or debit cards, cheque payments, net banking, etc. Preference is to be given to those who value the treatment offered while being strict with "window shoppers". Dental emergencies need to be addressed immediately and sympathetically. Satisfied patients are one good source of advertisement for the dentist. Consistently crafting helpful working relationship with your patients enables one to generate good number of patients with "WORD OF MOUTH REFERRALS". Also, through practice the dentist comes across a vast section of the public and hence it is all the more important that he/she maintains a very high standard of honesty, work ethics and principles while he/she is discharging his/her duties.

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Fee for Service

There are neither fixed rate scales nor legal guidelines for charging fee for treatment provided. A fee charged should, ideally, commensurate with the work done, in principle. Pricing may vary between dentists in the same area or location. Popular dentists and "high street" dentists demand a high fee for the services rendered. However, like in all other establishments, profit at the end of the day is a welcome sign of growth. However, earning "target" amount per day is not ethical as well as it pushes the dentist and his/her associates into enormous depths of personal conflict, which can be detrimental to his/her success.

Personal Qualities Related to a Dentist

The important personal qualities required by the dentist in order to be successful are: **(1) humane attitude, (2) confidence, (3) salesmanship, (4) punctuality, (5) perseverance, (6) personality, (7) politeness, (8) patience, (9) good health, and (10) dental ergonomics.**

(1) Humane attitude: The search for excellence in dentistry is wonderful as it is a journey which lasts almost one's entire life. Each one can achieve whatever he/she want in his/her unique way. Remember patient is a human being. These patients have their own fears, frustrations, ambitions and expectations just like any dentist.

The individuality of the patient, his/her humanity should not be forgotten. The training at most dental colleges is more mechanical in nature, making students often strictly confined to restrictive standards, resulting in students generally constrained to treat their patients within clinical parameters as specified by the academicians. On account of these reasons dentists tend to treat their patients as clinical specimens.

In practice dentists have to develop a friendly, understanding, tender and loving approach while dealing with patients who are often scared, suffering with pain, depressed etc. There are a number of opportunities to understand the patient's right from taking appointment, reporting to the clinic and the first personnel contact of the dentist, patient hearing, performing the clinical examination, arriving at a diagnosis and rendering services with the least discomfort. Developing humane attitude towards one's patients is very important.

(2) Confidence: This quality is probably most important without which it is impossible to succeed in life. This is essential to the practicing dentist or every patient and his/her problems are a challenge to the dentist, and unless the dentist has utmost confidence to provide the necessary, appropriate treatment resulting in uneventful success.

(3) Salesmanship: The starting of any business venture is always a critical time financially; the heart of good business management is regarding "cash flow" which should be profitable. There is no point in being sentimental about "money" collection, and dentists have to make profits. This is exclusively based on how the dentist sells dentistry to the patients. This will happen duly when you have convinced the patients their need for it and what is best for their and your ability to communicate with them. Dentists need to make the patients realize that the work the dentist has provided is of immense value and necessary for preserving their own health.

(4) Punctuality: Time is precious for everybody whether it is for the patient or the dentist in practice. Receiving patients personally at the scheduled appointed time and also delivering the "goods of dentistry" at the exact day and time is important. Missed appointments for both the patients and the dentist affect in many ways. For the dentist, every second should be productive as a lot of investment has been made. And for the patient "disappointment" adversely affects the "confidence in the dentist". Hence being "punctual" pays dividends in dental practice.

(5) Perseverance: Another attribute essential in practice in order to achieve the ultimate goal through hard work, skill and knowledge coupled with patience. The maxim, "Arise, awake persevere till the goal is achieved" should be the motto in practice. This striving for improvement is known as the pursuit of excellence.

(6) Personality: Appearance does make lasting impressions. The dentist's first personal contact will always have lasting impact on the patient. A pleasing, soft spoken, with smile, well groomed with appropriate dress etc. certainly along with the skill, knowledge and confidence greatly contributes to success in dentistry.

(7) Politeness: Being polite to patients during the delivery of services is important for many reasons. The array of patients visiting the dental clinic of different age groups and sexes makes the dentist to be careful in observing, and handling patients with dental problems. The least any dentist can do to any patient is "being polite" even if you do not serve them.

(8) Patience: This is another unique quality every dentist must have in abundance. Dentists need to have "tons of patience" not only to get patients but also once they have a patient in the dental chair to diagnose and deliver dental services along with collecting fee from them successfully. Patience is the key word for successful dental practice. If any dentist lacks patience, it is reflected in his/her work, which adversely affects the quality of dentistry and success.

(9) Good health: Every individual in any profession cannot function if one is not fit physically as disabilities can cripple performance.

Dental Ergonomics

Dentistry being extremely demanding profession poses a huge challenge because of work as they expose themselves during their work to many burdensome and harmful factors. The biggest risk factors are awkward prolonged seated postures with no back support and limited range of

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motion and isometric muscle contraction created by working in a confined area, namely the mouth. These postures adopted by the dentist during his work cause discomfort and disorders of musculoskeletal system and peripheral system.

A system is designed leading to less of fatigue, discomfort, injury or chronic health disorders in dental practice called *Dental Ergonomics*. Ergonomics is a way to work smarter not harder by designing tools, equipment, workstations and tasks to fit the job to the worker–not the worker to the job. It is a perfect balance between the job characteristics and human capabilities (Fig. 23.2).

So in order to have an ideal working environment and a practitioner wishing to improve his or her work environment may follow work with equipment designed to address the need for productivity and stress reduction. Every dentist need to be physically, mentally and dentally fit without which the financial health cannot be rewarding. Dentist's dental condition is equally important as every patient looks forward to the dentist from whom they are seeking as a model.

Good ergonomic practices should be followed in the fields of

- Instrument design
- Operators position (Fig. 23.3a and b)
- Instrument layout
- Patients position (Fig. 23.4)
- Instruments should be looked for adequate lumen size, ease in the activation, good finger grip, sufficient power, light weighted, balanced models and ease in maintenance. Operator's chair should have a height adjustable back rest, height adjustable arm rest and adjustable seat tilt. Dental chair should be stable, with good lumbar support, hands free seat height adjustment, adjustable foot rests and seamless upholstery.
- Operator should ensure to keep neck straight, instrument tray with in the reach, tray at the height of the hand elbow, arms at rest by the side on the operators stool with good lumbar spine support and to avoid static and awkard postures.
- Instruments and materials should be easily accessible while seated and hoses to be positioned away from the body and at the same time promote patient comfort.

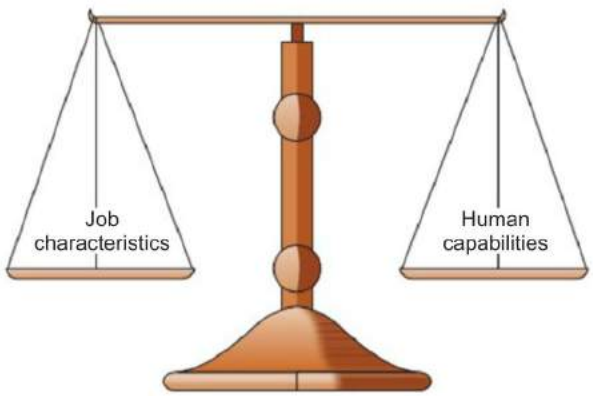


Figure 23.2 Dental ergonomics.



Figure 23.3 A Fatigued operators position.

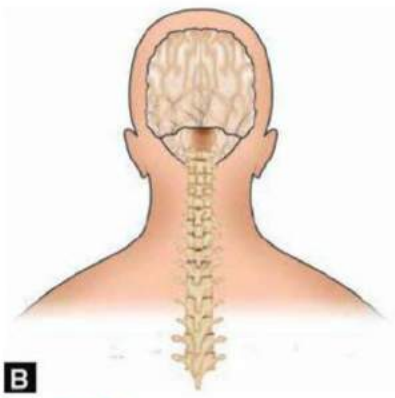


Figure 23.3 B Fatigued spinal cord.



Figure 23.4 Appropriate operators' position.

Records and Accounting

Maintenance of clinical records of patients, consent papers, radiographs, casts, photographs, haematological reports and other investigations carried out during the course of the treatment is a must, and they should be kept confidential. These records not only serve as the basis for future treatment but also as evidence in cases of legal claims or when summoned by law.

Accounting gives the dentist the figurative information on the performance of a practice. The accounting includes: income generated, expenses met, tax paid, interest on loans, professional indemnity and membership

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fee for associations etc. Proper accounting gives insight to the direction of the practice and also to plan for future additions. The dentist or his/her assistant can do accounting, but by preference, should be done by a qualified auditor.

Growth and Expansion

Growth and expansion are related directly to the ability of the dentist to deliver through performance. Growth, in most cases, is the measure of the popularity achieved and the monetary status of the dentist over a period of time. Expansion is the extension of the operatory and the inclusion of qualified associates into the practice. The growth and expansion should not merely be in physical terms to increase income of a practice but also be able to meet the dental demands of the public, both ethically and professionally.

Measure of Success in Dental Practice

Success is a relative term. Although extended practice, awards, citations, good bank balance, a dentist who is well known and respected in his/her fraternity for his/her professionalism, loved by his patients for his/her concern, kindness and devoted work and when his/her absence is felt are some of the indicators, but not necessarily if one desires to measure success. If the dentist who has completed 30 or more years in practice and asked the question, "If you are given the chance of the last 30 or more years back would you truly choose dentistry as your career once again" and if the answer is "*Yes* ," then that dentist is truly successful.

Rules for a successful dental practice and management:

"Know yourself"—through self-discovery
"Know your patient"—through relationship development, comprehensive examinations and co-discovery
"Know your work"—both technically and behaviorally through organized and disciplined skill development
"Apply your knowledge"—through careful preplanning and measured execution

Always weave through your conversations with patients, an expression of the purpose of the care you are providing and acknowledgement of the patient's expressed belief and values.

CONCLUSION

Most of us who have practised dentistry have witnessed many advances in the practice of dentistry. Many procedures used today in our practices were not even known when I was at the dental college. But today the diagnosis and treatment capabilities have achieved impressive levels to take care of more complex problems with success that is predictable. The current state of the art and science of dentistry has enabled to achieve a level of sophistication that makes the present day dentistry to provide his/her patients an optimum status of oral health, aesthetic status close to natural beauty and relief from pain.

Dentists often are imposed with constraints, because of health, patient desire, finances and knowledge about dental health, which needs evaluation while arriving at what is best for the patient.

Creating a new environment for the practice is likely the largest single investment we will make in the business. Therefore, we should allow adequate time to make decisions associated with a design or redesign so that we make the right decisions that will affect the practice positively for the rest of the professional life. Therefore, a well-designed dental office will definitely contribute for the success of clinical practice as well as personal life.

There is so much of enjoyment and fulfillment in dentistry, which can be expressed by quoting a phrase of Robert Louis Stevenson "Dentistry is so full of such wonderful things".

REVIEW QUESTIONS

1. Define practice management and describe dental practice management.
2. Discuss factors associated with successful dental practice.
3. Write a short note on overheads.

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24 Ethics in Dentistry

Manjunath P Puranik

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INTRODUCTION

Dentistry as a profession has come a long way. It has grown from the stage of undifferentiated profession to the stage of advanced professionalism. During this period dentistry has witnessed changes; accepted new concepts adhered to ever changing technology while shedding old dogmas and methodologies. At some point of time, a need to regulate dental practice was felt to protect the public from the quacks and also to observe the practice of dentistry in a stipulated way. These efforts culminated in the enactment of dentist acts worldwide such as Dentist Act (1948) in India followed by the enforcement of professional code of ethics by professional bodies such as Dental Council of India.

ETHICS AND HUMAN CONDUCT

Professional code of ethics are statements encompassing the rules that apply to persons in professional roles. It specifies professional etiquette or conduct between professional groups and stresses universal moral principles. Some rules are morally obligatory and legally required. Ethics is a branch of philosophy, which deals with the examination of human conduct. Ethics is derived from Greek word *ethos,* which means custom, more of fixed type and used in the context of man's character. While the Latin word for custom is *mos*/mores. So, ethics is often referred to as moral philosophy. Ethics deals with customs and not conventions such as table manners, different modes of dress, forms of speech and etiquette.

These conventions vary geographically and change with time while customs are more fundamental such as telling truth, respecting each other. The conduct is judged as right if one abides by the custom and wrong if deviates from it. These are morals, and ethics deals with morals. Hence, ethics is concerned with right and wrong of human conduct.

Ethics is defined as the science of the ideal human character and behaviour in situations where distinction must be made between the right and the wrong, duty must be followed and good interpersonal relations maintained.

The core aspect of ethics is human conduct, the actions which one performs consciously and willfully is held accountable. Ethics studies the conduct whether it is right or wrong. There are three kinds of actions:

1. One ought to do.
2. One ought not to do.
3. One may either do it or not.

If a man does something he ought to do, he is right while he is wrong if he does something he ought not to do. The judgement of correct/wrong comes from the fact of experience. This judgement is applied not just to oneself but also to the mankind. Thus, ethics deals with the investigation of ought and remains distinct from other social sciences.

ETHICS AND SOCIAL SCIENCES

Customs are commonly dealt by ethics and anthropology. Anthropology studies the origin and development of human customs and moral values whereas ethics criticizes these issues in terms of right and wrong.

Ethics and psychology take interest in human behaviour. Psychology studies how man actually behaves whereas ethics studies how he ought to behave.

Other social sciences such as sociology economics and political sciences study social life in terms of social, economic and political situations about their nature and their functions while ethics decides what it ought to be in terms of rights and duties. Application of ethics can provide solutions to some of the social, economic and political problems.

Law is closely related to ethics, yet the difference between civil law and moral law remains. Civil law deals

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only with external acts and positive legality, and ethics deals with internal acts of will and the tribunal of conscience. The discipline of philosophy of law is the result of mingling of ethics and civil law.

Moral theology also studies the right and the wrong, the basis being the religion while ethics is philosophy.

Often it is debated whether ethics is a science or an art. Ethics is a body of systematized knowledge; it deals with the purpose and final cause of human life; revolves around a solid core of established truth. It discovers, explains and demonstrates the rule of right conduct. As an art, it applies rules to the conduct of the individual resulting in good life actually lived; it shapes the destiny. Ethics is a practical science because it directs action, and a normative science because it gives norms or rules for conduct.

Ethics, like most disciplines, presupposes that man can know truth, reason logically, can act and communicate etc. Ethics makes use of a mixture of induction and deduction approaches in making rules and then applying it to a particular situation. Accordingly basic ethics and applied ethics arise. Basic ethics lays down broad principles that must govern all human conduct while applied ethics deals with the application of basic principles to man's pattern of conduct.

EVOLUTION OF MEDICAL ETHICS

"It would not be correct to say that every moral obligation involves a legal duty; but every legal duty is founded on a moral obligation".

—Lord Chief Justice Coleridge (1893)

Egyptian Medicine

- Rigid rules were laid down as to experimental treatment—there was no culpability in failure to cure so long as the standard textbooks were followed.
- Severe penalties were, however, threatened for those who ignore the instructions, the reason being that very few men would be expected to know better than the best specialists who had gone before.

Babylonian Medicine

The code of Hammurabi (1900 BC) was the first known legal code. It contained:

- An element of medical ethics
- Payment system based on outcome and, to some extent, patients' ability to pay
- Penalties for negligent failure, some of which were draconian to an extent, which must have deferred people from entering the profession

Greek Medicine

A code of intraprofessional conduct evolved—the dawn of what has become known as medical etiquette.

Hippocratic oath

- Implies the need for co-ordinated instruction and registration of doctors, the public is to be protected, so far as is possible from the dabbler or the charlatan.
- It is clearly stated that the doctor is there for the benefit of his patients—to the best of his ability he must do them good and nothing which he knows will cause harm.
- The nature of the doctor and patient relationship is outlined and an undertaking is given not to take advantage of that relationship.
- Oath expresses the doctrine of medical confidentiality.

Judaeo-Christian Influence

Jewish

- Medicine was governed by law and the law was administered by priests.
- The rights of the individual must be sacrificed for the good of the community such as isolation of patients with infectious disease and also disposal of domestic waste to safeguard the community.

Christians

- Concepts of equality, charity and devotion to less fortunate.

BASIS FOR MEDICAL ETHICS

- The day-to-day judgments of doctors are dictated by medical morals whereas medical ethics analyze the universal principles on which decisions are made.
- It is the conscience directed by an intuitive sense of goodness, which lies at the heart of medical ethics.
- It follows that the practice of medicine cannot be conducted solely on the basis of individual conscience; the conduct of the doctor is circumscribed by the public conscience and whether the public conscience fashions the law or whether the law moulds the public attitudes, these latter attitudes are inevitably reflected in the law.
- In general, the stability or urgency of the medical methods in relation to particular issue is proportional to the interest taken by the public in that issue.

PRINCIPLES OF ETHICS

Often health care practitioners are confronted with certain situations where decision-making becomes difficult. Knowing and understanding certain principles of ethics definitely helps in choosing the right course of action. The principles of ethics are as under:

1. To do no harm (non-maleficence)
2. To do good (beneficence)
3. Autonomy
4. Justice
5. Veracity or truthfulness
6. Confidentiality

To Do No Harm (Non-maleficence)

Hippocrates, pioneer in Greek medicine, has laid an emphasis on non-maleficence or to do no harm. As per this, the first and foremost duty of the health care professionals is to ensure that their actions do not harm to the

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patient in any way. Use of unsterilized instruments, underfilling or overfilling, carelessness in handling hard and soft tissues of the mouth are some of the instances, which can harm the patients. Such circumstances are to be avoided in the best interest of the patient by carefully thought and implemented health care.

To Do Good (Beneficence)

This principle is also attributed to Hippocrates. The health care professional, before instituting any action or care, should question himself whether such actions will help the patient to recover or to perform his functions better or not. He has to place the interest of the patient above his own interest. He has to plan a treatment or order an investigation only if it is necessary.

At a community level, one has to balance harms and benefits of programmes and select the one, which provides the greatest balance of good over evil. Second, make use of cost-benefit analysis to determine appropriate programme for the community.

Autonomy

This principle is in line with interactive model of health care wherein patient is the prominent member in the process of decision-making. This principle emphasizes the patient's right to make decisions and is free to determine what will happen on his/her body. The health care professional has to ensure that consent is obtained before any care is instituted. Patients are provided with relevant information such as different modes of treatment, their risks and benefits consequences of not availing the treatment etc. Information given should be easily understood facilitating the patient to make a voluntary consent. In case of minors, parents or legal guardians can grant the consent for the care.

Justice

This principle directs health care professional to provide equal treatment to all, giving to each patient what he/she needs. Dental practitioners are often found to be reluctant to treat the poor because they cannot afford; treat the children or mentally retarded because it takes longer time. But dentists also have responsibilities for such group of patients and cannot shy away from the responsibilities bestowed on them by the society. Dentists probably can provide care at a concessional rate or designate certain time for the care of such patients or support programmes for such patients conducted by local, regional or state bodies.

On the other hand, when the resources are limited, especially at a community level, one has to choose a group of patients eligible for treatment as well as the type of care. Also whether it is possible to give same or equal treatment for all or equitable treatment for the group concerned is to be considered.

Truthfulness or Veracity

Patient–doctor relationship is based on mutual trust. Patients expect the dentist to be truthful about the information given, treatment rendered and the prognosis. Even if the dentist believes lying or concealing or manipulation of the information is required in the best interest of the patient, the relationship is bound to suffer.

Confidentiality

This principle figures in Hippocratic oath and also in International Code of Medical Ethics. Health is a sensitive issue and it is not incorrect on the part of patients to expect all communications and records are kept confidential. Health care professionals have to maintain confidentiality at all times barring situations where disclosure is needed to protect others.

In health care relationships, duty to observe the rule of confidentiality is not always absolute. It is considered as a prima facie duty, i.e. it can be overruled when a conflict arises with other duties that are morally stronger or when legally required. Some situations could be:

- When in conflict with other duties towards the patient such as protecting the patient would be more important than the confidential information related to patient's self-destruction wishes or efforts.
- When in conflict with duties towards individuals than patient such as protection of other individuals may overweigh the confidential information of infectious diseases in the patient.
- When in conflict with duties towards others or rights and interests of community, in general, in certain cases law requires diseases such as tuberculosis, venereal diseases have to be reported regardless of the confidential nature of the information.

Resolving Ethical Problem

These principles are not absolute in themselves but certainly help in making reasoned decisions when confronted with an ethical dilemma. A model suggested by Harron et al probably will be a useful tool in resolving ethical problems. The model consists of five steps:

1. *Analyzing:* Dividing the problem into its leading alternatives
2. *Weighing:* Assessing the strengths and weaknesses of alternatives by balancing one against the other
3. *Justifying:* Providing a compelling and sufficient moral reason that appeals to an established moral principle such as to tell the truth respecting each other
4. *Choosing:* Selecting one or more of the alternatives for which some justification can be made
5. *Evaluating:* Re-examining the choices and their justifications based on one's exposure to other similar moral cases.

ETHICAL RULES FOR DENTISTS IN INDIA

Ethical rules for dentists in India is prescribed by Dental Council of India (DCI) that includes details about practice of dentistry, duties and obligation of dentist towards the patients, dentists and public. It mentions about unethical practices and action on unethical conduct.

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CONCLUSION

Ethics forms an important dimension of a profession. The code of ethics prescribed by regulatory bodies as well as professional associations act as a guiding light in distinguishing between the right and the wrong, observing one's duties and maintaining good interpersonal relationships. It should be remembered that profession exists as long as it enjoys the trust of the society, and this can be assured by always placing the interest of the patient above one's own interest.

REVIEW QUESTIONS

1. Define ethics. Discuss principles of ethics.
2. Write notes on:
   a. Hippocratic oath
   b. Autonomy
   c. Steps in resolving ethical problems
   d. Duties and obligation of dentists towards the patient
   e. Duties of dentist to the public

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25 Dentist Act—1948

Manjunath P Puranik

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INTRODUCTION

The Dentist Act 1948 is an Act to regulate the profession of dentistry in India. Hence, it extends to the whole of India. Any reference in this Act to a law, which is not in force in the state of Jammu and Kashmir, shall, in relation to that state, be constructed as a reference to the corresponding law, if any, in force in that state.

Definitions

"Dental hygienist" means a person not being a dentist or a medical practitioner, who scales, cleans or polishes teeth, or gives instruction in dental hygiene.

"Dental mechanic" means a person who makes or repairs denture and dental appliances.

"Dentistry" includes:

i. the performance of any operation on, and the treatment on any disease, deficiency or lesion of human teeth or jaws, and the performance of radiography or in connection with human teeth or jaws or the oral cavity;
ii. the giving of any anaesthetic in connection with any such operation or treatment;
iii. the mechanical construction or the renewal of artificial dentures or restorative dental appliances;
iv. the performance of any operation on, or the giving of any treatment, advice or attendance to any person preparatory to, or for the purpose of, or in connection with, the fitting, inserting, fixing, constructing, repairing or renewing of artificial dentures or restorative dental appliances, and the performance of any such operation and the giving of any such treatment, advice or attendance, as is usually performed or given by dentists.

"Dentist" means a person who practices dentistry;

"Medical practitioner" means a person who holds a qualification granted by an authority or who practices any system of medicine and is registered.

State Registers

1. For the purpose of first preparing the register of dentists, the [State] Government shall, by notification in the Official Gazette, constitute a Registration tribunal consisting of three persons and shall also appoint a Registrar who shall act as Secretary of the Tribunal.
2. The [State] Government shall, by the same or a like notification, appoint a date on or before which application for registration, which shall be accompanied by the prescribed fee, shall be made to the Registration Tribunal.
3. The Registration Tribunal shall examine every application received on or before the appointed date, and if it is satisfied that the applicant is qualified for registration under section 33, shall direct the entry of the name of the applicant on the register.
4. The register so prepared shall thereafter be published in such manner as the [State] Government may direct, and any person aggrieved by a decision of the Registration Tribunal expressed or implied in the register as so published may, within 30 days from the date of such publication, appeal to an authority appointed by the [State] Government in this behalf by notification in the Official Gazette.
5. The Registrar shall amend the register in accordance with the decisions of the authority appointed under sub-section (4) and shall thereupon issue to every person whose name is entered on the register a certificate of registration in the prescribed form.
6. Upon the constitution of the [State] Council, the register shall be given into its custody, and the [State] Government may direct that all or any specified part of the application fees for registration in the first register shall be paid to the credit of the [State] Council.

Registration

1. A person shall be entitled on payment of the prescribed fee to have his name entered on the register

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when it is first prepared, if he resides or carries on the profession of dentistry in the [1][State] and if he

a. holds a recognized dental qualification, or
b. does not hold such a qualification but, being a [Citizen of India] has been engaged in practice as a dentist as his principal means of livelihood for a period of not less than five years prior to [the date appointed under sub-section (2) of section 32]:

Provided that no person other than a [citizen of India] shall be entitled to registration by virtue of a qualification

2. A person domiciled in a (State 19[9]) shall be entitled on payment of the prescribed fee to temporary registration as a dentist for a period of five years, if he has been engaged in practice as a dentist as his principal means of livelihood for a period of not less than two years during the five years prior to [20][10][the date appointed under sub-section (2) of section 32], and a person so registered shall be entitled to permanent registration if [21][11][for a period of five years from the date of his temporary registration he has been engaged in practice as dentist].

[1.] After the date appointed under sub-section (2) of section 32 a person shall, on payment of the prescribed fee, be entitled to have his name entered on the register of dentists, if he resides or carries on the profession of dentistry in the [23][2][State] and if he—

i. holds a recognized dental qualification or
ii. does not hold such a qualification but, being a [24][3][citizen of India], has been engaged in practice as a dentist as his principal means of livelihood for a period of not less than [25][4][two years before the date appointed under sub-section (2) of section 32] and has passed, within a period of [26][5][ten years after the said date], an examination recognized for this purpose by the [27][6][Central Government]:

Provided that no person other than a [3][citizen of India] shall be entitled to registration by virtue of a qualification.

a. specified in Part I of the Schedule unless by the law and practice of the State or country to which such person belongs persons of Indian origin holding dental qualification registrable in that State or country are permitted to enter and practice the profession of dentistry in such State or country, or

[28][7][b. recognized, in pursuance of a scheme of reciprocity, under sub-section (5) of section 10]:

Provided further that a person registered in Part B of the register shall be entitled to be registered in Part A thereof, if within a period of [29][8][ten years after the date of his registration in Part B] he passes an examination recognized for the purpose by the [6][Central Government].

[30][9][2. Notwithstanding anything contained in subsection (1)

a. a [31][10][State Council] may during the period of two years immediately after the commencement of the Dentists (Amendment) Act, [32][11][1955], permit for sufficient reasons the registration in the State register of any displaced person who does not hold a recognized dental qualification but has been actually practicing the profession of dentistry as his principal means of livelihood from a date prior to the 29th day of March, 1948.

Explanation: In this clause "displaced person" means any person who, on account of the setting up of the Dominions of India and Pakistan or on account of civil disturbances or fear of such disturbances in any area now forming part of Pakistan has, after the 1st day of March, 1947, left or been displaced from, his place of residence in such area and who has since then been residing in India;

[33][1][aa. the State Council may, during the period of two years immediately after the commencement of the Dentists (Amendment) Act, 1972, permit, for sufficient reasons, the registration in the State register of any dis-placed person or a repatriate who does not hold any recognized dental qualification but has been actually practicing the profession of dentistry as his principal means of livelihood from a date prior to the 29th day of March, 1948.

Explanation: In this clause,

i. "displaced person" means any person who, on account of civil disturbances or fear of such disturbances in any area now forming part of Bangla Desh, has, after the 14th day of April, 1957 but before the 25th day of March, 1971, left, or has been displaced from, his place of residence in such area and who has since then been residing in India;
ii. "repatriate" means any person who, on account of civil disturbances or fear of such disturbances in any area now forming part of Burma or Ceylon, has, after the 14th day of April, 1957, left or has been displaced from, his place of residence in such area and who has since then been residing in India;]

b. (a) a person other than a citizen of India, holding a reputable dental qualification and employed for teaching or research in a dental institution situated in any of the States may be permitted [34][2] temporary registration in the State register of dentists for the period of his employment or for a period of five years, whichever is shorter;

Provided that he does not practice the profession of dentistry for personal gain and his application for registration is approved by the President of the Council.]

35. 1. After the date appointed for the receipt of applications for registration in the first register of dentists all applications for registration shall be addressed to the Registrar of the [35][3][State] Council and shall be accompanied by the prescribed fee.

2. If upon such application the Registrar is of opinion that the applicant is entitled to have his name

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entered on the register, he shall enter thereon the name of the applicant:

Provided that no person, whose name has under the provisions of this Act been removed from the register of any [36][4][State], shall be entitled to have his name entered on the register except with the approval of the [3][State] Council from whose register his name was removed.

3. Any person whose application for registration is rejected by the Registrar may, within three months from the date of such rejection, appeal to the [3][State] Council, and the decision of the [3][State] Council thereon shall be final.
4. Upon entry in the register of a name under this section, the Registrar shall issue a certificate of registration in the prescribed form.

[37][1][35A. 1. Notwithstanding anything contained in this Chapter, the Registrar may, by order in writing, amend the register by deleting therefrom the name of any person who by reason of the formation of the State of Andhra, has ceased to reside or carry on the business or profession of dentistry in the State of Madras:

Provided that the Registrar shall, before passing an order, make such inquiry as he deems necessary.

2. Any person aggrieved by an order under sub-section (1) may appeal to such authority and within such time, as may be specified in this behalf, by the State Government of Madras; and such authority shall pass such order on the appeal as it thinks fit.
3. An order of the Registrar under sub-section (1), or where an appeal has been preferred against it under sub-section (2), the order of the appellate authority shall be final.
4. The provision of this section shall cease to be in force from such date as the State Government of Madras may by notification in the Official Gazette appoint.]

36. 1. The [38][2][State] Government may, by notification in the Official Gazette, direct that the [2][State] Council shall maintain a register of dental hygienists or a register of dental mechanics.
2. The provisions of section 35 shall, so far as they may be made applicable, apply in respect of applications for registration in a register referred to in this section.

37. A person shall be entitled on payment of the prescribed fee to have his name registered on the register of dental hygienists, if he resides in the [39][3][State] and holds a recognized dental hygiene qualification:

Provided that for the purposes of the first register of dental hygienists, a person shall be entitled to be registered if he has been engaged as a dental hygienist as his principal means of livelihood for a period of not less than two years prior to the date of notification under sub-section (1) of Section 36.

38. A person shall be entitled on payment of the pre scribed fee to have his name entered in the register of dental mechanics if he satisfies the prescribed requirements referred to in section 12:

Provided that for the purposes of the preparation of the first register of dental mechanics, a person shall be entitled to be registered if he has been engaged as a dental mechanic as his principal means of livelihood for a period of not less than two years prior to the date of notification under sub-section (I) of section 36.

39. 1. The [40][1][State] Government may, by notification in the Official Gazette, direct that for the retention of a name in a register after the 31st day of December of the year following the year in which the name is first entered in the register, there shall be paid annually to the [1][State] Council such renewal fee as may be prescribed in respect of each register, and where such direction has been made, such renewal fee shall due to be paid before the 1st day of April of the year to which it relates.
2. Where a renewal fee is not paid before the due date, the Registrar shall remove the name of the defaulter from the register: Provided that a name so removed may be restored to the register on payment in such manner as may be prescribed.

[41][2][3. On payment of the renewal fee, the registrar shall issue a certificate of renewal and such certificate shall be proof of renewal of registration.]

40. A registered dentist shall on payment of the prescribed fee be entitled to have entered in the register any further recognized [42][3][dental] qualification which he may obtain.

41. 1. Subject to the provisions of this section, the [1][State] Council may order that the name of any person shall be removed from any register where it is satisfied, after giving that person a reasonable opportunity of being heard and after such further inquiry, if any, as it may think fit to make,
   i. that his name has been entered in the register by error or on account of misrepresentation or suppression of a material fact, or
   ii. that he has been convicted of any offence or has been guilty of any infamous conduct in any professional respect [43][4][or has violated the standards of professional conduct and etiquette or the code of ethics prescribed under section 17A], which in the opinion of the [1][State] Council renders him unfit to be kept in the register, [44][5][or]
   [5]iii. that he having been permitted temporary registration under clause (b) of sub-section (2) of section 34 has, on such registration, been found to practice the profession of dentistry for personal gain.
2. An order under sub-section (1) may direct that any person whose name is ordered to be removed from a register shall be ineligible for registration in the [45][6][State] under this Act either permanently or for such period of years as may be specified.
3. An order sub-section (1) shall not take effect until the expiry of three months from the date thereof.
4. A person aggrieved by an order under subsection (1) may, within 30 days from the date thereof,

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appeal to the [1][State] Government, and the order of the [1][State] Government upon such appeal shall be final.

5. A person whose name has been removed from the register under this section or under subsection (2) of section 39 shall forthwith surrender his certificate of registration [46][1][and certificate of renewal, if any,] to the Registrar, and the name so removed shall be published in the Official Gazette.

[47][2][6. A person whose name has been removed from the State register of dentists under this section or under sub-section (2) of section 39 shall not be entitled to have his name registered in the register of dentists in any other State register of dentists except with the approval of the State Council from whose register his name has been removed.]

42. The [48][3][State] Council may at any time, for reasons appearing to it sufficient and subject to the approval of the [3][State] Governments, order that upon payment of the prescribed fee the name of a person removed from a register shall be restored thereto.
43. No order refusing to enter a name in a register or removing a name from a register shall be called in question in any Court.
44. Where it is shown to the satisfaction of the Registrar that a certificate of registration [49][4][or a certificate of renewal] has been lost or destroyed, the Registrar may, on payment of the prescribed fee, issue a duplicate certificate in the prescribed form.
45. As soon as may be after the 1st day of April in each year, the Registrar shall cause to be printed copies of the registers as they stood on the said date and such copies shall be made available to persons applying therefore on payment of the prescribed charge, and shall be evidence that on the said date the persons whose names are entered therein were registered dentists, registered dental hygienists or registered dental mechanics, as the case may be.

EFFECT OF REGISTRATION

46. 1. Any reference in any other law to a person recognized by law as a dentist shall be deemed to be a reference to a dentist registered under this Act.
2. No certificate required by or under any other law from a dentist shall be valid unless the person signing it is registered as a dentist under this Act.
3. After the expiry of [50][5][three years] from [51][6][the date appointed under sub-section (2) of section 32], a person who is not registered in Part A of the 3[State] register of dentists shall not, except with the sanction of [52][7][the Central Government or the State Government] hold any appointment as dentist in any dispensary, hospital or other institution [53][8]which is supported wholly or partially from public or local funds:

Provided that the provisions of this sub-section shall not apply to any such person who is holding such an appointment [54][9][immediately before the said date].

4. After the expiry of two years from the publication of a register of dental hygienists in a [55][1][State], no person whose name is not entered in that register shall hold appointment as dental hygienist in any dispensary, hospital or other institution in the [1][State], which is supported wholly or partially from public or local funds.
5. Any person who is a registered dentist, registered dental hygienist or registered dental mechanic in a [1][State] may practice as such in any other [1][State].

[56][2][46A. Where a dentist registered in one State is practicing dentistry in another State, he may, on payment of the prescribed fee which shall not exceed its renewal fee for registration in such other State, make an application in the prescribed form to the Council for the transfer of his name, from the register of the State where he is registered, to the register of the State in which he is practicing dentistry, and on receipt of any such application, the Council shall, not withstanding anything contained elsewhere in this Act, direct that the name of such person be removed from the first-mentioned register and entered in the register of the second-mentioned State Councils concerned shall comply with such directions:

Provided that such a person shall be required to produce a certificate to the effect that all dues in respect of his registration in the former State have been paid.

Provided further that where any such application for transfer is made by a dentist against whom any disciplinary proceeding is pending or where for any other reason it appears to the Council that the application for transfer has not been made bona fide and the transfer should not be made, the Council may, after giving the dentist a reasonable opportunity of making a representation in this behalf, reject the application.]

MISCELLANEOUS

47. If any person whose name is not for the time being entered in a register falsely represents that it is so entered, or uses in connection with his name or title any words or letters reasonably calculated to suggest that his name is so entered, he shall be punishable on first conviction with fine, which may extend to five hundred rupees, and on any subsequent conviction with imprisonment, which may extend to six months or with fine not exceeding one thousand rupees or with both.
48. If any person,
    a. not being a person registered in a register of dentists, takes or uses the description of dental practitioner, dental surgeon, surgeon dentist, or dentist, or
    b. not being a person whose name is entered on a register of dental hygienists, takes or uses in [57][1][State] where such register has been published, the title of dental hygienists, or
    c. not being a person whose name is entered on a register of dental mechanics, takes or uses in a [1][State] where such register has been published, the title of dental mechanic, [58][2][or]

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[2][d. not possessing a recognized dental qualification, uses a degree or a diploma or an abbreviation indicating or implying a dental qualification], he shall be punishable on first conviction with fine, which may extend to five hundred rupees, and on any subsequent conviction with imprisonment, which may extend to six months or with fine not exceeding one thousand rupees or with both.

49. 1. After the expiry of [59][3][three years] from [60][4][the date appointed under sub-section (2) of section 32] in the case of dentists, and in the [61][5][States] where a register of dental hygienists or dental mechanics has been prepared under section 36 from such date as may be specified in this behalf by the [62][6][State] Government by notification in the Official Gazette, in the case of dental hygienists or dental mechanics, no person, other than a registered dentist, registered dental hygienist or registered dental mechanic, shall practice dentistry, or the art of scaling, cleaning or polishing teeth, or of making or repairing dentures and dental appliances, as the case may be, or indicate in any way that he is prepared to so practice:

Provided that the provisions of this section shall not apply to—

a. practice of dentistry by a registered medical practitioner;
b. the extraction of a tooth by any person when the case is urgent and no registered dentist is available so, however, that the operation is performed without the use of any general of local anaesthetic;
c. the performance of dental work or radiographic work in any hospital or dispensary maintained or supported from public or local funds.

2. If any person contravenes the provisions of sub-section (1), he shall be punishable on first conviction with fine, which may extend to five hundred rupees, and on any subsequent conviction with imprisonment, which may extend to six months or with fine not exceeding one thousand rupees or with both.

50. If any person whose name has been removed from a register fails without sufficient cause forthwith to surrender his certificate of registration [63][7][or certificate of renewal, or both], he shall be punishable with fine which may extend to fifty rupees per month of such failure and in the case of continuing offence with an additional fine which may extend to two rupees per day after the first day during which the offence continues.

51. 1. Except as hereinafter provided, the profession of dentistry shall not be carried on by a company of other corporate body.

2. The provisions of sub-section (1) shall not apply to—

a. a company or other corporate body which carries on no business other than the profession of dentistry or some business ancillary to the profession of dentistry and of which the majority of the directors and all the operating staff are registered dentists;
b. the carrying on of the profession of dentistry by employers who provide dental treatment for their employees by registered dentists otherwise than for profit;
c. the carrying on of the profession of dentistry by any hospital or dispensary or institution for the training of dentists or dental hygienists or by any local authority or other body authorised or required by law to provide dental treatment;

Provided that any company or other corporate body carrying on the profession of dentistry [64][1][immediately before the date appointed under sub-section (2) of section 32] may continue so to do until the expiry of three years from such date.

3. If any person contravenes the provisions of sub-section (1), he shall be punishable with fine which may extend, on first conviction to five hundred rupees, or on any subsequent conviction with imprisonment which may extend to six months or with fine not exceeding one thousand rupees or with both.

52. No court shall take cognizance of any offence punishable under this Act except upon complaint made by order of the [65][2][State] Government or the [2][State] Council.

53. The [2][State] Council shall before the end of June in each year pay to the Council a sum equivalent to one-fourth of the total fees realised by the [2][State] Council under this Act during the period of twelve months ending on the 31st day of March of that year.

[66][3][53A. 1. The Council shall maintain appropriate accounts and other relevant records and prepare an annual statement of accounts including the balance-sheet, in accordance with such general directions as may be issued and in such form as may be specified by the Central Government in consultation with the Comptroller and Auditor General of India.

2. The accounts of the Council shall be audited annually by the Comptroller and Auditor General of India or any person appointed by him in this behalf and any expenditure incurred by him or any person so appointed in connection with such audit shall be payable by the Council to the Comptroller and Auditor General of India.

3. The Comptroller and Auditor General of India and any person appointed by him in connection with the audit of the accounts of the Council shall have the same right and privileges and authority in connection with such audit as the Comptroller and Auditor General of India has in connection with the audit of Government accounts, and in particular, shall have the right to demand the production of books of accounts, connected vouchers and other documents and papers and to inspect the office of the Council.

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4. The accounts of the Council as certified by the Comptroller and Auditor General of India or any person appointed by him in this behalf, together with the audit report thereon, shall be forwarded annually to the Central Government.
5. A copy of the accounts of the Council as so certified together with the audit report thereon shall be forwarded simultaneously to the Council.]

54. 1. Whenever it appears to the Central Government that the Council is not complying with any of the provisions of this Act, the Central Government may appoint a Commission of Enquiry consisting of three persons, two of whom shall be appointed by the Central Government, one being the Judge of a High court and one by the Council; and refer to it the matters on which the enquiry is to be made.
2. The Commission shall proceed to enquire in a summary manner and report to the Central Government on the matters referred to it together with such remedies, if any, as the Commission may like to recommend.
3. The Central Government may accept the report or remit the same to the Commission for modification or reconsideration.
4. After the report is finally accepted, the Central Government may order the Council to adopt the remedies so recommended within such time as may be specified in the order and if the Council fails to comply within the time so specified, the Central Government may pass such order or take such action as may be necessary to give effect to the recommendations of the commissions.
5. Whenever it appears to the [67][1][State] Government that the [1][State] Council is not complying with any of the provisions of this Act, the [1][State] Government may likewise appoint a similar Commission of Enquiry in respect of the [1][State] Council to make enquiry in like manner and pass such order or take such action as specified in sub-section (3) and (4).

55. 1. The [1][State] Government may, by notification in the Official Gazette, make rules to carry out the purposes of Chapters III, IV and V.
2. In particular and without prejudice to the generality of the foregoing power, such rules may provide for
   a. the management of the property of the [68][1][State] Council, and the maintenance and audit of its accounts;
   b. the manner in which elections under Chapter III shall be conducted;
   c. the summoning and holding of meetings of the [1][State] Council, the times and places at which such meetings shall be held, the con duct of business threat and the number of members necessary to form a quorum;
   d. the powers and duties of the President and Vice-President of the [1][State] Council;
   e. the constitution and functions of the Executive Committee, the summoning and holding of meetings thereof, the times and places at which such meetings shall be held, the number of members necessary to constitute a quorum;
   f. the term of office and the powers and duties of the Registrar and other officers and servants of the 1 [State] Council, including the amount and nature of the security to be given by the Treasurer;
   g. the particulars to be stated, and the proof of qualifications to be given in applications for registration under this Act;
   [69][2][gg. the form of application for transfer of registration from one State to another;]
   [70][3][h. the charge for supplying printed copies of the registers, and the fees payable for—
      i. registration or renewal of registration;
      ii. supplying a duplicate certificate of registration or renewal; and
      iii. transfer of registration from one State to another;]
   i. the forms of certificates of registration and renewal;
   j. any other matter which is to be or may be prescribed under chapters III, IV and V, except sub-sections (1), (2), (3) and (4) of section 54.

[71][4][(3) Every rule made by the State Government under this section shall be laid, as soon as may be after it is made, before the State Legislature.]

THE DENTISTS (AMENDMENT) ACT, 1993

No. 30 of 1993

[2nd April, 1993]

An Act further to amend the Dentists Act, 1948 But it enacted by Parliament in the 44th Year of the Republic of India as follows:

1. a. This Act may be called the Dentists (Amendment) Act, 1993
   b. It shall be deemed to have come into force on the 27th day of August, 1992
2. After section 10 of the Dentists Act, 1948 (hereafter referred to as the Principal Act), the following sections shall be inserted, namely:

10A. 1. Notwithstanding anything contained in this Act or any other law for the time being in force,
   a. no person shall establish an authority or institution for a course of study or training (including a postgraduate course of study or training) which would enable a student of such course or training to qualify himself for the grant of recognized dental qualification; or
   b. no authority or institution conducting a course of study or training (including a post-graduate course of study or training) for grant of recognized dental qualification shall—
      i. open a new or higher course of study or training (including a post-graduate course of study or training) which would enable a student of such course or training to

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qualify himself or the award of any recognized dental qualification; or

ii. increase its admission capacity in any course of study or training (including a post-graduate course of study or training) except with the previous permission of the Central Government obtained in accordance with the provisions of this section.

Explanation 1: For the purposes of this section "person" includes any University or a trust but does not include the Central Government.

Explanation 2: For the purposes of this section "admission capacity," in relation to any course of study or training (including a post-graduate course of study or training) in an authority or institution granting recognized dental qualification, means the maximum number of students that may be fixed by the council from time to time for being admitted to such course or training.

2. a. Every person, authority or institution granting recognized dental qualification shall, for the purpose of obtaining permission under sub-section (1), submit to the Central Government a scheme in accordance with the provisions of clause (b) and the Central Government shall refer the said scheme to the Council for its recommendations.
   b. The scheme referred to in clause (a) shall be in such form and contain such particulars and be preferred in such manner and be accompanied with such fee as may be prescribed.
3. On receipt of a scheme by the Council under sub-section (2), the Council may obtain such other particulars as may be considered necessary by it from the person, authority or institution concerned, granting recognized dental qualification and thereafter, it may—
   a. If the scheme is defective and does not contain any necessary particulars, give a reasonable opportunity to the person, authority or institution concerned for making a written representation and it shall be open to such person, authority or institution concerned for making a written representation and it shall be open to such person, authority or institution to rectify the defects, if any, specified by the Council;
   b. Consider the scheme, having regard to the factors referred to in sub-section (7), and submit the scheme together with its recommendation thereon to the Central Government.
4. The Central Government may, after considering the scheme and the recommendations of the Council under sub-section (3) and after obtaining, where necessary, such other particulars as may be considered necessary by it from the person, authority or institution concerned, and having regard to the factors referred to in sub-section (7), either approve (with such conditions, if any, as it may consider necessary) or disapprove the scheme and any such approval shall be a permission under sub-section (1):

Provided that no scheme shall be disapproved by the Central Government except after giving the person, authority or institution concerned granting recognized dental qualification a reasonable opportunity of being heard:

Provided further that nothing in this sub-section shall prevent any person, authority or institution whose scheme has not been approved to submit a fresh scheme and the provisions of this section shall apply to such scheme, as if such scheme has been submitted for the first time under sub-section (2).

5. Where within a period of one year from the date of submission of the scheme to the Central Government under sub-section (2), no order passed by the Central Government has been communicated to the person, authority or institution submitting the scheme, such scheme shall be deemed to have been approved by the Central Government in the form in which it had been submitted, and, accordingly, the permission of the Central Government required under sub-section (1) shall also be deemed to have been granted.
6. In computing the time-limit specified in sub-section (5), the time taken by the person, authority or institution concerned submitting the scheme in furnishing any particulars, called for by the Council or by the Central Government, shall be excluded.
7. The Council, while making its recommendations under clause (b) of sub-section (3) and the Central Government, while passing an order either approving or disapproving the scheme under subsection (4), shall have due regard to the following factors, namely:
   a. whether the proposed authority or institution for grant of recognized dental qualification or the existing authority or institution seeking to open a new or higher course of study or training, would be in a position to offer the minimum standards of dental education in conformity with the requirements referred to in Section 16A and the regulations made under sub-section (1) of section 20;
   b. whether the person seeking to establish an authority or institution or the existing authority or institution seeking to open a new or higher course of study or training or to increase its admission capacity has adequate resources;
   c. whether necessary facilities in respect of staff, equipment, accommodation, training and other facilities to ensure proper functioning of the authority or institution or conducting the new course of study or training or accommodating the increased admission capacity have been provided or would be provided within the time- limit specified in the scheme;
   d. whether adequate hospital facilities, having regard to the number of students likely to attend such authority or institution or course of study or training or as a result of the increased admission capacity have been provided or would be provided within the time-limit specified in the scheme;
   e. whether any arrangement has been made or programme drawn to impart proper training to students likely to attend such authority or institution or course of study or training by persons having the recognized dental qualifications;
   f. the requirement of manpower in the field of practice of dentistry; and
   g. any other factors as may be prescribed.
8. Where the Central Government passes an order either approving or disapproving a scheme under this

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section, a copy of the order shall be communicated to the person, authority or institution concerned.

10B. 1. Where any authority or institution is established for grant of recognized dental qualification except with the previous permission of the Central Government in accordance with the provisions of section 10A, no dental qualification granted to any student of such authority or institution shall be a recognized dental qualification for the purposes of this Act.

2. Where any authority or institution granting recognized dental qualification opens a new or higher course of study or training (including a post-graduate course of study or training) except with the previous permission of the Central Government in accordance with the provisions of section 10A, no dental qualification granted to any student of such authority or institution on the basis of such study or training shall be a recognized dental qualification for the purposes of this Act.

3. Where any authority or institution granting recognized dental qualification increases its admission capacity in any course of study or training (including a post-graduate course of study or training) except with the previous permission of the Central Government in accordance with the provisions of section 10A, no dental qualification granted to any student of such authority or institution on the basis of the increase in its admission capacity shall be a recognized dental qualification for the purposes of this Act.

Explanation: For the purposes of this section, the criteria for identifying a student who has been granted a dental qualification on the basis of such increase in the admission capacity shall be such as may be prescribed.

10C. 1. If, after the 1st day of June, 1992 and on and before the commencement, of the Dentists (Amendment) Act, 1993 any person has established an authority or institution for grant of recognized dental qualification or any authority or institution granting recognized dental qualification has opened a new or higher course of study or training (including a post-graduate course of study or training) or increased its admission capacity, such person, authority or institution, as the case may be, shall seek, within a period of one year from the commencement of the Dentists (Amendment) Act, 1993, the permission of the Central Government in accordance with the provisions of section 10A.

2. If any person, or, as the case may be, any authority or institution granting recognized dental qualification fails to seek the permission under sub-section (1), the provisions of section 10B shall apply, so far as may be, as if permission of the Central Government under section 10A has been refused.

3. In section 20 of the principal Act, in sub-section (2), after clause (f), the following clauses shall be inserted, namely:

"(fa) prescribe the form of the scheme, the particulars to be given in such scheme, the manner in which the scheme is to be preferred and the fee payable with the scheme under clause (b) of subsection (2) of section 10A;

(fb) prescribe any other factors under clause (g) of sub-section (7) of section 10A;

(fc) prescribe the criteria for identifying a student who has been granted a dental qualification referred to in the Explanation to sub-section (3) of section 10B."

4. 1. The Dentists (Amendment) Ordinance, 1993 is hereby repealed.

2. Notwithstanding such repeal, anything done or any action taken under the Principal Act, as amended by the said Ordinance, shall be deemed to have been done or taken under the Principal Act, as amended by this Act.

B.R. ATRE,
Joint Secy. to the Govt. of India

REVIEW QUESTIONS

1. Write notes on:
   a. Dentist Act of 1948
   b. Unethical practice

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26 Dental Council of India (DCI) and Indian Dental Association (IDA)

Hiremath SS and Sowmya KR

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DENTAL COUNCIL OF INDIA

INTRODUCTION

The Dental Council of India is a statutory body which was formed under an Act of Parliament – the Dentists Act, 1948 (XVI of 1948) on 12th April 1949. The amendments were made through an ordinance circulated by the President of India on 27th August 1992. New sections i.e. section 10A, section 10B, section 10C were added in the Dentists Act, 1948, mainly to curb mushroom growth of dental colleges, raise the seats in any of the course and open of new higher courses without the permission of the Central Government, Ministry of Health and Family Welfare.

DEFINITIONS

1. "Dental Hygienist" means a person not being a dentist or a medical practitioner, who scales, cleans or polishes teeth, or gives instruction in dental hygiene;
2. "Dental Mechanic" means a person who makes or repairs denture and dental appliances;
3. "Dentistry" includes
   i. the performance of any operation on, and the treatment on any disease, deficiency or lesion of, human teeth or jaws, and the performance of radiographic or in connection with human teeth or jaws or the oral cavity;
   ii. the giving of any anaesthetic in connection with any such operation or treatment;
   iii. the mechanical construction or the renewal of artificial dentures or restorative dental appliances;
   iv. the performance of any operation on, or the giving of any treatment, advice or attendance to any person preparatory to, or for the purpose of, or in connection with, the fitting, inserting, fixing, constructing, repairing or renewing of artificial dentures or restorative dental appliances, and the performance of any such operation and the giving of any such treatment, advice or attendance, as is usually performed or given by dentists;
4. "Dentist" means a person who practices dentistry;
5. "Medical Practitioner" means a person who holds a qualification granted by an authority specified or notified under section 3 of the Indian Medical Degrees Act, 1916, or specified in the Schedules to the Indian Medical Council Act, 1956 or specified in any other law for the time being in force in any [State] or who practices any system of medicine and is registered or is entitled to be registered in any 3[State] medical register by whatever name called;
6. "Prescribed" means prescribed by rules or regulations made under this Act;
7. "State Council" means a 3[State] Dental Council constituted under section 21, and includes a Joint 3[State] Council constituted in accordance with an agreement under section 22;
8. "Register" means a register maintained under this Act;
9. ["Recognised dental qualification" means any of the qualifications included in the Schedule;]
10. Recognised dental hygiene qualification" means a qualification recognised by the Council under section 11;
11. "Registered dentist", "registered dental hygienist" and "registered dental mechanic" shall mean, respectively, a person whose name is for the time being registered in a register of dentists, a register of dental hygienists and a register of dental mechanics.

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CONSTITUTION OF THE COUNCIL

The Central Government will have to form a council consisting of the following members, namely:

a. one registered dentist holding a recognised dental qualification elected by the dentists registered in Part A of each State register;
b. one member elected by the members of the Medical Council of India among themselves;
c. maximum of four members elected from among themselves, by—
   i. Principals, Deans, Directors and Vice-Principals of dental colleges in the States
   Provided that one member shall be elected from the same dental college;
a. Heads of dental wings of medical colleges in the States training students for recognised dental degrees;
b. One member from each University established by law in the States, which grants as recognised dental qualification, to be elected by the members of the Senate of the University;
c. One member to represent each State will be nominated by the state government from persons registered either in a medical or dental register;
d. Six members will be nominated by the Central Government, of whom at least one shall be a registered dentist holding a recognised dental qualification and holding an appointment in an institution for the training of dentists in a Union territory, and at least two shall be dentists registered in Part B of a State register;
e. The Director General of Health Services.

MODE OF ELECTIONS

Elections will be conducted in the approved manner, and where any disagreement arises regarding any such election, the decision of the central government will be deemed final.

1. An elected or nominated member will be serving a term of five years.
2. An elected or nominated member may at any time resign his membership by writing personally to the President, and the seat of such member will become vacant.
3. An elected or nominated member will be deemed to have vacated his seat if he is absent without excuse, from three consecutive ordinary meetings of the Council.if he ceases to havethe appointment as the Principal, Dean, Director or Vice-Principal of a dental college, or as the Head of the dental wing of a medical college.
4. A casual vacancy in the Council shall be filled by fresh election or nomination.
5. Members of the Council shall be eligible for re-election or re-nomination.
6. **A,** The President and Vice-President of the Council shall be elected by the members from among themselves.
   B, An elected President or Vice-President shall be in the office as such for a term not exceeding five years.
7. The Council can also
   a. appoint a Secretary who may also act as Treasurer;
   b. appoint such other officers and servants as the Council deems necessary;
   c. require and take from the Secretary or from any other officer or servant such security for the due performance of his duties as the Council considers necessary;
   d. The fees and allowances of the President, Vice-President and other members of the Council, and the pay and allowances and other conditions of service of officers and servants of the Council can be fixed with the previous sanction of central government.

THE EXECUTIVE COMMITTEE

1. The Council can form an executive committee from among its members and can also form other committees for such general or special purposes as the Council deems it necessary for carrying out its functions under this Act.
2. The Executive Committee will be consisting of the President and Vice-President *ex officio* and the Director-General of Health Services *ex officio,* and five other members elected by the Council.
3. The President and Vice-President of the Council will be Chairman and Vice-Chairman of the executive committee, respectively.
4. A member of the Executive Committee can be in the office as such until the expiry of his term of office as member of the Council.
5. In addition to the powers and duties conferred on it by this Act, the Executive Committee shall exercise and discharge such powers and duties as may be recommended.

RECOGNITION OF DENTAL QUALIFICATION

1. The dental qualifications, granted by any authority or institution in India, which are included in Part I of the Schedule will be recognized dental qualifications.
2. Any institution in India, which grants a dental qualification not included in Part I of the Schedule, may have to apply to the Central Government to have such qualification recognized and included in that Part, and the Central Government, after consulting the Council, and after such inquiry may, by notification in the Official Gazette, include such qualification by amendment in Part I of the schedule.
3. a. The dental qualifications, granted by any authority or institution outside India, shall be recognized dental qualifications only for the purposes of the registration of citizens of India, which are included in Part II of the Schedule.
   b. Where any dental qualification granted by any authority or institution outside India, and held by a citizen of India, the Central Government may amend Part II of the Schedule after consultation with the Council, by notification in the Official

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Gazette, so as to include the recognized dental qualification.

4. a. The dental qualification granted by any authority or institution outside India, which are included in Part III of the Schedule, will be recognized dental qualification , but no person possessing any such qualification shall be entitled for registration unless he is a citizen of India.
   b. Any dental qualification granted by any authority or institution outside India, and held by a citizen of India, is recognized, the Central Government may, after consultation with the Council, by notification in the Official Gazette, amend Part III of the Schedule, so as to include therein the dental qualification that is recognized.

QUALIFICATION OF DENTAL HYGIENISTS

Any authority or institution in a state, which grants a qualification for dental hygienists, may apply to the Council to get the qualification recognized, and the Council may, after such inquiry and after consulting the Government and the State Council, declare that such qualification shall be a recognized as dental hygiene qualification.

QUALIFICATION OF DENTAL MECHANICS

The Council may lay down period and nature of training which shall be undergone by a person before he is entitled to be registered under this Act as a dental mechanic.

PREPARATION AND MAINTENANCE OF REGISTER

1. The State Government has to provide register of dentists for the State.
2. The State Council assumes the duty of maintaining the register.
3. The register of dentists should be maintained in two parts A and part B, persons possessing recognized dental qualifications being registered in Part A and persons not possessing such qualification being registered in Part B.
4. The register shall include the following particulars, namely:
   a. the full name, residential address, professional address and nationality of the registered person;
   b. the date of his admission to the register;
   c. his qualification for registration, and the date of attaining the degree or diploma in dentistry and the authority which awarded this

Functions

- To prescribe the standard curricula for the training of dentists, dental hygienists and dental mechanics. To prescribe the standards of examinations and other requirements to be satisfied to secure for qualifications recognition.

To Achieve these, the Needs are

- Uniformity of curriculum standards of technical and clinical requirements, standards of examinations;
- A uniform standard of entrance to various courses in dentistry;
- Affiliation of every dental college to a university;
- Supervision over all the dental institutions to ensure that they maintain the prescribed standards;
- Regulation of the profession of dentistry.

THE INDIAN DENTAL ASSOCIATION (IDA)

The All India Dental Association was founded in 1946 under the able guidance of Dr Rafiuddin Ahmed, the doyen of dentists in the country and the founder of the first dental college and hospital in India. Dr Rafiuddin Ahmed became its first President and continued for a three-year term till 1948. IDA was formed to unite dental professionals and patients across India and to foster education, improve awareness and enhance communication. Later, the All India Dental Association became the Indian Dental Association, as it is known today.

Today, Indian Dental Association has all dental professionals as its members spread across State and local branches. Being an exclusive body of dentists in India, it effectively harnesses its vast resources aimed at attaining professional excellence in their day to day clinical and research activities and to ensure optimal oral health for all. It is comprised of 29 State Branches, 7 Union Territories, more than 450 Local branches and 1 Defence branch have a combined membership of over 75,000 dedicated dental professionals.

Composition

The Central Council
State Branches
Local Branches
Defence Branches

Official Relations

World Dental Federation
Common Wealth Dental Association
Asia Pacific Dental Federation
International Association of Dental Research
Society for Research on Nicotine and Tobacco

Registered Head Office

Registered Head Office shall be where Honourable Secretary General resides or practices.

Objectives of the Association

1. Promotion, encouragement and advancement of the dental and allied sciences;
2. Encourage the members to undertake measures for the improvement of public health and dental education in India; and
3. Maintenance of the dignity and honour of the dental profession and to protect the rights and interests of the members of Association and foster friendship, cooperation and co-existence among the members of the Association and implement well

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formulated schemes for the social security of members of the Association.

For the attainment of the aforementioned objectives, the Association may:

a. Conduct periodical meetings and conferences for the members of the association and for the dental profession.
b. Publish a journal which is the official organ of the association adapted to the requirements of the dental profession.
c. Maintain the office of the association.
d. Promote the opening of libraries in Head office, State/ Local branches and acquire other relevant materials, books etc. utilising the funds of the association.
e. Publish papers representing dental researches conducted by members.
f. Promote research and Continuing Dental Education in dental and allied sciences with the funds of the Association, by establishment of scholarships, prizes or awards.
g. Carryout an educational campaign among the masses regarding oral hygiene by partnering with different public bodies working with the similar objects.
h. Put across views on all questions pertaining to the Indian Legislation affecting public health, Dental profession and Dental education and take such steps the same.
i. Grant seal of approval of IDA to oral health products with regard to safety, efficacy and quality in public interest.
j. Grant seal of approval of IDA to dental instruments, materials and equipment in the interest of dental profession.
k. To represent the interest of dental fraternity, protect and plead the rights and secure all benefits for its members and defend their rights.
l. Safeguard the professional interest, social security and individual member as a consumer.

MANAGEMENT OF THE ASSOCIATION

A. Central Council Executive Committee

The general management of the Association as a whole shall be vested with Central Council and while that of the State/Local branches shall be vested with the respective Executive Committee of the branch, under guidance from Head Office. No one in receipt of salary or honorarium from the funds of the Association can be elected as office bearer of the Association. This applies to the branches also (Tables 26.1 and 26.2).

Table 26.1 Composition of the central council

	Post	Tenure
i.	President	One term
ii.	President-elect	One term
iii.	Four Vice-Presidents	One term
iv.	Honorary Secretary General	Five years
v.	Honorary Joint Secretary	Five years
vi.	Honorary Assistant Secretary	Five years
vii.	Honorary Treasurer	Five years
viii	One Editor of the Journal	Five years
ix.	Chairman of Council of Dental Health	Two years
x.	Chairman of the Continuing Dental Education	Two years
xi.	Immediate Past President	One term
xii.	Chairman – International Committee	Two years
xiii.	Vice Chairman – International Committee	Two years
xiv.	Chairman – ICCDE India Division	Two years
xv.	Secretary-ICCDE India Division	Two years
xvi.	Representatives from state to central council	Two years

Table 26.2 Composition of the executive committee of the state branch

	Post	Tenure
i.	One President	One year
ii.	One President Elect	One year
iii.	Three Vice-Presidents	One year
iv.	One Honorary State Secretary	One year
v.	Honorary Joint Secretary	Three year
vi.	One Honorary Asst. Secretary	Three years
vii.	One Honorary Treasurer	Three years
viii.	One Editor of Journal (Optional)	Three years
ix.	Chairman Community Dental Health	One year
x.	Chairman Continuing Dental Education	One year
xi.	Immediate Past President	One year
xii.	Members of Executive Committee (The number shall be on the basis of total strength of the Local Branch. For every 100 Life/Annual members or part there off there shall be one EC Member)	One year
xiii.	Representatives from—Local Branches to State Executive." It is optional for Local Branches to decide whether they should be member of Local Branch Executive Committee also or not in addition to their duties as representative to State Executive Committee.	One year

B. Functions and Powers of Central Council

1. To conduct meetings of the Central Council for the maintenance and administration of the Association, library, properties and for the organization and direction of publications.
2. To outline the rules and bhyelaws of the association by 2/3rd majority in central council subject to the approval of annual general body meeting.
3. To frame different committees for the functioning of the association.

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4. To employ an Arbitration Committee comprising of ruling President, Hon Secretary, General, immediate Past President, President Elect and convener.
5. To represent any matter in which the interests of the association or the dental profession are affected to Government, public bodies or any constituent authority.
6. To consider and decide application for direct membership and resignation, to take disciplinary action on any member, removal of members for want of qualification and the question of taking disciplinary action against any member or branch.
7. To delegate all or some of its powers to a working committee except altering rules and byelaws.
8. To appoint or terminate employees of the Association.
9. To purchase or take on lease, sell, mortgage, or otherwise buy or dispose immovable properties of every description in particular any land, building, etc. to form a Trust as per Govt. Regulation for which 2/3rd majority of Central Council is required.
10. To purchase, manage, lend, exchange movable properties and to buy utensils, books, newspapers, periodicals, instruments, fittings, appliances, apparatus, rent any accommodation when deemed necessary in the interest of the Association.
11. To build, maintain, improve or alter buildings for the purpose of the Association.
12. To borrow or raise money by collecting subscriptions and donations for the purposes of the Association.
13. To Approve/Derecognise State/Local Branches and also to give directive to the branches.
14. To grant seal of approval of IDA for Oral Health Products/Instruments/Dental Materials by 2/3rd majority.
15. To appoint one conference secretary, one chairman organizing committee, organizing secretary and treasurer for national conference.
16. To represent matters pertaining to DCI.

REVIEW QUESTIONS

1. Write note on DCI.
2. Write notes on constitution and composition of DCI.
3. Write notes on composition of central council of IDA.
4. Discuss function and powers of central council of IDA.
5. What are the objectives of IDA?
6. Discuss about branches of IDA.

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27 Consumer Protection Act

Hiremath SS and Sowmya KR

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INTRODUCTION

Consumer Protection Act (COPRA) is an act (Act No.68 of 1986), which recognizes "consumer sovereignty." It applies to all goods and services, but excludes the free services without payment; contract of personal service. The Act aims to settle consumer disputes and protect the interest of the consumers. In India this act has provided statutory recognition to the rights of the consumers. Previously the rights of the consumers were under the **Law of Torts.** "Tort" is a Latin term derived from the "*tortum*," a judicial word that redresses any violation of legal right. Any harm is a tort and the law of torts has given recognition to several new types of immoral actions including the immoral actions inflicted on the consumers.

Late John F Kennedy expressed the need for consumer protection and adopted the consumer rights. The rights are: (1) right to safety, (2) right to be informed, (3) right to choose and (4) right to be heard.

Medical services were brought under Consumer Protection Act of 1986. Thereafter, a new horizon has been added to the history of health care system. Medical, dental and other associations reacted sharply when the medical profession was brought into the ambit of the Consumer Protection Act of 1986 by the now famous ruling in the IMA Vs VP Shanta case in 1995 (but, the Supreme Court of India in a landmark judgment delivered on November 13, 1995 included the health profession under the act). Services rendered to a patient by way of consultation, diagnosis and treatment—medical or surgical—would fall within the ambit of "SERVICE" defined in Section 2 (1) (o) of the CP Act.

The patients expect standards of skill leading to expected result. He or she also expects skills to be adapted professionally within a framework of professional moral standards. This makes the doctor more accountable to the patients. Doctors have several ethical, moral and legal obligations in the performance of their duties. It is very important therefore, that all doctors understand the nature of these obligations, and then fulfil these obligations to the best of their ability (Table 27.1). All doctors should know about medicolegal cases and the procedures to be adopted in them. Dentists have their own association Dental Council of India (DCI) and similar bodies, which are regulatory bodies. These should be strong in forming the professional ethical standards and should effectively regulate and control the professional ethical standards.

As these bodies are not performing their duties strictly, therefore, such formal court system has been started to

Table 27.1 Differentiating features of profession and trade

Profession	Trade
1. Based on definite specialized knowledge, which a person has to acquire at a college	1. There is no such requirement Anybody can enter any trade and pass the examination
2. Service is primary, money is secondary	2. Money is primary, service is secondary
3. Ethical standards have to be strictly followed	3. No such standards and bindings followed
4. Medicine including dental surgery is based on systemic knowledge	4. No such requirement

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bring the responsibility to justice and also due to the heightened consumer awareness in the 1980s Government of India enacted Consumer Protection Act in 1986, which paved the way for the establishment of consumer courts. This Act was amended in 1991, 1993 and 2002 which extended its coverage and scope to redress new consumer issues.

Fifteenth March is celebrated as World Consumer Day and 24th December as National Consumer Day.

SUPREME COURT DECISIONS OF THE CONSUMER PROTECTION ACT

A fast pace of urbanization on all walks of life, medical profession is not left behind. Ever since the implementation of the Consumer Protection Act, 1986 the litigation against the medical professionals has raised. The judicial forum has extended its interference against the medical professionals. So, the professionals have resorted to defensive treatment, which has enhanced the cost of the health care and this has made the underutilization of health care facilities because of inaccessibility by the common man. However, the Indian judicial system has outrightly rejected this issue; but also has clearly stated that guarantee of life cannot be given by doctors. In *Indian Medical Association* v. *V.P. Shantha and Ors.88*, the apex court has put an end to this controversy and has stated that no deficiency in the treatment protocol is accepted by the patient whether the patient seeks treatment from either private clinics or Government hospitals. The patient is liable for compensation for the damages incurred during treatment under the Consumer Protection Act, 1986. A few important principles laid down in this case include:

1. Service rendered to a patient by a dental practitioner (except where the doctor renders service free of charge to every patient or under a contract of personal service) by way of consultation, diagnosis and treatment, both medicinal and surgical, *would fall within the ambit of "service" as defined in section 2(1) (o) of the C.P. Act.*
2. The fact that dental practitioners belong to dental profession and are subject to disciplinary control of the Dental Council of India and, or the State Dental Councils *would not exclude the service rendered by them from the ambit of C.P. Act.*
3. The service rendered by a doctor was under a contract for personal service rather than a contract of personal service and was not covered by the exclusionary clause of the definition of service contained in the C.P.Act.
4. A service rendered free of charge to everybody would not be service as defined in the Act.
5. The hospitals and doctors cannot claim it to be a free service if the expenses have been borne by an insurance company under medical care or by one's employer under the service conditions.

DEFINITIONS

- *Complainant:* a consumer; or any voluntary consumer association registered under the Companies Act, 1956 (1 of 1956) or under any other law for the time being in force; or the Central Government or any State Government, one or more consumers, where there are numerous consumers having the same interest; in case of death of a consumer, his or her legal heir or representative; who or which makes a complaint;
- *Patient:* is defined as a person who hires or avails any service for a consideration which has been paid or promised or partly paid and partly promised or under a system of deferred payment or advance payment, when such services are availed of with the approval of the first mentioned person, includes those who mainly promise to pay and also the selective free patients, who do not pay anything.
- *Complaint:* A complaint is an allegation in writing made by a complainant, that is patient, that he or she has suffered loss or damage as a result of any deficiency in service.
- *Deficiency in service:* Any fault, imperfection, shortcoming or inadequacy in the quality, nature and manner of performance which is required to be maintained by or under any law for the time being in force or has been undertaken to be performed by a person in pursuance of a contract or otherwise in relation to any service. For the cause of the complaint, the patient must have suffered in any manner whatsoever, as a result of a deficiency in service.

Reasonable degree of care and skill: Means that degree of care and competence which an "ordinary competent member of profession who possess to have those skills would exercise in the same circumstances in question." When an injury occurs to the patient due to lack of skill or care from the dental surgeon which is irreparable the liability of the dental surgeon arises. The patient is liable for only those injuries, which are a consequence of a breach of dentist's duty.

CONSUMER REDRESSAL FORUMS AND COMMISSIONS

In India the CPA 1986 envisages three-tier grievance redressal mechanisms:

a. District Consumer Disputes Redressal Forum (DCDRF)
b. State Consumer Disputes Redressal Commission (SCDRC)
c. National Consumer Disputes Redressal Commission (NCDRC)

District Consumer Disputes Redressal Forum (District Forum):

- Established by State Government for each district.
- Headed by president and two members.
- Presently 569 district forums (DF) are functioning.

Jurisdiction

i. Pecuniary where compensation claimed not exceeding 20 lakh rupees
ii. Territorial where the cause of action arose

State Consumer Disputes Redressal Commission (SCDRC):

- Established by State Government.
- Headed by president and two members

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- Presently 32 State Commissions are functioning in the country.

Jurisdiction

i. Original jurisdiction: to hear original complaint. It includes pecuniary jurisdiction where compensation claimed exceeds Rs. 20 lakhs up to Rs. 1 crore.
ii. Appellate jurisdiction
iii. Supervisory jurisdiction: Over district forums

National Consumer Disputes Redressal Commission (NCDRC)

- Established by Central Govt., located in New Delhi Headed by president and five members.

Jurisdiction

i. Original Jurisdiction: Entertain complaints where compensation claimed for value of goods or services exceeds rupees one crore
ii. Appellate Jurisdiction
iii. Supervisory Jurisdiction: Over SCDRC
iv. Power of review.

AUTHORITIES FOR FILING COMPLAINTS BASED ON AMOUNTS OF COMPENSATION

Within 30 days from the date of decision, appeal can be filed in the higher commission (Table 27.2).

a. Appeal against the decision of the district forum can be filed before the state commission.
b. Appeal against the decision of the state commission can be filed before the national commission.
c. Appeal against the decision of the National commission can be filed before the Supreme Court.

Table 27.2 Filing of compensations claimed to the authorities

Maximum limit of compensation claimed (₹)	Authority with which the complaint is filed
1. Up to 20 lakhs	District consumer protection forum
2. 2 to 1 crore	State consumer protection commission
3. Exceeds rupees one crore	National consumer protection commission

POWERS OF CONSUMER REDRESSAL FORUMS AND COMMISSIONS

1. The summoning and enforcing the attendance of any defendant or witness and examining the witness on oath.
2. The discovery and production of any document or other material object producible as evidence.
3. The reception of evidence of affidavits.
4. The summoning of any expert evidence or testimony.
5. The requisitioning of the report of the concerned analysis or test from the appropriate laboratory or from any other relevant source.
6. Issuing of any commission for the examination of any witness.
7. Any other matter which may be prescribed.

Structure of consumer redressal forum and their jurisdictions: These deal with consumer grievances like (Fig. 27.1):

1. Deficiency in service
2. Defects in goods
3. Unfair trade practice.

WHO CAN SUE THE DOCTOR UNDER CPA?

1. Patient himself or herself
2. Registered consumer organizations
3. State or Central Government
4. The legal heir or legal representative.

AGAINST WHOM CAN A COMPLAINT BE FILED?

- All medical practitioners (medical, dental, others)
- All private or trust hospitals, NH (national health), polyclinics, government hospitals and doctors
- Laboratories, X-ray clinic

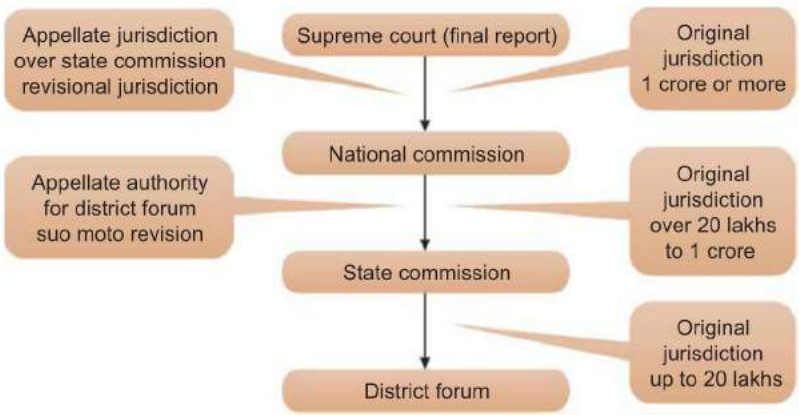


Figure 27.1 Structure of consumer redressal forum for a commission and their jurisdictions.

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- The nurses and paramedical staff
- Medical stores, pharmaceutical companies
- Quacks.

WHO ARE EXEMPTED?

- Free service—free service in a hospital; offering paid service to others is not exempted.
- Contract of service—vicarious liability.
- Government doctors working in free hospitals. Government hospitals charging a fee are liable. Free non-government hospitals and doctors are exempted.
- Emergency care in the interest of patient is exempted.

WHAT SHOULD YOU DO WHEN YOU RECEIVE A COMPLAINT?

If you receive a summons from a court of law or consumer forum, steps to be taken immediately are:

- Inform your insurance company at the earliest.
- Keep a photocopy of the papers and envelope, received and send the originals to the insurance company.
- Write a summary of the treatment using treatment record to refresh your memory and include all that you can remember.
- Make a photocopy of the complete records and lock the original at a safe place.
- Tell your staff about the suit and instruct them not to talk to anyone about the case without your permission.
- Cooperate with your insurance company.

Should do the following:

- Don't get upset.
- Tell your patient that you are insured.
- Agree to offer a settlement without consultation from your insurance company.
- Alter your patient's records.
- Agree to or offer a specialist fees without consulting your insurance company.
- Give your original treatment records to the patient or anyone except the court, if required. Preserve the photocopy in your record.
- Discuss about the patient's treatment with anyone, except the insurance company.
- Admit fault or guilt to anyone.
- Contact any other practitioner about the case.
- Agree to treat the patient plaintiff during the pendency of the case.

WHAT IS A COMPLAINT?

Sec 2 (C) of CPA—it is any allegation in writing made by the complainant that;

Sec 2(C) (i)—an unfair trade practice or restrictive trade practice has been adopted by the trader (in case of doctor—wrong representation about qualification or facilities available).

Sec 2(C) (ii)—services hired or availed of or agreed to be hired or availed by him or her suffer from deficiency in any respect.

(Service rendered by doctors, hospitals and their staff) Deficiency—Section 2(g) of CPA: It is any fault, imperfection, shortcomings or inadequacy in quality, nature and manner of performance, which is required to be maintained by or under any law for time being in force, or has been undertaken to be performed by a person in pursuance of contract or otherwise in relation to service.

Following allegations most frequently appear in complaints brought against members of the dental profession:

1. Slipping instruments
2. Broken needles
3. Root left in the socket without the knowledge of the patient
4. Flying fragments entering the respiratory passages
5. Injury in fitting or ill-fitting plates and dentures
6. Infection from use of unsterile instruments
7. Fracture and dislocations of jaw occurring during dental procedures
8. Extraction of wrong tooth or lack of consent
9. Failure to fulfil duty to advice patients of injury or condition such as fragment of broken needle and root or tooth remaining in tissues
10. Death from anaesthesia.

Actions not amounting to negligence:

1. Not accepting patients
2. Not attending on patients outside clinic timing
3. Collecting fees
4. Referring patients.

Common Causes for Filing Complaint

1. Doctor too busy to talk
2. Criticism of doctor by other doctor (bad professional ethics)
3. Pressure from others
4. To prevent happenings to others
5. To relieve guilt by blaming the doctor
6. For vengeance or money.

TIME LIMIT TO FILE A COMPLAINT

It is two years from the date of injury. If the patient is aware of certain facts regarding treatment then time starts from that point.

The time starts from the date of injury and not from the date of disability certificate. However, if the injury is continuous then the time starts from the date of last treatment given.

Major issue in complaint is negligence. Negligence is failure to take care resulting in injury. Elements of negligence include:

- Duty to care
- Violation of duty
- Resultant injury
- Injury should be linked to violation of duty.

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GUIDELINES TO BE ADOPTED TO AVOID NEEDLESS LITIGATIONS

1. Maintaining proper clinical records, documents of the treatment and diagnosis rendered to a patient.
2. Prescriptions given by the doctors should stick to the accepted norms of the medical practice.
3. Whenever certificates are issued, duplicates should be taken for any future reference.
4. Avoid any comments in front of the patient regarding the line of management adopted by your colleagues in a given situation.
5. Before any invasive/costly investigational or therapeutic procedures are to be undertaken, informed consent of the patient or the nearest relatives should be obtained.
6. Obtaining professional indemnity.
7. Continuous updating of recent developments.

CONSENT

According to section 13 of Indian Contract Act, 1872 the term "consent" is defined as "when two or more persons agree upon the same thing in the same sense." It is the legal issue that protects every patient's right not to be touched or in any way treated without the patient's authorization.

Types of Consents (Fig. 27.2)

1. Implied consent: The attitude of the patient towards seeking health care determines implied consent. The fact that the patient himself or herself comes to a doctor for ailment implies that he or she has given consent to general medical examination. This consent cannot be applied however, for more complex procedures than that of routine inspection, palpation, percussion, auscultation and sonography.
2. Expressed consent: expressed consent is either the oral or written consent. Expressed oral consent is obtained for relatively minor examinations or therapeutic procedures, preferably in the presence of an external third party. A written consent with the signature of the patient provides substantial evidence for a dental surgeon against any litigation. For all major diagnostic procedures, general anaesthesia, surgical operations and intimate examinations expressed written consent need to be obtained .

Informed consent: Informed consent is the process wherein the subject or the patient is given an opportunity to decide whether he or she is interested to participate in a study or in seeking health care. This means understanding by the patients of:

1. The nature of his or her condition
2. The nature of the proposed treatment or procedure
3. The alternative to such course or action
4. The risks involved in both the proposed and alternative procedure
5. The relative chances of success or failure of both procedures, so that the patient may accept or reject the procedure
6. If it is experimental, it should be stressed.

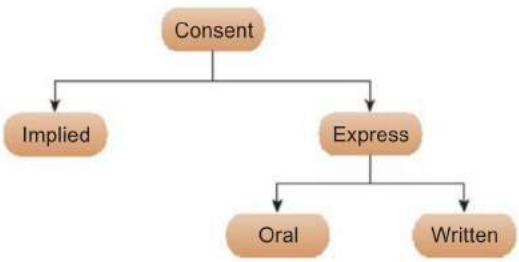


Figure 27.2 Consent: types.

Consent is invalid when:

1. Given by a person under 12 years
2. Given by a person of unsound mind
3. Given under fear of intimidation or intoxication or by other false means
4. Procedure for illegal surgical procedure.

Failure to obtain consent results in civil litigation (trespass, assault or battery) or even lead to criminal proceedings for common, aggravated or indecent assault.

How to Deal with Verbal Complaint

1. Listen
2. Understand his or her problem
3. Explain
4. Offer solutions
5. Politely decline unreasonable settlement.

Dealing with Notice

Reply through registered post with acknowledgement due/certificate of posting.

a. self
b. through lawyer.

Get yourself a trusted legal advisor.

- Review the case with your colleagues—preferably a medical professional with legal knowledge. If there is genuine negligence and you have a poor case—settle!
- Read—texts, journals and case reports.
- Work closely with your lawyer. He or she may not understand medical implications.
- Do not allow the lawyer to take complete control. Appeal only if you are confident.

How to Prevent?

- Know your rights
- More importantly know your duties
- Equip yourself with competence and confidence
- Be honest and treat your patient with dignity
- Explain procedures—be realistic
- Don't guarantee
- Get an informed consent—if you anticipate unpleasant consequences
- Charge nominally
- Maintain records
- Refer appropriately
- Do not sponsor litigation
- Encourage second opinion.

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SALIENT FEATURES OF CONSUMER COURTS

- Quasijudicial—one sitting or retired district judge and two lay members.
- It has the powers of a civil court and functions like one.
- Speedy justice avoids cumbersome procedures.
- Accepts expert opinions as affidavits.
- Summary trials—Res Ipsa Loquitar accepted.
- No Court Fees (changed with effect from 15/3/2003).
- No appeal fees (changed with effect from 15/3/2003).
- The court shall forward complaint to opposite party within 21 days.
- Opposite party replies within time given by court.
- Decision within 3 months (Act no 62 of 2002).
- Adjournment only with recorded reasons (Act no 62 of 2002) Appeal in 30 days to State Commission.
- Appeal in 30 days to National Commission.
- Appeal in 30 days to Supreme Court.

CONSUMER PROTECTION ACT AND PATIENTS

Advantages

1. Costly and time-consuming litigation is avoided by going to consumer courts.
2. These courts ensure a cheap and fairly quick remedy.

Disadvantages

1. The doctors will practice "defensive medicine," that is more referrals than may normally be required—this will make medicinal treatment more expensive.
2. Insurance premium for doctors and hospitals will shoot up. This will be passed on to the patient in terms of higher medical cost.
3. Patient–doctor relationship based on mutual trust and confidence will gradually disappear and a completely formal, contractual and antagonistic relationship might replace it.

CONSUMER PROTECTION ACT AND DOCTORS

Disadvantages

1. The doctor prescribes medicine or treatment on the basis of a personal judgment formed "at the time of examination." The situation might change shortly thereafter. It is difficult for lay people to judge all the cases.
2. Any unwillingness or negligence on the part of the patient may negate the efficacy of medicines or treatment prescribed.
3. As there are no court fees, many frivolous and vexatious cases may be filed against doctors. This may affect his or practice as also reputation even if the case is eventually dismissed, the complainant loses nothing.
4. Danger of professional blackmailers—trying to tarnish the good name of doctors or squeeze money out of them even when they are not to be blamed.

Penalty

Minimum 1 month and maximum 3 years imprisonment with fine not less than ₹ 2000 for failure to comply with orders of court.

Attachment of property. After 3 months, property can be sold to recover cash.

A maximum of Rs. 10,000 for frivolous or vexatious complaints—sponsored litigation.

LIMITATION OF CONSUMER FORUM

On many occasions national consumer redressal forum has observed that, if a consumer complaint pertaining to medical negligence is required to be adjudicated in the light of detailed evidence, not the consumer forum but a regular civil court is the proper forum.

- These courts languish because of inadequate facilities and funds from state governments and in some cases appointment of politicians or ill-qualified persons on the panel. These defects should be rectified.

How Can We Protect Ourselves?

- Indemnify yourself against litigation—insurance policy.
- Join a professional protection linked social security scheme (PPLS).
- Pressure your professional association to start PPLS. Adopt safe practices.
- Leave nobility out of the argument.
- Accept that the medical profession is a business—but with a difference.
- Highlight technical complexity and humanitarian benefits.
- Accept CPA with an insistence that there should have been a medical person in the forum.

CONCLUSION

Law should not be a source of fear or an obstruction in the delivery of professional services. The profession should take an inward look and correct malpractices and distortions which have given a negative image to a noble profession. Professionals should inculcate in their behaviour and minds that the professions are for the service of the people and not professionals. Answer to all the problems lies in the strict self-control and standardization of professional care. Dental and medical councils should exercise their powers more vigilantly and strictly so that the lost prestige of the noble profession can be gradually restored. These councils should help in structuring law and legal processes, primarily for the service of the society and secondarily to the advantage of the professionals.

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REVIEW QUESTIONS

1. Write short notes on:
   a. Consumer Protection Act
   b. Types of consent
   c. Informed consent
   d. Doctor–patient relationship
   e. Contract law
   f. Negligence and malpractice
   g. Importance of dental records
   h. COPRA

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28 Forensic Odontology

Pushpanjali K

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INTRODUCTION

Astute dental clinicians, anthropologists, archaeologists and palaeontologists have used the shape and condition of human teeth to identify age, sex and lifestyles for many hundreds of years. Detailed patient dental records and accompanying radiographs became remarkably useful in forensic dentistry soon after the discovery of X-rays in the beginning of the 20th century. Throughout this century, odontological examinations have been a critical determinant in the search for identity of individual human remains.

The most reliable means of identification include: fingerprints, dental comparisons and biological methods such as DNA profiling. A high degree of reliability can be achieved by dental examination and comparisons between antemortem and postmortem dental records and radiographs. Dental examination and comparisons between antemortem and postmortem dental records and radiographs produce results with a high degree of reliability and relative simplicity.

Assuming that reasonably complete and accurate antemortem records can be obtained, comparisons with postmortem evidence usually are used when fingerprints are unavailable. Because dentition has a high resistance to postmortem breakdown, sufficient dental evidence often can be obtained in cases of severe decomposition or incineration. Though soft tissues and skeletal tissues are destroyed by decay or incineration, teeth will survive intact for a long time in view of the nature of teeth which can endure the temperature of 1600°C without loss of microstructure. Teeth are the most durable organs in the body and can be heated to temperatures of 1600°C without appreciable loss of microstructure. Teeth can survive virtually intact long after other soft tissue and skeletal tissues have been destroyed by decay or incineration.

In spite of medical breakthroughs and developments in modern technology, the criminal activities are increasing in large scale in the society shattering the lives of victims and families. Though the law takes its own course to prosecute the perpetrators, and maintain law and order, the difficulty in apprehending the culprits still exists and it is the speciality of forensic odontology which plays a significant role in identifying the criminals. As we enter a new millennium, society is faced with fresh challenges in every conceivable area. Despite leaps in modern technology, medical breakthroughs and the geographical changes that the last century has brought, crime still persists in all aspects of our lives. Violent and heinous activities that shatter the lives of victims, their friends and families occur everyday. Often little can be done to repair such damage. The apprehension and subsequent prosecution of the perpetrator(s) is essential to maintain law and order. Through the specialty of forensic odontology, dentistry plays a small but significant role in this process.

Forensic science helps us in determining the identity of a corpse to a large extent. Identification through forensic science is the art of giving a corpse a name, a real-life detective work that would put even Sherlok Holmes to shame.

Dr. Oscar Amedo is generally recognized as the father of forensic odontology who in 1898 has written the first treatise on forensic odontology. The first treatise on forensic odontology as a subject in its own right was written in 1898 by Dr Oscar Amedo, who is generally recognized as the father of forensic odontology.

The increase in crime, accidents, mass disasters, identification of the criminal or culprit, and the victim is of paramount importance from a social, emotional and legal viewpoint. Though forensic medicine is by and large involved in the above, identification by dental records is also possible.

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This branch can be called forensic dentistry or odontology and can be best defined as the science of dentistry as related to the law. In this process dental records that can be used are tooth, arch shape, saliva, bite-marks by which age, sex and person-identification can be made accurately.

Forensic dentistry involves the processing, review, evaluation and presentation of dental evidence to contribute scientific and objective data in legal processes. It requires knowledge pertaining to a number of disciplines, since the dental records obtained can identify an individual or afford the information needed by the authorities to establish neglect, fraud or abuse. Dental identification can have three different applications:

(a) Antemortem and postmortem records of an individual are compared in order to assess if the records belong to same person; comparative identification, in which the postmortem dental records are compared with the antemortem records of an individual in order to establish whether both records correspond to the same person.
(b) In case of lack of data to identify a subject, dental information helps in narrowing the search of the individual; obtaining dental information to narrow the search for an individual when the antemortem records are not available and there are no possible data referring to the identity of the subject.
(c) Identification of victims following mass disasters or catastrophes.

To determine whether records correspond to the individual, comparisons have been made between postmortem dental records and the antemortem (living) records (presence of dental fillings, endodontic treatments, crowns or bridges, radiological studies to verify the clinical findings, the presence of malocclusions or dental fractures, etc.). Traditionally, comparisons have been made between postmortem dental records and the antemortem (living) records to determine whether both records correspond to the same individual.

The enamel and dentin layer isolate the pulp cavity from the exterior, thereby affording a valuable source of DNA. To analyse the DNA contained in pulpal tissue a number of identification techniques are used by forensic dentists, including rugoscopy, cheiloscopy (lip prints), the obtainment of imprints, or the use of molecular techniques such as polymerase chain reaction (PCR). The enamel and dentin layer isolate the pulp cavity from the exterior, thereby affording a valuable source of DNA. A number of identification techniques are used by forensic dentists, including rugoscopy, cheiloscopy (lip prints), the obtainment of imprints, or the use of molecular techniques such as polymerase chain reaction (PCR) for analysing the DNA contained in dental pulp tissue.

Major crimes can be solved by means of forensic odontology which helps in identification of individuals who otherwise cannot be identified visually and the accuracy is ensured owing to the unique nature of dental anatomy. Forensic dentistry plays a major role in the identification of those individuals who cannot be identified visually or by other means and helps in solving major crimes. The unique nature of our dental anatomy and the placement of custom restorations ensure accuracy when the techniques are correctly employed.

HISTORY

Though this particular science has been given importance recently, on the contrary, teeth have been used for identification for more than 2000 years.

One of the earliest known "authentic" cases of the application of dental information leading to the identification of an individual was that of Lollia Paullina in the year AD 49, she was the second wife of Claudius, the Emperor of Rome and was identified by her teeth which had certain distinctive characteristics.

An 80-year-old English warrior John Talbot, Earl of Shrewsbury, who fell in the battle of Castillon in 1453 was the first reported case of dental identification.The first formally reported case of dental identification was that of the 80-year-old English warrior John Talbot, Earl of Shrewsbury, who fell in the battle of Castillon in 1453. The scientific employment of dental evidence in identification of individuals began only in the 17th century with the solving of a case of disputed identity by a dentist, Paul Revere.

1. Earliest recorded case is identification of a female associated with the emperor Nero by the unique arrangement of her teeth.
2. Body of major general Joseph Warren after exoneration was identified positively by a dentist Paul Revere.
3. 1850: Dr George Parkman, a physician was identified through dental evidence, that is by a partial denture and portion of the jaw which was incinerated and then disposed in privacy.

1897: After a mass disaster by fire, dental identification was used.

1692: Bite marks evidences were used to prove guilt of Reverend George Burroughs who solicited young women into witchcraft.

1870: Bite marks were used to prove guilt of Mr Robenson by bite marks on the body of victims and model of his teeth.

Examples of postmortem identification of "famous" individual by their dentition include that of Hitler whose remains were recovered from a bunker at the end of World War II, and General Zia ul Haque, the former President of Pakistan who died in an air crash in 1988. A famous Indian case relates to the identification of the mutilated body of Raja Jai Chandra Rathor of Kanouj, recovered from battlefield in 1193.

The recent one is the identification of mutilated body of Rajiv Gandhi, former Prime Minister of India.

We had one case which was referred to Govternment Dental College, Bangalore where the culprit was identified by the model of his teeth which matched to the bite marks on the victim's body.

COMMON REASONS FOR IDENTIFICATION OF FOUND HUMAN REMAINS

- **Criminal:** Victim should be identified first to begin criminal investigation. Typically an investigation to a

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criminal death cannot begin until the victim has been positively identified
- **Marriage:** In certain religion people cannot remarry unless their spouses are confirmed dead. Individuals from many religious backgrounds cannot remarry unless their partners are confirmed deceased
- **Monetary:** Normally the family pension and other benefits like life insurance are given only on confirmation of the death of policy holder. The payment of pensions, life insurance and other benefits relies upon positive confirmation of death
- **Burial:** In certain religions it is mandatory to identify the dead body before burial in specified sites. Many religions require that a positive identification is made prior to burial in geographical sites
- **Social:** Identification of the body in a society is of utmost importance in order to preserve the human rights and dignity after death. Society's duty to preserve human rights and dignity beyond life begins with the basic premise of an identity.
- **Mass disasters:** To identify the victims in situations like floods, train accidents, air crash, earthquakes, etc.
- **Closure:** The identification of individuals missing for prolonged periods can bring relief to family members.

PRINCIPLES OF DENTAL IDENTIFICATION

Forensic Dental Consultation

Forensic odontologist acts as a consultant to medical examiner or coroner in the determination of identity of a deceased individual. Depending on each situation, he or she may be accountable to perform a complete postmortem examination and confirmation with antemortem records, or he or she may be asked to do only a portion of the examination and confirmation process.

Phases of Identification Process

The dentist proceeds in an orderly, stepwise fashion to ensure accuracy and a comprehensive consultation. In sequence, the steps of this process are:

a. Preliminary evaluation
b. Postmortem examination
c. Antemortem investigation and data collection
d. Comparison and conclusion.

Though there are many categories of identification used by dentists, the most commonly used is that of the standardized levels and terminology by American Board of Forensic Odontology.

- **Positive identification:** There is a sufficient match between antemortem and postmortem data to establish that they are from the same individual. There are no explained discrepancies.
- **Possible identification:** There are consistent features between antemortem and postmortem data, but because of poor quality records or missing postmortem information, a positive identification cannot be established.
- **Insufficient evidence:** The information available is not adequate to make a reasonable conclusion.
- **Exclusion:** There are clear (unexplainable) inconsistencies between the antemortem and postmortem data.

Forensic odontology can be used to identify the criminal and the victims. The records that can be used are: (i) antemortem and (ii) postmortem.

Identification of human remains by dental characteristics is a well-established component of forensic science with a definite scientific basis.

Bite Marks

Debate is still on among forensic dentists as to whether the dentition or behaviour of the human skin in response to biting action is unique for identification of the culprit. Consensus is currently lacking among forensic dentists as to whether the dentition or behaviour of the human skin in response to biting action is characteristic, individual and unique.

In case of sexual assault the bite marks are commonly found in breasts and legs of females whereas in males they are found on arms and shoulders. Human bite ranges between 25–40 mm in diameter and can be found on any part of the body. Human bite marks can be found on practically any part of the body. While in females human bites are more commonly found on the breasts and legs secondary to sexual assault, in males bite marks are mainly found on the arms and shoulders. The diameter of the human bite typically varies between 25-40 mm. Bite injuries are frequently seen in circumstances of rape and skirmishes between young children (Fig. 28.1). A central contusion zone is normally observed within the teeth marks.

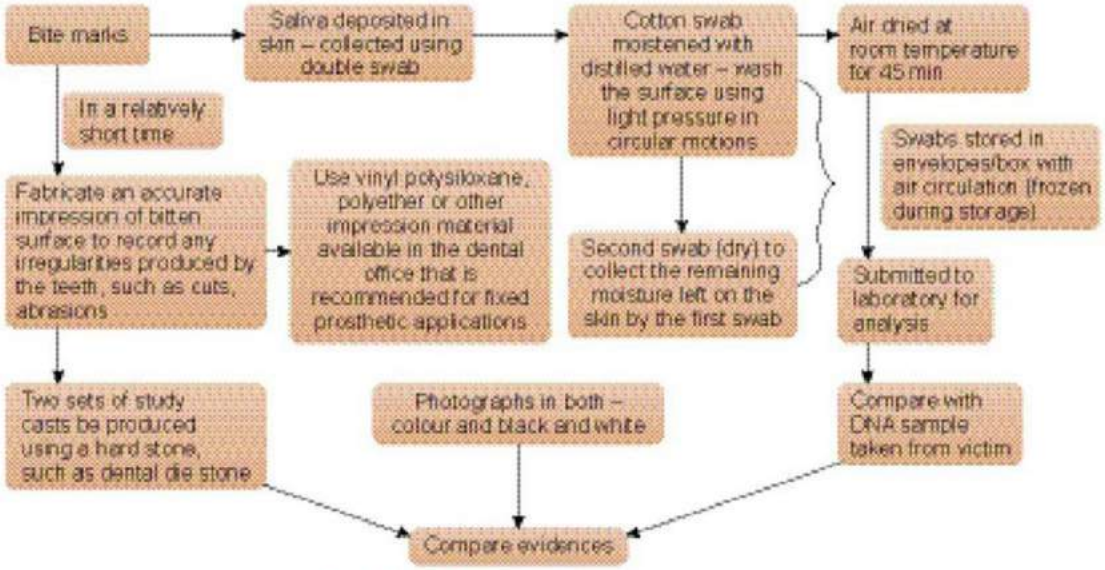
Without documenting the individual bites it is practically not possible to positively identify the suspect. Certain significant dental features are fractures, dental rotations, attrition and wear, congenital malformations, etc. The documentation process should commence immediately of the actual bite as physical and biological findings deteriorate quickly. The individual bite characteristics must be documented in order to positively identify the suspect. Certain important dental features can include fractures, dental rotations, attrition and wear, congenital malformations, etc. The physical and biological findings deteriorate from the moment of the actual bite, and therefore should be documented as quickly as possible.



Figure 28.1 Bite marks.

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Methodology (Flowchart 28.1)



Flowchart 28.1 Methodology of bite marks.

Age Estimation

Age estimation of the victim or remains is important to sort out the legal issues. Methods utilized for determination of age from dentition include: (i) visual or clinical method, (ii) radiographic examination and (iii) histological and biochemical methods.

Authors like Gustafson, Cameron, Soplur, Harvey, Dayal have given various assessment methods:

Visual and clinical methods

a. *Eruption of teeth*
   i. Time of eruption: Simple tool for age estimation based on the time of eruption of permanent teeth is kusris triangle.
   ii. Stages of eruption.
b. *Spacing between deciduous teeth:* Gustafson has quoted that by about 4 years there is usually spacing between the deciduous teeth with some exception. A negative finding did not necessarily mean an age below four. On the other hand, a positive finding usually implies an age above four.
c. *Tooth count:* Tooth count can be applied at ages when emergence would be expected.

Radiologic and histologic methods. Sopher estimated the age by previous methods by grouping them as:

a. Sound knowledge of the development of tooth organs and the formation of enamel and dentin, bud, cap, bell is a prerequisite. Neonatal line, calcification, incremental lines are observed for the above.
b. Residual growth of the second molar root structures and the third molar development through apical closure. Charts given by Masselr and Schour show progressive stages of dental development.

Third molar development can also be used for age estimation owing to its unusual characteristics in formation timings as it tends to continue over a long period.

Histological and biochemical methods

a. Fluorescence from dentin and cementum
b. Dental root translucency increases with advancing age
c. Para-radicular cementum deposition (as a criterion for age estimation in human beings).

Other methods of age estimation. Tooth colour, number of dentinal tubules (number of dentinal tubules decreases with increasing age).

Chemical methods: Racemisation of aspartic acid (amino acid) in enamel, dentin and cementum by liquid or gas chromatography is to estimate D/L (dextro/laevo) ratio of aspartic acid which correlates with age.

Age determination of an individual using noninvasive methods was first published by Gustafson in 1950 based on Six criteria related to the changes in hard dental tissue with the progress in age. They are: occlusal wear, secondary and tertiary dentin layers, cement thickness, the extent of root resorption, the length of the root transparency and the height of gingival attachment. Gustafson assigned a score of 0–3 to all these factors (according to intensity). Lamendin et al. in turn devised a technique to estimate the age of an adult using single-root teeth. This system involved the measurement of two parameters related to age: gingival recession and root transparency (a phenomenon not seen before 20 years of age, and which is due to the formation of hydroxyapatite deposits within the dentinal tubules). These authors measured the maximum length of the transparency on the vestibular surface of the root, which is where the phe-

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nomenon is most obvious. This technique showed significantly lower error when compared to Gustafson (8.9±2.2 and 14.2±3.4 years, respectively). Another method for estimating dental age is based on the superposition of dental cement layers, whereby the chronological age of the individual is related to the number of deposited cement layers and to the age of eruption of the tooth. Condon et al, based on the analysis of 80 teeth corresponding to individuals of known age, established a correlation rate between true age and estimated age of 78%. The teeth with their different development stages offer a noninvasive method for determining the age of an individual. In the year 1950, Gustafson was the first to publish a method for estimating the age of a person from the teeth, based on six criteria related to hard dental tissue changes that progress with advancing age: occlusal wear, secondary and tertiary dentin layers, cement thickness, the extent of root resorption, the length of the root transparency and the height of gingival attachment. Gustafson assigned a score of 0–3 to all these factors (according to intensity) – the results being subjective, however, since the scores were not included in an integrating scale. Lamendin et al. in turn established a technique for estimating the age of an adult using single-root teeth. This system involved the measurement of two parameters related to age: gingival recession and root transparency (a phenomenon not seen before 20 years of age, and which is due to the formation of hydroxyapatite deposits within the dentinal tubules). These authors measured the maximum length of the transparency on the vestibular surface of the root, which is where the phenomenon is most apparent. The mean error associated with this technique is significantly lower than in the case of the method developed by Gustafson (8.9±2.2 and 14.2±3.4 years, respectively). Another method for estimating dental age is based on the superposition of dental cement layers, whereby the chronological age of the individual is related to the number of deposited cement layers and to the age of eruption of the tooth. Condon et al, based on the analysis of 80 teeth corresponding to individuals of known age, established a correlation rate between true age and estimated age of 78%, with standard errors according to dental class of between 4.7 and 9.7 years. Czermak et al. facilitated the search for the best location to calculate the cement layers at microscopic level, based on the software-mediated obtainment of images – thereby reducing the human error factor associated with subjectiveness and fatigue.

Dental age estimation of an individual was studied by Mohite et al. based on the radiological and histological changes that take place in mandibular bone. Radiologically, with mental foramen as reference, the mandibular ramus was seen to increase in length with advancing age. However this process was more gradual beyond 50 years of age with a decrease in the alveolar process as measured in the craniocaudal direction. With advancing age there was a decrease in osteoblastic activity with expansion of the Haversian canal system secondary to increased remodeling within the osteons which led to the increased porosity of the cortical bone. Beyond 50 years of age the number of concentric laminas per osteon decreases Mohite, et al. studied the radiological and histological changes that take place in mandibular bone with the purpose of estimating the dental age of the individual. Radiologically, and taking the mental foramen as reference, the mandibular ramus was seen to increase in length with advancing age – this process being more gradual after 50 years of age – with a decrease in the alveolar process as measured in the craniocaudal direction. Osteoblastic activity was found to decrease with advancing age, with expansion of the Haversian canal system secondary to increased remodeling within the osteons – this giving rise to increased porosity of the cortical bone. The number of concentric laminas per osteon decreases with age, particularly after 50 years of age.

Rugoscopy and Cheiloscopy

Rugoscopy is an identification technique based on the study and analysis of the number, shape, length, direction and merging pattern of the palatal ridges or rugae (rugosities). Table 28.1 shows the rugae classification proposed by Lysell and posteriorly modified by Thomas and Kotze.

The palatal rugae are anatomical ridges, wrinkles or folds located on the anterior portion of the palate, immediately posterior to the upper anterior teeth and the incisive papilla, on either side of the midline. As compared to finger prints palatal rugae are studied for identification of individual as the rugae are present for life starting from 3rd month of intrauterine development and are unique to each individual (including twins). They are hardly affected by decomposition and incineration and are well protected by lips, teeth, Bichat's fat pad and maxillary bones. The fact that the rugae are present for life, starting from the 3rd month of intrauterine development; are unique to each individual (including twins) and are relatively well protected by the lips, teeth, Bichat's fat pad and the maxillary bones implies that they are less affected by decomposition and incineration. As a result, the palatal rugae are studied as a method of identification, comparable to the finger prints of the individual.

According to Ohtani et al., three situations complicate identification based on the palatal rugae: changes in rugae height, the presence of flat or poorly accentuated ridges and the absence of uncomplicated patterns. However other elements such as the incisive papilla, the shape of the mid-palatal raphe and the palatal tori, where present can supplement the study of the palatal rugae. Nevertheless, other elements can supplement the study of the palatal rugae, such as the incisive papilla,

Table 28.1 Palatal rugae classification of Thomas and Kotze

Criterion	Criterion
Length	**Shape**
Primary rugae:	Fragmented: less than 3 mm
A. 5–10 mm	Curvy
B. 10 mm or more	Wavy
Secondary rugae: 3–5 mm	Straight
	Circular

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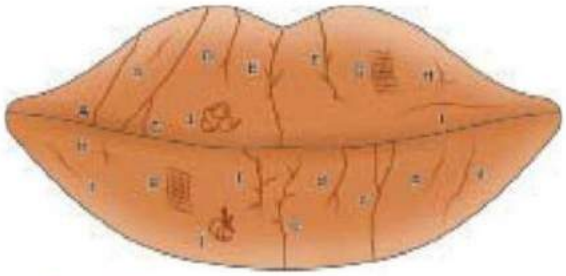


Figure 28.2 Lip print classification of Renaud.

the shape of the mid-palatal raphe and the palatal tori, where present.

Cheiloscopy involves the study of a series of elevations and depressions that form a characteristic pattern on the lips known as lip prints. Lip prints are unique to each individual (except monozygous twins) and are permanent and constant like finger prints. Renaud describes 10 types of lip prints (Fig. 28.2) designated by letters from A to J – capital letters being applied to the upper lip and lowercase letters to the lower lip.In the same way as the finger prints, the lip prints are permanent and constant, and are therefore unique to each individual (except monozygous twins). A number of lip print classifications have been developed, such as that published by Renaud , which describes 10 types of lip prints (Fig. 28.2) designated by letters from A to J – capital letters being applied to the upper lip and lowercase letters to the lower lip.

Sex Determination

Sex chromosomes are known to have a direct effect on tooth size, shape, contour and time of eruption. DNA from coronal pulp chamber, radicular canals is used for sex determination.

Approaches to sampling dental source DNA

1. Crushing entire tooth
2. Conventional endodontic access
3. Vertical split
4. Horizontal sections.

There is a slight difference in the major protein of the human enamel in male and female (amelogenin or AMEL) and in males the AMEL is located on Y chromosome. Recent scientific advances show that the major protein found in human enamel (amelogenin or AMEL) has a slightly different signature (or size and pattern of nucleotide sequence) in male and female enamel.The AMEL gene that encodes for the male amelogenin is located on the Y chromosome. The female has two identical AMEL genes or alleles, whereas the male has two different AMEL genes (i.e. the female and the male AMEL genes).

Polymerase chain reaction (PCR) methodology enables amplifications of very fine amount of DNA to concentrations suitable for diagnostic analysis. This is called DNA typing, and a sample as small as 20–70 picogram (picogram – 1/100,000,000 gram) of target genomic DNA is sufficient to perform highly reliable forensic DNA typing.

Gender identification can be made by palatal rugae which is demonstrated in studies conducted by Thomas and Kotze and Kapali et al where they observed that in females convergent rugae is common where as in males its in the form of circular ridges, besides the length and number of rugae. The palatal rugae of an individual can be regarded as a complement in the identification of gender. A study based on the methods of Thomas and Kotze and Kapali et al. analysed the number, length, shape and merging pattern of the palatal rugosities, and found convergent rugae to be more common in females and circular ridge morphologies to be more frequent in males. Gender differences were also observed in terms of the number and length of the rugae.

Gender identification can also be done with the help of lip print morphology which has shown that vertical or intersection-shaped lip print pattern are more common in females whereas in males they are ramified or reticular in pattern. Lip print morphology can also help in the determination of gender. In this context, females more often present a vertical or intersection-shaped lip print pattern, while ramified or reticular lip print patterns are more frequent in males.

Sex Determination Using Pulp

Pulpal tissue can be used in sex determination based on the presence or absence of X chromosome. In females Barr body is usually found lying against the nuclear membrane. Pulpal tissue for sex determination of cadavers can be possible up to 4 weeks. Teeth are excellent source of genetic material especially non-restored teeth which helps for DNA analysis. Posterior teeth are preferred over anterior teeth. For DNA analysis enough material can be yielded by cryogenic grinding of pulverized teeth under sterile conditions in the presence of liquid nitrogen. The remnants of human dental tissues, buried mummies and well preserved fossils normally contain small amounts of DNA which could be amplified by PCR to concentrations suitable for diagnostic analysis. The sex determination from pulpal tissue depends on the presence or absence of X-chromosome. Barr body is an intranuclear mass usually lying against the nuclear membrane in the females. Sex determination from human tooth pulp in cadavers is possible up to a period of 4 weeks. But teeth can also serve as an excellent source of genetic material. Non-restored teeth are more appropriate for DNA analysis than restored teeth. Molars are preferred over anterior teeth. Small amounts of DNA are relatively well-preserved in fossils, buried mummies and various remnants of human dental tissues. The procedure consists of cryogenic grinding of pulverized teeth under sterile conditions and in the presence of liquid nitrogen can yield enough material for DNA analysis. PCR enables the amplification of very tiny amounts of DNA to concentrations suitable for diagnostic analyses.

Race Identification

Anthropologists have divided race into following broad groups: (i) Caucasoid—Fig. 28.3, (ii) Negroid—Fig. 28.4, (iii) Mongoloid—Fig. 28.5, (iv) Eskimos, (v) American Indians and (vi) Orientals.

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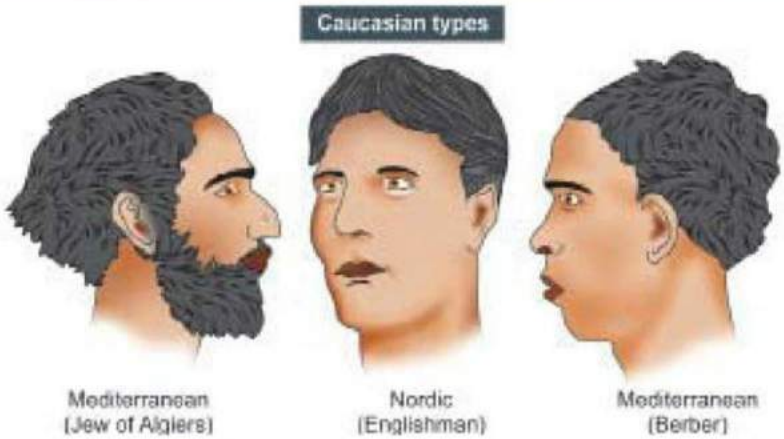


Figure 28.3 Racial identification: caucasoid race.

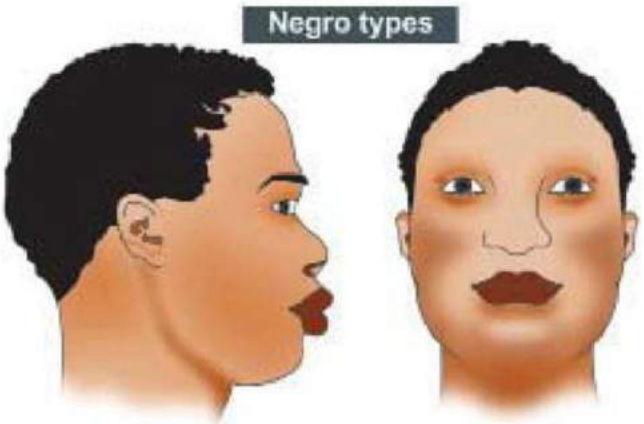


Figure 28.4 Negroid race.

Size of teeth. Both deciduous and permanent dentitions are considered. It is shown that size of teeth varies in different races:

- Smaller teeth is seen in Yemenites, Filipinos and Indian Jats.
- Larger teeth is seen in Melanesians (Nasioe), Australian Aborigines, South American Indian tribes.
- Intermediate sized teeth are seen in Taiwanese Aborigines and Australian whites respectively.
- Lateral incisor is relatively large compared to central incisor in Mongoloids.

Nonmetric Dental Traits

Nonmetric dental traits include Carabelli trait, cusp 6 and 7, protostylids, shovel-shaped incisors, cusp number and groove and pattern of molars. Mitochondrial DNA represents 0.5% of total DNA and it survives longer than chromosomal DNA. It is the best way to test relatedness between ancestors and living descendants which is inherited from maternal line.

Sex Determination Using Pulp

Using the pulp tissue sex can be determined by fluorescence.

Skull. Male skulls (Fig. 28.6) can be identified by their prominent temporal lines, mastoid process, nuchal lines, external occipital protuberance, supercilliary arches and ridges; all these are smoother in females. The anatomical differences at skull base level between males and females can also be of help. In the case of females the cranium is softer contoured with smaller bone crests and protruberanceas compared to male cranium which is heavier, thicker and large. Dentition in males are larger than that of females besides the mandible having a square shape as compared to females who tend to have pointed chin.

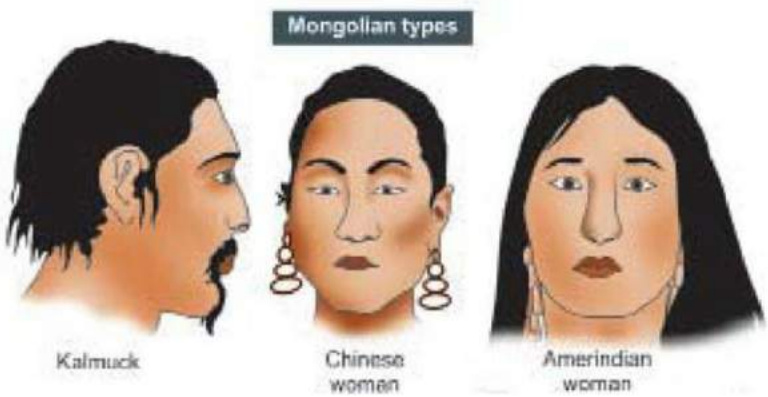


Figure 28.5 Mongoloid race.

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Figure 28.6 Male skull.

In males in extreme cases the are a around gonial angle is flared whereas in females the gonial angle is smooth and not projected.

Palatal dimensions. Race and sex of unknown individuals can be predicted from fragmentary craniofacial remains.

Carabelli trait. This appears on the lingual surface of the mesiolingual cusp of maxillary molar teeth, particularly deciduous second molar and permanent first molar, expression of the character ranges from pits and grooves to protuberances and free cusps (Fig. 28.7).

Shovel-shaped incisors. This trait is a combination of elevated marginal ridges enclosing a central fossa and concave lingual surface in the upper central incisors.

Cusp 6 and cusp 7. These accessory cusps have been reported to be present on mandibular deciduous second molars and permanent mandibular molars.

The 6th accessory cusp occurs on the distal marginal ridge between the distal and distolingual cusps. The seventh accessory cusp is located in the lingual surface between the mesiolingual and distolingual cusps.

Australian aborigines, Polynesians and Melanesians tend to show high frequency of cusp 6.

Supernumerary cusps were a frequent finding in Eskimos, and many lower premolars in Negros have 3 cusps.

Protostylid. It appears as a pit, furrow and cusp of varying sizes on the buccal surface of the mesiobuccal cusp of mandibular molars. This trait is common in women in Peruvian and Pima Indians, but rare in Canadian whites.

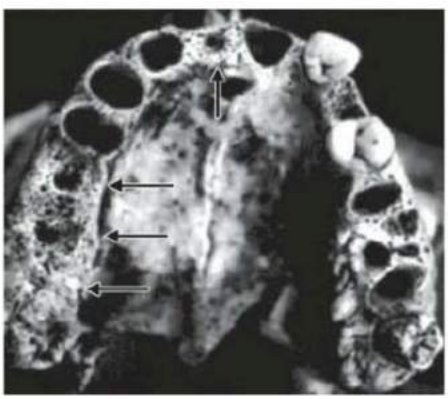


Figure 28.7 Carabelli trait.

Other features

- Leong's premolar and dens evaginatus is an accessory cusp seen on the mandibular premolars between buccal and lingual cusps, found mostly in people of mongoloid ancestory
- South Africans have larger teeth than Europeans with first premolar frequently having two and sometimes three distinct well-formed roots.
- Three rooted molars occur frequently in the Chinese, and average tooth size is larger than that of Europeans.
- Missing lower incisors and third molars, frequently impacted third molars with five or more cusps are reported in Chinese.
- Peg-shaped lateral incisors are common in western Europeans, and bulky cingulum on upper incisors are characteristics of central Europeans.

Jaw Relations

An edge to edge relationship is frequently found in Australian aborigines, South Africans and Maoris. Good occlusion is common among Tristans and bimaxillary prognathism is a common feature in Kerala.

Geographic Factors

Fluorosis, dental caries, type of dental restorations can aid in identifying a person's location.

Morphological Characteristics Other than Teeth

These are tori, arch dimensions, palatal shape and dimensions, mandibular arch dimensions, palatal rugae. Tori commonly occurs in Alexls, Australian aborigines, Icelander, Norwegian Lapps, Tristans, Maoris. It is very rare in Negroes and Melanesians.

Postmortem Dental Evidence

Anatomic dental charts, photographs, radiographs, models, tape recordings and/or descriptions can be used for postmortem dental examinations. With this the record should also include case numbers, date/time, jurisdiction/authority/location, putative ID, body description, approximate age, race, gender, jaw fragments description, general description and condition of remains (Fig. 28.8).

Engraving on fixed restorations that is metal crowns and fixed partial dentures using electrical engraver is very cost effective and greatly reduces the possibility of an inaccurate identification.

Dental examinations. Universal tooth numbering system should be used. It should include any missing dental structures, jaw fragments, restorations, erosions or any other features like with alignment, occlusion, status, type of dentition, etc. (Fig. 28.9).

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Figure 28.8 Postmortem dental evidence.

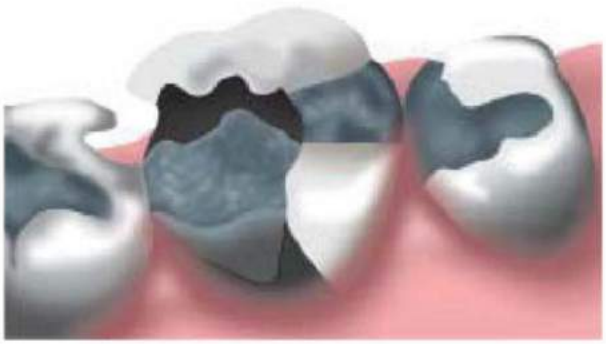


Figure 28.9 Postmortem—dental remnants.

Impressions should be made whenever necessary. Postmortem radiographs must be used as the prime methods of identification.

Antemortem Data

Antemortem data include dental radiographs, written records, models and photographs. If possible original radiographs should be obtained for comparison purposes.

Records can be located by following sources: hospitals, others health care facilities, dental insurance carriers, public and insurance administrator, prisons or penal institutions.

Other sources can be family, friends, coworkers, prior military service and prior judicial detection if any.

Comparison of Antemortem and Postmortem Evidences

Identification from dental prosthesis: Full dentures correlation with anatomical structure, and sometimes labelling of the denture.

Requirements for Marking a Prosthesis for Identification

1. The strength of prosthesis should be maintained
2. It should not be costly and difficult to achieve
3. The identification system must be effective
4. The markings should be long-lasting, visible and should be able to withstand humidity and fire
5. Radiopaque label should be used.

Methods

Engrave (using bur): This includes metal foil matrix band placed beneath tissue surface of a denture. *Partial denture.* These offer more information than complete denture because of variable designs.

Radiographic Identification (Fig. 28.10)

The two most important recording techniques available are radiology and photography. The single most accurate and reliable source by which remains can be identified is comparison of antemortem and postmortem radiographs. Radiological evaluation of the bones is extremely valuable for positive identification and comparison. Distinctive shapes of restorations, bases under restorations, tooth and root shapes, endodontic treatment and maxillary sinuses can be identified only by examination of radiographs.

Photographic Identification

Photograph is an important adjuvant which along with other records enhances and completes the file of a case (Fig. 28.11).



Figure 28.10 Postmortem—radiographic identification.



Figure 28.11 Photographic identification.

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Advantages

- Accuracy and reliability are widely accepted
- Clear and comprehensible
- Relationship of size and shape can often be depicted
- Even a minute detail can be rapidly recorded and studied later at length and as verifiable evidence.

Ultraviolet Photography

The structures that are not normally seen with the naked eye is revealed by UV light. The complete photographic examinations may utilize white light, fluorescence techniques and direct UV techniques which record primarily absorption and reflection.

Suggested photographs

1. In situ full body photographs
2. Full face and profile photographs
3. Photographs of anterior teeth
4. Photographs of resected jaw specimens or skeletonised jaws
5. Photographs of antemortem radiographs.

Mass Disaster Identification

Mass disasters can be natural, accidental or criminal, for example hurricanes, earthquakes, floods, typhoons, mud slides, transportation mishaps, aircraft accidents, fires, volcanic eruptions, industrial accidents, terrorists acts and armed conflicts (Fig. 28.12). During such situation a forensic dentist is often called to assist the pathologist in identification, especially when physical features are destroyed beyond recognition. The teeth are heavily calcified, resists fire and are strong enough to resist severe trauma.

It is very important to identify these victims for legal, social and forensic reasons.

It is a part of the law of most civilized countries that a body should be identified whenever possible before being disposed.

The response to a disaster may differ with respect to jurisdiction throughout the world. Society, religion, government structure, laws and resources are some of the response determining factors.



Figure 28.12 Mass disaster identification.

Identification is essential and allows remaining family members to go through the grieving process, to settle business, personal, legal, insurance affairs, etc.

Use of Dental DNA for Identification

As mentioned earlier, in teeth DNA is found in pulp tissue dentin, cement, periodontal ligament and alveolar bone. Pulp tissue is an excellent source of DNA as the hard tissues of the teeth are resistant to environmental actions such as decomposition or trauma, incineration, etc. The oral cavity is a useful source of DNA. The latter is obtained from saliva, the oral mucosal cells and the teeth. The main DNA source is blood, though in some situations this type of sample is not available for analysis. In teeth, DNA is found in the pulp tissue, dentin, cement, periodontal ligament and alveolar bone. Due to the resistance of the hard tissues of the teeth to environmental actions such as incineration, immersion, trauma or decomposition, pulp tissue is an excellent source of DNA. The pulp tissue samples are collected in three ways: crushing, horizontal or vertical tooth sectioning and through an endodontic access.

Though no standardized protocols have been established so far, a number of methods are available for forensic odontologist to extract DNA from biological samples. They normally use dentin or cementum for DNA extraction though pulp tissue is easier to prepare and analyse. This is because the analysed tooth may be contaminated by micro organisms or by nonhuman DNA or may have been endodontically obturated or lacks pulpal tissue. Pulp tissue is easier to prepare and analyse than other sources. However, in many cases the analysed tooth lacks pulp tissue or may have been endodontically obturated. It also may be contaminated by microorganisms or by nonhuman DNA. In such cases dentin or cement is used for DNA extraction. Forensic dentists should incorporate these new technologies, since a number of methods are available for the extraction of DNA from biological samples, though no standardized protocols for their use have been established to date.

DNA fingerprinting can be applied to establish paternity for personal reasons, in affiliation, wardship or divorce proceedings, in any type of disputes and in provision to immigration authorities of clear evidence of a family relationship (Fig. 28.12A, B).

Child Abuse

Child abuse is defined as any nonaccidental trauma inflicted upon a child by a care taker. Orofacial injuries are quite common in these cases and includes laceration of the mucosa, on the inner aspect of the upper lip, near the frenum, the frenum itself, fractured or displaced teeth, fractured jaws and bruising of the face.

The dentist can help by providing evidence in the prosecution or other satisfactory resolution of the case who is, in turn, protected by the law.

Identification by Facial Reconstruction

For the purpose of individual identification, forensic facial reconstruction helps in visualization of faces on skulls. Forensic facial reconstruction is a mixture of art

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and science in which the visualization of faces on skulls is attempted for the purpose of individual identification.

Techniques

1. Based on the skull, an artistic representation of 2D facial reconstruction is done. Two-dimensional facial reconstruction is an artistic representation based on the skull.
2. Photographic or video superimposition—comparison of the skull with premortem photographs.
3. Three-dimensional facial reconstruction—plastic or computer generated.

CONCLUSION

Forensic dentistry in last half century made giant strides and has become a field of specialized study. Although, we have attained civilization and culture, still we see deaths due to suicides, homicides, accidents, natural disasters and also sudden, unexpected and unwitnessed deaths.

As Adelson has pointed out, "while there is only one way to be born there are many ways to die." Each of us desires to live in a decent orderly society with capable judiciary, therefore every citizen should help the noble cause of the "defence of the innocent and punishment of the guilty."

The realm of forensic odontology can represent the most challenging and rewarding aspect in the field of dentistry. Major crimes can be solved by means of forensic odontology which helps in identification of individuals who otherwise cannot be identified visually and the accuracy is ensured owing to the unique nature of dental anatomy. Forensic dentistry plays a major role in the identification of those individuals who cannot be identified visually or by other means. The unique nature of our dental anatomy and the placement of custom restorations ensure accuracy when the techniques are correctly employed. If various investigating agencies become increasingly aware of the potential contribution of the dental surgeon in identification, demand for individuals with knowledge of forensic dentistry is bound to increase. Forensic odontology is one of the most unexplored and intriguing branch of forensic medicine. Major dental clues, once upon a time neglected, are now increasingly used to solve crime. While extensive work has led to the rapid development of the subject of forensic odontology in western countries, there is a need for heightening the awareness about the importance of this specialty amongst the Indian dental professionals. Hence it is the public duty of the dentist to assist in problems involving medicolegal identification of the unknown body. Dental evidence plays a vital role in establishing the identity of the dead. Various methods are used in identification.

The realm of forensic odontology can represent the most challenging and rewarding aspect in the field of dentistry.

REVIEW QUESTIONS

a. Discuss the role of forensic odontology in identification of victims and culprits
b. Explain the process involved when bite marks are used as evidence in forensic odontology.
c. Discuss the contribution of forensic dentist in identifying prominent personality in history of mankind.

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PART 3

PREVENTIVE DENTISTRY

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29

Introduction and Principles of Preventive Dentistry

Hiremath SS

CHAPTER OUTLINE

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"The day is surely coming and perhaps within the lifetime of you young men before me, when we will be engaged in practice in preventive rather than reparative dentistry".

—DR GV BLACK MADE PROPHECY TO A GROUP OF HIS STUDENTS IN 1896.

Few diseases are inescapable lot of humanity, for a problem that is common in one place usually would be too rare somewhere else. There is no known biological reasons why every population should not be as healthy as the best. It is better to be healthy than ill or dead. That is the beginning and the end of the real argument for preventive philosophy.

Despite strides made in dentistry over the past two to three decades, dental caries and periodontal diseases continue to be the most dominant of dental diseases as well as two of the most common afflictions known to man. The major impact of these diseases on society warrants implementation of global level at nationwide or at of preventive dental health programmes. However, these programmes must be tailored to meet the specific dental health needs of a large number of target groups from different countries and societies. A significant part of prevention entails not only educating the population about the necessity for making routine periodic visits to the dentist and practicing good dental health habits but also involves the maintenance of preventive philosophy on part of the dental profession. We know that bacterial plaque, sugar and fluoride are inextricably linked to the two most common dental diseases, the caries and periodontal disease. The control of plaque build-up, radical reduction of sugar in the diet and expedient use of fluoride would, to a large extent, prevent these diseases.

With regard to dental caries prevention, many strategies have been advocated both at individual and group level. Not all patients eat snacks containing excess sugars need dietary advice, but only for those individuals who are highly susceptible to caries, dietary counselling can be beneficial. A simple initial screening is required to review patients' typical dietary intake over the past 1 to 7 days. This type of assessment will assist in identifying possible dietary excesses or deficiencies, relevant to important nutritional factors as well as sugar exposures. Diet counselling does not succeed with everyone. People who agree to counselling must be willing and expend a great deal of effort to alter their eating habits. They must give a high priority to preventive health care, which might translate in their desire to preserve their natural dentition for lifetime. In the beginning of the century, many dental practitioners were refusing to accept children as patients although their needs were great. Hence, this neglected attitude presented a high amount of untreated dental caries and, in turn, resulted in widespread tooth loss. However in 1950s, a preventive philosophy emerged and also treatment for dental diseases with preventive approach.

The elderly represent an extremely heterogeneous group. Older adults, particularly those in non-traditional settings, provide a unique challenge to the dental profession. Certainly as the older adult population grows, their demands for dental care are increasing, and it has a definite impact on practice of preventive dentistry. At present more and more older patients retain their natural teeth on account of improvement in the health care facilities and also increased awareness.

The individuals' knowledge, attitude, values, motives and needs play a definite role in making a decision or taking action to save his or her teeth. Hence, attitude and behaviour of an individual or the community becomes the most important parameter, which will decide in acceptance of the preventive programmes sometimes. Socioeconomic factors and behavioural pattern of the patients may greatly affect the demand for dental care. The interaction of all these factors must be considered in designing and implementing preventive health programmes, both for individuals and community. In order to prevent dental caries in the most deprived communities, we do not have to rely on a change in behaviour. Water fluoridation has been found to reduce socioeconomic inequalities in caries.

Tobacco is the costly health hazard throughout world and is a major factor underlying illness and disability in many countries. Globally, tobacco use is the single most important preventable cause of premature death.

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Tobacco causes lung cancer, heart disease, lung disease and also oral cancer. Also failure to reduce the use of tobacco already imposes a serious cost and, in future, will consume considerable health care funds. At the same time, prevention of HIV infection has been on the rise in most of the developing countries. This has also added to the miseries of the greater prevention of chronic diseases and has become a burden in many developing countries.

The burden of disease is the cost; a society bears, measured in death and disability for illness and disease. The health care system must anticipate and respond to this changing burden of disease ideally for preventive and curative measures. Typically in developing countries, the greatest burden of the disease results from communicable disease, malnutrition, ignorance, lack of health care facilities and complication of pregnancy and childbirth. In developed countries, burden of disease is greatest from non-communicable diseases. Developing countries typically experience epidemiological transition from a communicable disease profile to one characterized to a non-communicable disease on their path to economic development. The worst possible scenario is a partial transition wherein a large part of society makes the transition and begins requiring costly hospital treatment for chronic illnesses, including dental and oral diseases.

In the epidemiological model a disease state is due to interplay of three main parameters or factors, the host, agent and environment. Disease is prevented where optimal interplay of the primary and much secondary level of preventive factors result in increasing effective host resistance, elimination of disease causing agent and a healthy environment. Primary preventive measures are aimed at reducing occurrence of new cases of disease in a population. Prevention of disease normally is accomplished by health promotion and specific protective measures. Use of fluorides or restricting intake of sucrose containing snacks to reduce new carious lesions are an example of primary prevention. Secondary prevention aims at minimizing the prevalence of existing disease, which can be achieved by early diagnosis of initial lesions followed by prompt treatment, whereas tertiary prevention involves the maximum disability limitation and rehabilitation. It is ideal to have more of primary level of prevention, less of secondary level prevention and should have very minimum of tertiary level of prevention.

Dental caries is also biosocial disease whose causes are rooted in the culture and socioeconomic status of our society. In this context, explanation given to the population that caries can be prevented or reduced by dietary restriction of sugar has met only with moderate success. Although increase in use of fluoride in the form of dentifrices and rinses has played a vital role in controlling dental caries, but cultural values are changing on individual level. At the same time, training more and more dental graduates to meet the increased demand for dental treatment is neither ideal nor feasible, and treating dental caries with repeated fillings does not itself eradicate or prevent the disease. Thus, clearly an answer to this major public health problem should be the prevention. Unfortunately, many patients and dentists are oriented towards restorative treatment and have very little consideration for the preventive philosophy in spite of the fact that many times they cannot afford the treatment.

Water fluoridation has been successful in reducing caries prevalence by 50–70% in permanent dentition. On account of use of different types of fluorides since 1950's, the greatest decline in caries has been noticed. Fluoridation programme is one among the most effective public health developments of the 20th century, because of its effectiveness, safety and ease of implementation, minimal cost, public compliance and ability to serve all people regardless of education or socioeconomic status.

Fortunately, current understanding of aetiology of dental caries is adequate to reduce tooth decays in most populations. However, this knowledge has not been translated into programmes that are effective in curtailing dental caries on the larger scale than until now occurred. The central problem, which faces us both in public health and private practice with the problem of making decision on priorities, should be given to the prevention of diseases as distinct from the treatment or control of the consequences and the sequelae of the disease.

The supreme goal of dental profession should be to eliminate the need for its own existence. For this to achieve, certain modifications need to be made in our approach when dealing with a scientific knowledge, e.g. dental caries is not a cavity in a tooth but it is a symptom of long standing diseases. Dental caries is a sucrose-dependent bacterial infection. If it is left undisturbed for long, it will produce cavity.

The armamentarium available to reduce the prevention of both dental caries and periodontal disease are many. The most important are dietary restriction of sugar, plaque control, use of systemic and topical fluoride and good oral hygiene measures. These procedures are relatively simple and inexpensive. It is beyond reasonable conclusion that use of fluoride alone more than other measures has contributed to dramatic decline in caries prevalence in the developed countries.

It is of utmost importance of having knowledge about the risk factors and attitude and behaviour of the people. At the same time, patient should have every right to decide on his/her health. Many patients are quite simply unable to suddenly break the habit and they are not prepared to accept suddenly the philosophy of preventive approach like good dietary and plaque control regime. In the past, the dental profession has taken a didactic stance on the prevention of dental diseases through the use of their highly specialized knowledge. This knowledge has been used in development of preventive messages, which have been passed to the 'lay person' in the hope, that they would affect a behavioural change that would bring about a reduction in the dental disease they suffered.

Hence, it is ideal to counsel patients regarding the use of various preventive strategies and as far as possible; they should be involved in decision-making. This kind of preventive approach, with its emphasis on individual needs of the patient, offers the best possible chance in the future. The reinforcement and active participation of patient results in extremely effective preventive programmes. Ultimately, dental profession, practitioner and patient achieve a perfect compromise and see that

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effective and affordable prevention is achieved in the easiest way with least financial burden.

It has long been recognized that there are major inequalities in mortality and morbidity between the rich and the poor. Unfortunately, the gap between the more affluent section of the community and those from the poorer groups is becoming wider. Inequalities in oral health also occur. Before the twentieth century, the highest caries rates were found in the more affluent groups. However, by the 1940s dental caries had become a disease of poverty rather than affluence. It might be thought that oral health education programmes could be undertaken to reduce these inequalities. However, there is little evidence that this strategy is likely to have a major effect. And also equity in access to health services and dental attendance also are of concern. Those who come from higher social class may make least use of health services, or they may actually use disproportionately more health services than those in the lower social groups after accounting for the variations in morbidity.

What can we, as public health dentist, do to help reduce these unacceptable inequalities in health? Clearly we have a professional responsibility to address the inequalities in oral health, especially among disadvantaged population. We need to continue to be active advocates of water fluoridation, and also target other oral health promotion programmes to the most deprived sections of the community, where these have been shown to be effective and ensure that access to appropriate dental service is available to those whose oral health needs are greatest.

The knowledge we already possess is sufficient to put into practice to achieve great health gains for all and to reduce our scandalous international and national inequalities in health. What impedes its translation into action? Some of the reasons are wholly deplorable, including widespread ignorance and lack of understanding of the issues and possibilities, and deliberate opposition of powerful vested interest. Such obstacles to better health need to be exposed and opposed.

The prevention of dental diseases is possible and preventive dentistry is a reality. Yet, how little is actually practised. We are steeped with the tradition of repair. Like busy ants we fill, we extract, replace, secure in the certainty that this is dentistry, and contend to let others follow the new preventive fashion. We must change, this is no question of fashion, it is the biggest shift in the philosophy of dentistry that has taken place in our life time. Our patients, irrespective of richness or poverty, desire the best what we can offer them, and even they are becoming aware that the best is no longer limited to the disease and repair. Preventive dentistry needs willingness and participation to practice more of preventive philosophy. It is the matter of attitude and motivation from both profession and patients. We have already had the skills and materials and may be cause is negligible. What is needed is an understanding of the cause of the disease and the desire to prevent it, which alone can motivate the patients and profession.

It is apparently a traditional approach to dental disease, treating the disease as it develops, has not been effective and that expansion of treatment facilities would be both difficult and almost prohibitedly expensive. It is especially true in case of developing countries where there is acute shortage of resources in terms of manpower, finance, materials and equipment. Fortunately, preventive methods, which are effective and economic, have been developed and these provide an effective alternative or rather a supplement to traditional methods. It must be appreciated and realized that complete prevention of dental diseases on a community basis, by any method or combination of methods, is not yet possible. Until it is, the best approach will be in combining and integrating the preventive and therapeutic measures to bring dental diseases under control.

Certainly, if a dental and oral health care programme is ever to reach it's a long-term goal "health for all"; it must have a basis in the **prevention** of disease rather than treatment of its consequences.

Employment of all measures necessary to attain and maintain oral health.

CONCEPTS OF PREVENTIVE DENTISTRY

- Spans from womb to tomb.
- Continuous process throughout patient's life.
- Is economical and effective.
- Is a teamwork including dentist, patients etc.
- Concept is not new in medicine and dentistry, e.g., immunization for smallpox.
- To avoid maleruption of permanent tooth, extraction of over retained teeth was advised/suggested 2000 years back.
- To keep teeth clean free from deposits and prevents cavity and gum diseases, practice of oral rinsing was there since 1500 years.

SCOPE OF PREVENTIVE DENTISTRY

1. Factors predisposing to disease
2. Factors encouraging the advance of disease
3. Complication of disease and deformity
4. Factors interfering with rehabilitation
5. Factors causing recurrence of disease

PRINCIPLES OF PREVENTIVE DENTISTRY

1. Control of disease
2. Patient education and motivation
3. Development of host resistance
4. Restoration of function
5. Maintenance of oral health

Control of Disease

- Emergency treatment and relief from pain
- Active caries should be controlled
- Removal of plaque and calculus
- Extraction of infected teeth

Patient Education and Motivation

- Evaluation and education by audiovisual aids
- Home care

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Development of Host Resistance

- Nutrition and balanced diet
- Water fluoridation
- Topical fluorides
- Use of dentrifice and mouthwashes

Restoration of Function

- Permanent restoration Prosthodontic, orthodontic treatment
- Periodic dental check-up

REVIEW QUESTIONS

1. Define preventive dentistry. Discuss current concepts and scope of preventive dentistry.
2. Discuss levels of prevention.
3. Write note on principles of preventive dentistry.

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30 Dental Caries

Hiremath SS and Sushi Kadanakuppe

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INTRODUCTION

Dental caries the disease of civilization is affecting the mankind since the dawn of the time. Caries has also been noted in the fossil remains of *Pithecanthropus erectus* and *Homo rhodesiensis,* early ancestors of man. Caries seems to have increased considerably in *Homo sapiens* during Neolithic period when it was perhaps as high as that seen in many contemporary primitive people. In fact, in prehistoric skulls about 5% of the teeth exhibited caries.

Dental caries is a chronic disease, a process that progresses very slowly in most individuals. The multifactorial aetiology of dental caries has been relatively understood. The disease is therefore not only treatable but also most aspects of it to an extent a preventable infection. The carious lesion should be regarded not as a disease entity but as tissue damage caused by the dental caries.

"Caries without cavitation"—caries should be considered as a process rather than simply as an event at a particular stage, i.e. a cavity requiring restoration. Evidence of frank cavitation was required for the diagnosis. There were two reasons for this; one being that from the public health standpoint there was little interest in lesions, which have no effect on the person in terms of requirements for treatment or restoration. When a caries-free individual is referred, it was found that such an individual had many pre-cavitational lesions approximally. However, epidemiologically it was of little concern if that person went through life without frank cavitation.

Tooth decay is an infectious disease generally affected by diet and the pattern of its consumption by the host. Its dependency on ingestion of fermentable dietary carbohydrate is beyond question. However, caries does not occur in germ free animals, no matter what their diets are, thus establishing it as a fundamentally microbiological disease. Sound enamel demineralizes, if plaque bacteria are given with carbohydrate substrate and they produce acids, however, the presence of saliva in the mouth can act as a buffering agent, which in turn to an extent can inhibit the demineralization process. The progression of carious lesion is not inevitable and disease can be controlled.

Salient Features of Carious Process

Salient features of carious process are listed in the following:

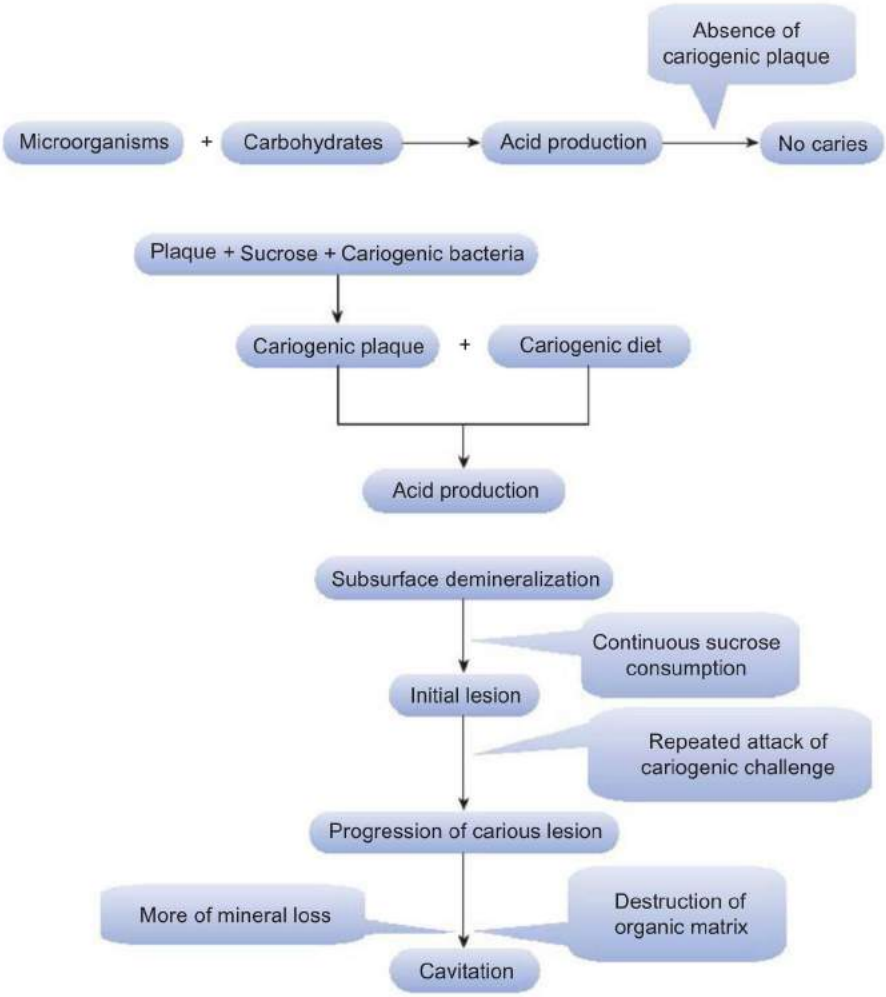
1. Carious process is spread over time
2. Carious process does not have to progress
3. The initial lesion can be arrested and reversed
4. All ages are susceptible to caries
5. The major cause of tooth loss in all age groups is dental caries

Definition

"Dental caries is an infectious microbial disease that begins as demineralization of inorganic portion of tooth, followed by destruction of organic portions, leading to cavity formation".

The interaction between the biofilm and the tooth surfaces is called the **caries process** and the manifestation of the stage of the process at one point in time is the **caries lesion** (Flowchart 30.1).

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Flowchart 30.1 Caries process.

EARLY THEORIES OF CARIES AETIOLOGY

Worm Theory

According to an ancient Sumerian text, a worm that drank the blood of the teeth and fed on the roots of the jaws caused toothache. *Guy de Cahuliac*, the greatest Surgeon of the middle Ages, believed that worming caused dental decay. As a cure he advocated fumigation with seeds of leech, onion and hyoscyamus.

Humour Theory

Ancient Greeks considered that relative proportions of four elementary fluids of the body determined a person's physical and mental constitution: (i) blood, (ii) phlegm, (iii) black bile and (iv) yellow bile. These four fluids corresponds to the four humours: (i) phlegmatic, (ii) choleric (iii) sanguine and (iv) melancholic. All diseases including caries were explained by an imbalance of these humours.

Parasitic or Septic Theory

Parasitic or septic theory was given by *Erdl (1843)*. According to this theory, dental caries was caused by filamentous parasites present in the "surface membrane" (plaque?) of teeth. Later, *Ficinus* observed filamentous microorganisms, which he called denticolae in material taken from carious cavities.

Vital Theory

The vital theory regarded dental caries as originating within the tooth itself, analogous to bone gangrene. A clinically well-known type of caries is characterized by extensive penetration into the dentin, and even into the pulp, but with a barely detectable catch in the fissure.

Chemical Theory

Chemical theory was given by *Parmly (1819)*. According to this theory, dental caries was caused by unidentified ***chemical agent***. Parmly stated that locations in enamel surface where food putrefied and acquired sufficient dissolving power helped produce the disease chemically.

Chemoparasitic Theory

Chemoparasitic theory is the most accepted theory for the aetiology of dental caries. This theory was given by

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Miller in 1890. A series of experiments was conducted which demonstrated that:

1. As shown by reaction on litmus paper, acid was present within the deeper carious lesion.
2. When different kinds of foods such as breads, sugar, but not meat were mixed with saliva and incubated at 37°C could decalcify the entire crown of the tooth.
3. Several types of bacteria in the mouth, at least 30 species, have shown to produce enough acid to cause dental caries.
4. An identifiable product in carbohydrate-saliva, incubation mixtures was lactic acid.
5. Different microorganisms such as filamentous, long and short bacilli and micrococci could invade carious dentin.

Critique of Chemoparasitic Theory

1. Miller's chemoparasitic theory is unable to explain the predilection of specific sites on a tooth to dental caries.
2. The phenomenon of arrested caries is not explained by the chemoparasitic theory.
3. Miller's theory does not explain why some populations are caries-free.

Proteolytic Theory

Proteolytic theory was given by Gottlieb in 1944. This theory suggested that the initial action was due to proteolylic enzymes attacking the lamellae, rod sheaths, tufts and walls of the dentinal tubules. Later, a coccus, probably *Staphylococcus aureus*, was involved because of the yellow pigmentation that he considered pathognomonic of dental caries.

Frisbie (1944) also described caries as a proteolytic process involving depolymerization and liquefaction of the organic matrix of enamel.

Pincus (1949) contended that proteolytic organisms first attacked the protein elements, such as dental cuticle, and then destroyed the prism sheaths.

Proteolysis–Chelation Theory

Proteolysis–chelation theory was proposed by Schatz et al in 1955. The theory proposes that a simultaneous microbial degradation of the organic components by proteolysis, and dissolution of minerals of the tooth can occur by the process of chelation. The word "chelate" is derived from the Greek "*chelé*" meaning claw and refers to compounds that are able to bind metallic ions such as calcium, iron, copper, zinc and other metals, by the secondary valence bonds.

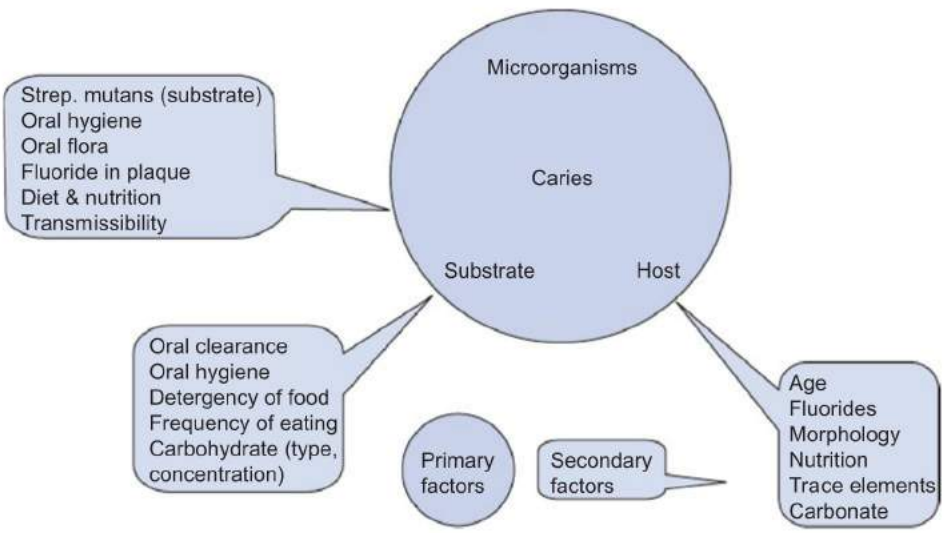
CURRENT CONCEPTS OF CARIES AETIOLOGY (Flowchart 30.2)

Caries is a multifactorial disease mainly consisting of three parameters most commonly contributing for the initiation of dental caries namely, host factor (susceptible tooth surface), microorganism *(Streptococcus mutans)* and diet (sucrose); however, the interplay between these factors has to take place in an **appropriate time**. Thus, the fourth factor has been considered either as an independent factor or all the three primary factors have been put under time factor (outer ring). This factor has been added to emphasize the importance of time factor in the origin of the disease along with other three primary factors. Hence, current concept of the aetiology of dental caries includes these important four factors as described in **Keyes circle** (Figs. 30.1)

Keyes Circle

The interaction of saliva, bacteria and microbial products in the production of biofilms on the tooth surface is an important factor to initiate dental caries. The susceptible host, cariogenic oral microbial flora and fermentable carbohydrate are important in the development of dental caries and they have been depicted through Keyes circles (Figs. 30.3).

Each one of them is of equal importance in aetiology of the disease. However, there are many secondary factors



Flowchart 30.2 Diagrammatic representation of interplay between primary and secondary factors in caries aetiology.

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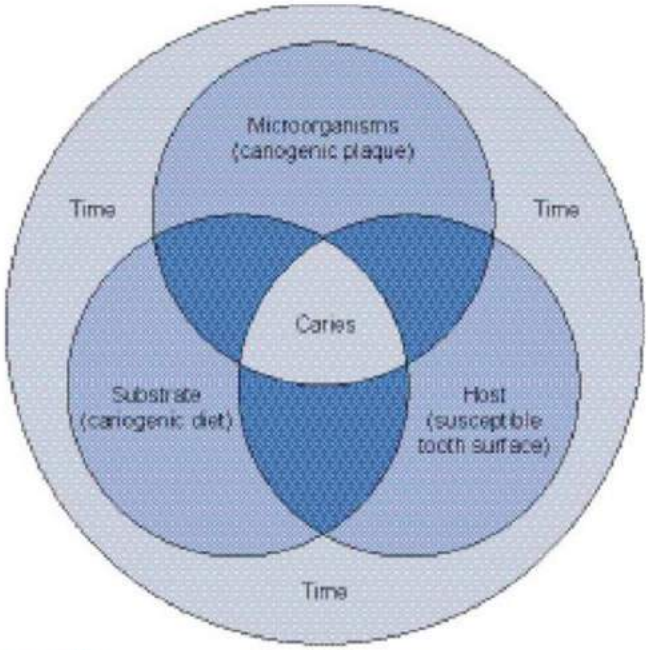


Figure 30.1 Keye's Circle—current concept of caries aetiology.

that either influence the progression or regression of dental caries (Fig. 30.4).

- Caries progression results when the demineralization and remineralization equilibrium is out of balance. This leads to net mineral loss.
- The process of remineralization can arrest or reverse progression of disease and can lead to changes in mineral quality

1. **Lesion detection** is an objective method of determining whether or not disease is present.
2. **Lesion assessment** is a method which aims to characterize or monitor a lesion, once it has been detected.
3. **Caries diagnosis** is a method which implies a human, professional, summation of all the signs and symptoms of the disease

It is now appreciated that caries is a disease of multifactorial etiology and initially reversible, chronic disease process.

Dental caries progresses slowly in most of the individuals as chronic disease. The disease is rarely self-limiting and in the absence of treatment, a caries progresses until the tooth is destroyed. The carious lesion is the localized destruction of the hard tissues, which is the sign or symptom of the disease. Lesion progression is often described on a linear scale ranging from initial loss of mineral at the ultra structural level to total destruction of the tooth. Nevertheless, caries lesion development is marked by a highly dynamic process with alternating periods of progression and arrest/regression.

At any stage of lesion development, the lesion progression can be arrested. even at the stage of frank cavitation, provided the local environmental conditions, e.g. biofilm control and topical fluoride exposure, are favourableThe key point is, when the cumulative result of the de- and remineralization process is loss of mineral, caries lesion develops or progresses.

Caries lesions may be classified in various ways. Lesions can be classified according to their anatomical site and location. The lesions may be commonly found in

- pits and fissures, or on
- smooth surfaces of the enamel (enamel caries) or on the
- exposed root cementum (root caries).

MICROBIOLOGY OF DENTAL CARIES

Cariogenic Bacteria

Orland and colleagues in 1954 proved by animal experiment that bacteria are important for the initiation of dental caries. This experiment demonstrated clearly that germ free rats did not develop caries when fed cariogenic diet. The experiments of Keye demonstrated the transmissible nature of the disease in humans, which showed that previously caries inactive hamsters developed caries after contacting caries active animals.

Fitzgeral and Keyes in 1960 applied Koch's postulates and showed for the first time the transmissibility of dental caries infection

Mutans streptococci and caries. The mutans streptococci (MS) are a group of bacterial species previously considered to be serotypes of the single species, Streptococcus mutans.

Streptococcus mutans (MS) are considered as a causative agent for dental caries for the following reasons:

1. Their ability to stick to tooth surfaces and production of abundant quantity of insoluble extracellular polysaccharides from sucrose
2. Their ability to produce organic acid such as lactic acid from a number of sugar substrates
3. Ability to resist aciduric and acidogenic environment
4. Production of intracellular polysaccharide, which acts as a reserve substrate for bacteria

It is generally known that children with the highest number of MS in primary teeth will experience a higher caries rate in their permanent teeth. Thus, *S. mutans* is the most common of the human MS and has the greatest evidence implicating it as the most virulent odontopathogen in the aetiology of dental caries.

Other Microbial Agents Responsible for Caries

1. ***Streptococcus sobrinus:*** It differs from *S. mutans* in that it lacks the adhesin required for sucrose-independent attachment and therefore accumulates only on smooth surfaces in the presence of sucrose rich diet.
2. ***Lactobacilli:*** Lactobacillus helps in the progression of dental caries and it is aciduric and acidogenic in nature. It is considered as essential acidogenic bacteria causing caries. *Lactobacillus* species are incapable of producing the range of pH values required for caries intiation as they have been shown to be in very low numbers. They have been shown to colonize white spot lesions before cavitation. More number of

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S. mutans appears during the initial phases of development of carious lesions, only to decrease in number as *Lactobacillus* population increases. Thus, as a general rule, they have been associated in lesion development. Thus, *S. mutans* are implicated in the initiation of the lesion and *Lactobacillus* (specifically *L. casei)* associated with progression.

3. ***Actinomyces (A. odontolyticus)*** they have also been associated with lesion progression including root surface caries.

MECHANISM OF ADHERENCE OF MICROORGANISMS TO TOOTH SURFACE

Adherence by *S. mutans* to the tooth surface is important both before and after colonization. While continuing to colonize in protected areas provided by the interproximal space along the gingiva or in the regions of pit and fissures, bacteria must have to establish a strong foothold on the tooth surface and maintain their positions. Otherwise, they would be swept away by the salivary flow.

Mutans streptococci are able to attach to the tooth surface by two mechanisms:

i. *Sucrose-independent adsorption:* In this mechanism, the bacteria attach to the acquired pellicle through specific extracellular proteins located on the fimbriae of these organisms.
ii. *Sucrose-dependent mechanisms:* In this mechanism, for attachment and accumulation, bacteria require the presence of sucrose to produce sticky extracellular polysaccharides or glucans.

Thus, the presence of insoluble glucans is an important factor in establishing the presence and virulence of an organism. Glucosyltransferase (GTF) is one of the key enzymes in conversion of the glucose moiety of sucrose to glucan. The enzyme sometimes may be altered resulting in the production of soluble glucan that does not support adherence to the tooth surface. These mutant strains lacking the insoluble glucan are usually noncariogenic.

The plaque of individuals restricting their sucrose intake have a decreased proportion of *S. mutans*. However, *S. mutans* number increases when sucrose is reintroduced into the diet. At the same time, sugar restriction has an influence to reduce the acidogenicity of dental plaque.

FORMATION OF PLAQUE

The initial colonization of microorganisms on the tooth surface probably begins with organisms other than *Streptococcus mutans*. The mechanism of initial colonization includes:

1. Bacterial adherence to pellicle or the enamel surface
2. Bacterial adhesion between the same or different species
3. Subsequent growth of bacteria from small enamel defects and from cells initially attached to the tooth surface

Plaque Hypotheses Theories

The Non-Specific Plaque Hypothesis (1976) purports the caries disease is an outcome of the overall activity of the total plaque microflora and not a specific organism. According to this hypothesis, everybody is treated alike since everybody has plaque and plaque is forming all the time.

In contrast, the Specific Plaque Hypothesis (Loesche 1986) proposes that only a few species of bacteria among the diverse collection of bacteria encompassing the plaque microflora, are involved in the disease. The plaque per se is not pathogenic, but the presence of pathogenic species, such as streptococcus mutans and lacto bacillus within the plaque causes dental caries.

Ecological Plaque Hypothesis (Philip D Marsh 1994) differs from the specific plaque hypothesis in that pathogens (MS and LB) can be present, but in too low numbers to cause disease. A shift in the homeostatic balance of the resident microflora due to a change in local encironmental conditions, such as pH, favors the growth of pathogens which results in disease. Research has demonstrated it is the pH, not the sugar, which causes the pathologic shifts of biofilms.

The plaque formation continues with the formation of extracellular polysaccharide chains via the breakdown of sucrose to glucose and fructose. The polysaccharide chains of glucose are called glucans and those of fructose are called fructans. These extracellular polysaccharides enhance the bacterial ability to adhere to the tooth and to each other by their sticky and gelatinous nature. They also affect the rate at which saliva can enter the plaque to buffer the acids and reverse the demineralization process. This leads to further accumulation of acids at the tooth-plaque interface. When sufficient amount of acids are produced, there will be a drop in pH of plaque to critical level which is detrimental to dental health.

The net result of interactions among aetiologic factors, many internal and external risk factors, and protective factors determines the quantity of plaque that forms on clean tooth surfaces during a given time:

1. The total oral bacterial population
2. The anatomy and surface morphology of the dentition
3. The wettability and surface tension of the tooth surfaces
4. The salivary secretion rate and other properties of saliva
5. The intake of frequency of fermentable carbohydrates
6. The mobility of the tongue and lips
7. The exposure to chewing forces and abrasion from foods
8. The eruption stage of the teeth
9. The degree of gingival inflammation and volume of gingival exudate
10. The individual oral hygiene habits
11. The use of fluorides and other preventive products, such as chemical plaque control agents

ROLE OF SALIVA IN DENTAL CARIES

Biological Role of Saliva

Saliva is also called 'liquid enamel' as it is a rich source of various minerals. Its pH is in the range of 6.9–7.2.

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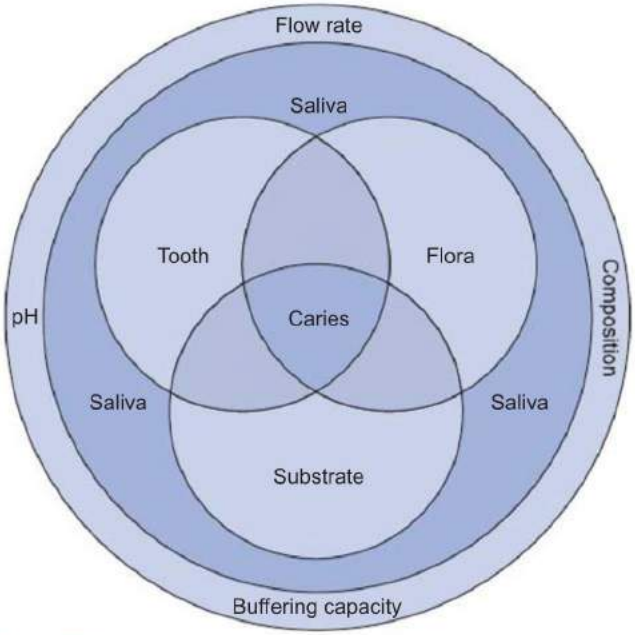


Figure 30.2 Diagrammatic representation of important role of saliva with other primary factors in caries aetiology.

As teeth are bathed in saliva constantly, the composition of saliva and velocity of the salivary film can play a significant role in maintaining the integrity of the tooth tissues. Saliva has many functions such as cleansing effect, buffering capacity, providing an environment saturated with calcium and phosphate and antibacterial action, which influence either progression or halting of carious process. (Fig. 30.2).

Saliva-acquired components present in the pellicle are cystatins, histatins, lysozyme, amylase, lactoferrin, lactoperoxidase, secretory immunoglobulin A and bacteria derived glucosyl transferase (GTF). Deleterious byproducts of bacterial metabolism in the dental biofilm are negated by these saliva-derived components.

1. The buffering effect of saliva is based prominently on bicarbonate, carbonic acid and phosphate buffer systems.
2. Lysozyme, a hydrolytic enzyme, lactoperoxidase, hemoprotein enzyme are present in saliva, which play a role in the prevention of bacterial colonization on tooth surface.
3. Lysozyme disrupts bacterial cell wall leading to bacteriolysis. Lactoferrin binds iron which results in sequestering iron away from bacteria and inhibits bacterial growth by both iron dependent and independent mechanisms. Iron is an essential element for bacterial metabolism. Since lactoperoxidase inhibits glucose metabolism, it protects salivary glycoprotein from degradation due to bacteria.
4. The most prominent antibody found in the saliva is the SIgA, which reflects the lifetime caries experience of the individual. It may not have a protective function.
5. Rapid flow of highly buffered, mobile saliva reduces the fall in plaque pH. Thus, less caries is associated with the rapid flow of saliva.
6. Low viscosity is also associated with low caries activity due to the rapid clearance of sugar from the oral cavity.

Buffering Power of Saliva

Inorganic buffers diffuse from saliva into the dental plaque, which play an important part in reducing the effect of acids produced by the bacteria. Bicarbonates are the most important buffers of saliva. Phosphates also play some part. Proteins can be disregarded as buffers. Buffers work by converting any highly ionized acids or alkalis, which tend to alter the pH of the solution into more weakly ionized substance. Bicarbonates release the weak carbonic acid when an acid is added. This acid is rapidly decomposed into water and carbon dioxide, which leave the solution. The result is not the accumulation of a weaker acid but the complete removal of acid.

It is clear that acid formation potential of plaque is such that, when confronted with sufficient fermentable carbohydrate, the buffers are overcome within minutes. The damage done to the tooth surface is caused by dissolution of the tooth minerals by the intense localized production of acids by bacteria, which breakdown the buffers.

Saliva contains considerable amounts of calcium and phosphate and hence is nearly always supersaturated with respect to enamel mineral and other biological appetites. Most importantly, unstimulated whole saliva is supersaturated with respect to hydroxyapatite and the level increases when the flow rate is stimulated. Enamel mineral does not dissolve in saliva under normal conditions, provided it is not acidified with dietary, gastric or medicinal acids.

It has been shown to be likely that hydroxyapatite crystals in the developing lesion will only be partly dissolved. Thus, the repaired section will contain less carbonate and will be less soluble and therefore much more resistant to future dissolution events. At the same time, fluoride ions from the saliva are likely to be incorporated so that repaired section will be not only lower in carbonate but richer in fluoride.

CLASSIFICATION OF DENTAL CARIES

Classification Based on Morphology

This classification is according to anatomical site of the lesions.

1. **Pit and Fissure Caries (Occlusal Caries)**
2. **Smooth surface caries**

Pit and fissure caries (occlusal caries)

- Most common type of dental caries (Fig. 30.3)
- Occurs on the occlusal surfaces of molars and bicuspids

Smooth surface caries. There are two variations of smooth surface caries. They are: (i) buccal and lingual surface caries, and (ii) proximal surfaces (interproximal).

a. Buccal and lingual surface caries

- Cervical caries (smooth surface caries)—occurring on buccal or lingual surfaces near the cementoenamel junction (Fig. 30.4).

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Figure 30.3 Pit and fissure caries.



Figure 30.4 Cervical caries.

b. Proximal surfaces (interproximal)

- Interproximal caries—occurring at mesial or distal contact points. Interproximal caries usually starts just cervical to the contact area (Fig. 30.5).

Classification based on Severity and Progression

1. **Rampant caries**
2. **Early childhood caries (nursing caries)**
3. **Radiation caries (xerostomia induced)**

Rampant caries. A sudden, rapid and almost uncontrollable destruction of teeth, involving surfaces of teeth that are



Figure 30.5 Proximal surfaces (interproximal).



Figure 30.6 Rampant caries.

ordinarily relatively caries free, is the characteristic feature of rampant caries. Proximal and cervical surfaces of anterior teeth including the mandibular incisors get affected (Fig. 30.6).

Early childhood caries (ecc). Early childhood caries is a specific type of rampant decay of the primary teeth of infants and toddlers. According to American Dental Association (ADA), it is defined as "the presence of one or more decayed, missing or filled tooth surfaces in any primary tooth in a preschool age child between birth and 71 months of age" (Fig. 30.8)

ECC is an infectious chronic and transmissible disease with complex and multifactorial etiology.

Factors known attributed to the etiology of ECC are

1. Excessive bottle feeding with sugar containing fluids.
2. Breast feeding on demand
3. Feeding during falling asleep
4. Nursing beyond the recommended age for weaning
5. Low socioeconomic status – parents education
6. Poor oral hygiene

It is a unique pattern of dental decay affecting maxillary primary incisors in young children. The factors include a mother with active decay or recently placed restorations, a family of low economic status, a child who frequently consumes snacks and drinks that are high in sugars or carbohydrates and a child who sleeps with a bottle or sippy cup containing anything other than water. It is also seen in children born prematurely, or with low birth weight are at increased risk for enamel defects.

Humans are not born with cariogenic bacteria. The transmission of Mutans Streptococci (MS) occurs from caregivers, usually mothers, by mouth-to-mouth transmission via kissing or by sharing a spoon during feeding.

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Figure 30.7 Radiation caries.

Radiation caries (xerostomia induced). A common complication of radiotherapy of oral cancer lesions and radiation-induced xerostomia is Radiation caries (from the Greek, *xeros* = dry, *stoma* = mouth).

Such patients develop rampant dental caries (Fig. 30.7). Xerostomia may be caused by factors other than radiation like

- Tumours of salivary glands
- Autoimmune diseases (e.g. Sjogren's syndrome)
- Anti-sialagogue drugs
- Prolonged illness

Classification Based upon Part of Tooth Structure Involved

1. Enamel caries
2. Dentinal caries
3. Root caries (Cemental caries)

Enamel caries

- **Incipient lesion:** Incipient lesion is also called the early carious lesion. It manifests as a white, opaque region, which is best demarcated when the area is dried.

Dentinal caries. On its way to progression, carious lesion involves dentin and over a period of time when the cariogenic challenge becomes more and more strong and along with other favourable factors, the lesion establishes in dentin. At the same time, outer layer of enamel might breakdown owing to the progression of caries and leads to cavitation.



Figure 30.8 ECC.



Figure 30.9 Incipient lesion.

Cemental caries. Recession of gingival margin is an inevitable process which occurs as a result of poor oral hygiene and loss of periodontal attachment with age. Subsequently, the exposed root surface becomes more vulnerable to plaque accumulation and caries process might initiate involving cementum.

Classification of Caries Based on Activity

1. **Primary caries**
2. **Secondary caries (recurrent caries)**
3. **Residual caries**
4. **Arrested caries**

Primary caries. Primary caries is used to differentiate lesions, which develop on the healthy enamel surface or on unrestored surfaces from those that develop adjacent to a filling.

Secondary caries. A carious lesion that develops at the interface of restoration and the cavosurface of the enamel is called secondary caries (Fig. 30.10). This type of caries may result from

- Poor cavity preparation
- Ditching around an amalgam restoration
- A defective restoration
- Or a combination of these factors

Residual caries. Residual caries is characterized by demineralised tissue that has been left behind before filling is placed (incomplete removal of carious dentin).

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Figure 30.10 Secondary caries.



Figure 30.11 Arrested caries.

Arrested caries. Caries lesion can become arrested at any stage of the caries process if causal factors are changed or protective factors are increased. The carious process is arrested and dentine becomes hard once the open carious lesion becomes self-cleansing, with improved oral hygiene measures, restricted intake of refined sugars and use of fluorides (Fig. 30.11).

CLINICAL MANIFESTATIONS OF DENTAL CARIES PROCESS

Early Changes

The earliest stage of caries is the first time demineralization of enamel, which occurs after the plaque pH depression below the critical pH (5.2-5.5). This amount of demineralization cannot be detected clinically (they go unnoticed); however, the repair process, remineralization and demineralization go hand in hand, and most of the time maintains the homeostasis (Figs. 30.12, 30.13 and 30.14).

- The risk of demineralization increases as the pH drops from bacterial acid by-products and the level of supersaturation of the calcium and phosphate also drops.
- Caries process is a dynamic process, which is the result of a shift in the balance between protective factors (that aid in remineralization) and destructive factors (that aid in demineralization) in favor of demineralization of tooth structure over time, which can be arrested at any time.

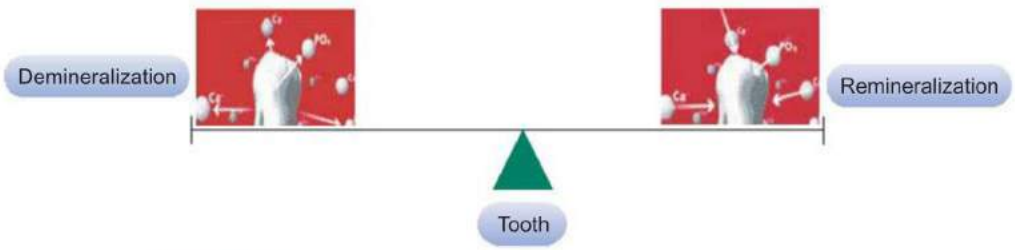


Figure 30.12 Equilibrium of demineralization and remineralization.

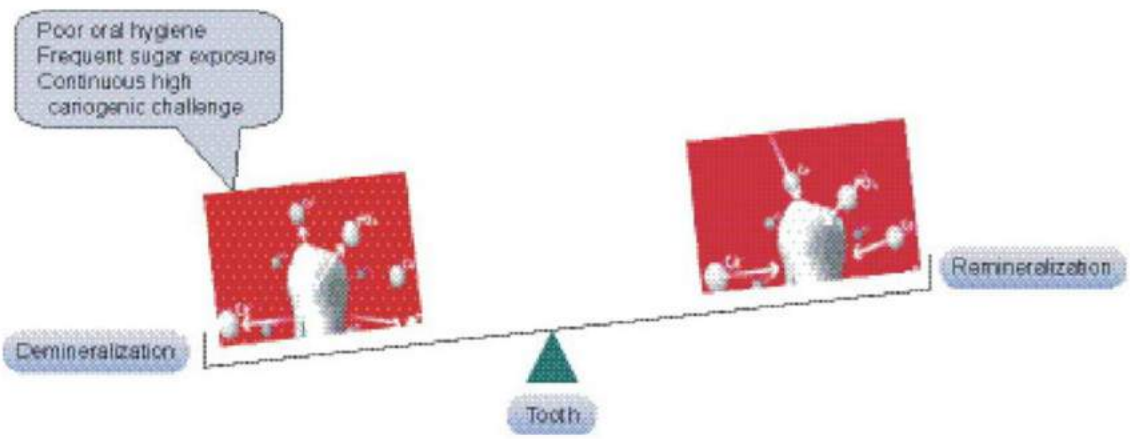


Figure 30.13 Deranged equilibrium of demineralization and remineralization.

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Demineralization: Demineralization is the loss of calcified material from tooth structure. This chemical process can be biofilm mediated (i.e., caries) or chemically mediated (erosion) from exogenous or endogenous sources of acid (from the diet, environment or stomach)

Remineralization: Remineralization is the net gain of calcified material within the tooth structure.

White Spot Lesion

White spot lesion is the first visible clinical presentation of dental caries. The clinical appearance of white spot lesion is loos of translucency caused by subsurface enamel demineralization.

Frank Cavitation

At this stage of carious process, tooth destruction progresses more rapidly because cavitation favours plaque accumulation and reduced salivary access.

Advanced Carious Lesions

Increasing frequent demineralization of the body of the enamel lesion over a period of time results in weakening and eventual collapse of the surface covering. This results in cavitation, which provides an even more protective and retentive zone for the cariogenic plaque, thus helps in accelerating the caries progression.

Affected Dentin: This is demineralised softened dentin that is not yet invaded by bacteria. It is vital and hence there is no need to remove this dentin as it can be repaired.

Infected Dentin: This is both softened and contaminated with bacteria and dead. It includes the superficial granular necrotic tissue, soft, dry and leathery dentin.

The outer carious dentin is the zone of decomposed dentin, which consists of soft infected dentin. This cannot be remineralized and must be removed during cavity preparation.

The inner layer of carious dentin although partially softened by demineralization contains only few bacteria and should be preserved, as it can be remineralized.

CARIES OF ENAMEL

Macroscopic Changes of Enamel

On smooth surfaces. On smooth enamel surfaces, the earliest visible changes are usually manifested as a loss of translucency, resulting in an opaque chalky white lesion in location where caries progressed most probably are becoming arrested, discoloured pigmentation of the enamel may be seen. When sectioned longitudinally smooth surface lesions are cone shaped with the apex directed towards the dentin (Figs. 30.15, 30.16 and 30.17).

Pit and fissure caries. In newly erupted teeth, brown stain or discoloured lesion is indicative of underlying decay, whereas in older individuals the lesions may be arrested or remineralised areas. This lesion is commonly described as cone shaped with the base directed towards the dentin and apex towards the enamel surface. Later, these macroscopic changes of the enamel in initial caries precede cavitation and occur without apparent break in the enamel surface.

Microscopic Changes of Carious Enamel
(Fig. 30.18)

Under microscope, the enamel caries (initial caries) shows four zones, starting from the inner advancing front of the lesion. The zones are:

1. Translucent zone
2. Dark zone
3. Body of the lesion
4. Surface layer

Zone 1: translucent zone. This zone of enamel caries is not seen in all lesions, but when it is present it lies at the advancing front of the lesion, which is the first recognizable alteration from the normal enamel. It is more porous than sound enamel, the pores having been created by the demineralization process. Sound enamel has a pore volume of about 0.1%, the translucent zone, however, has a pore volume of approximately 1%.

Zone 2: dark zone. The dark zone is the second zone of alteration from normal enamel and the most common

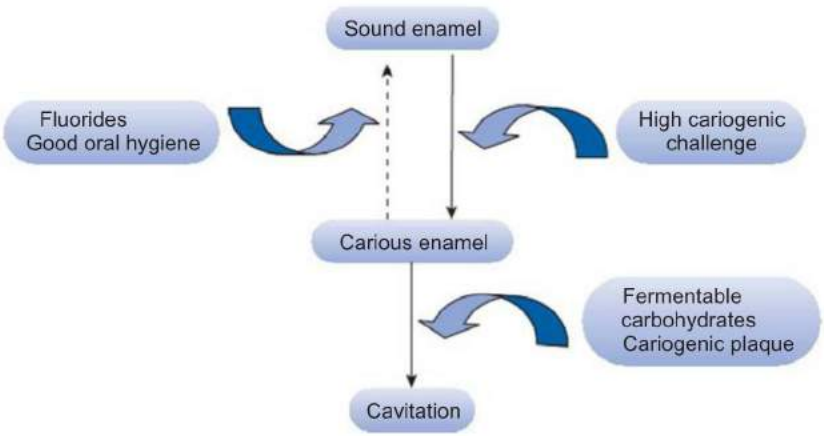


Figure 30.14 Schematic presentation of factors affecting sound and carious enamel.

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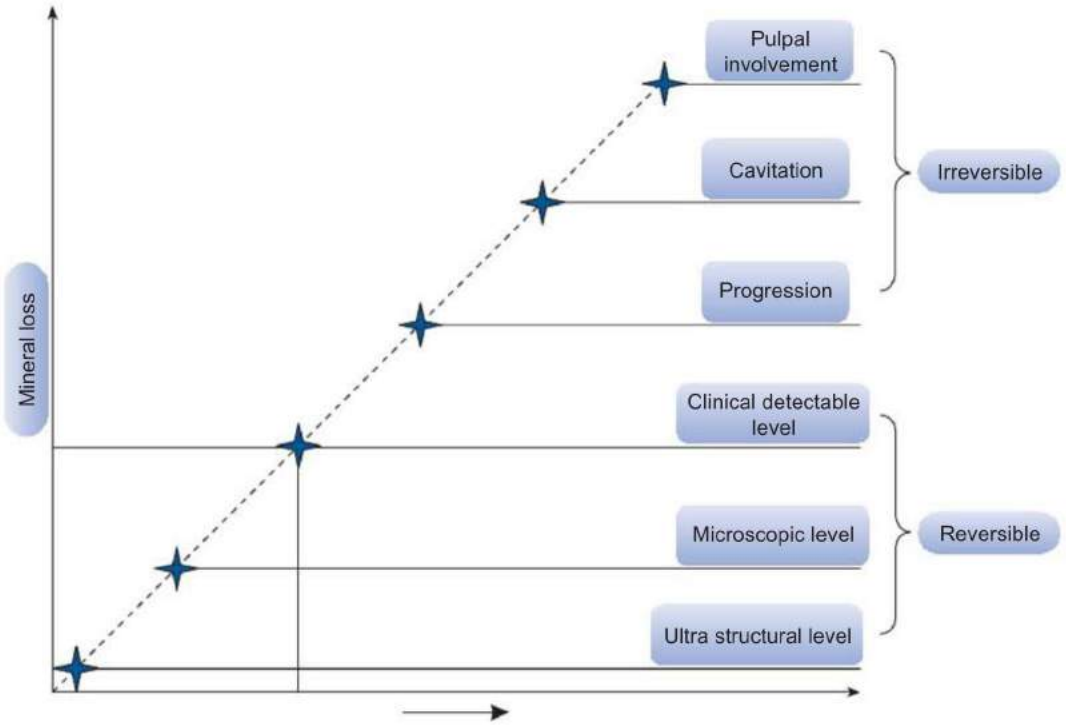


Figure 30.15 Schematic presentation of depicting progression of mineral loss in relation to time.



Figure 30.16 Smooth surface caries.



Figure 30.17 Longitudinal sectional view of pit and fissure caries.

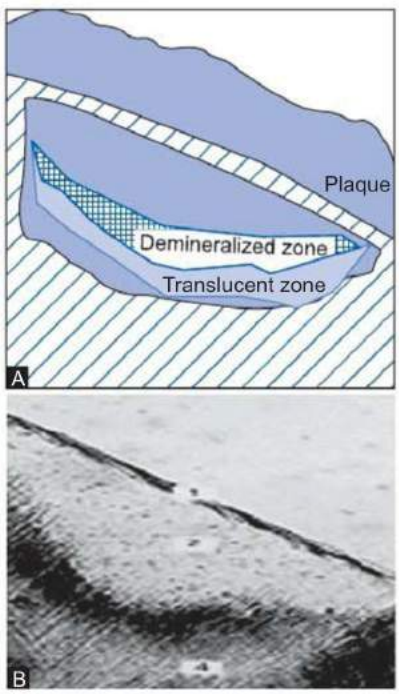


Figure 30.18 Microscopic changes of initial caries.

feature of the carious lesion. It lies just superficial to the translucent zone and appears dark when the ground section is placed in quinoline. This zone is more porous than translucent zone, with a pore volume of 2–4%.

Zone 3: body of the lesion. The body of the lesion comprises the largest proportion of carious enamel. This zone lies superficial to dark zone and deep to the relatively unaffected surface layer of the lesion. The maximum

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amount of mineral loss is found in this zone. The pore volume of this region is 5% at its periphery, increasing to 25% or more in the centre.

Zone 4: surface zone. The surface layer ranges between 30–100 mm thick which is thinner in active lesions and thicker in inactive carious lesions. The zone has a pore volume of 1%.

DENTINAL CARIES

Macroscopic Changes of Dentin

Dentin is the hard portion of the tooth and is covered by enamel on the crown and cementum on the root. Because of structural differences of dentin, the development and progression of caries in dentin is different from progression in the overlying enamel. Dentin has much less mineral and possesses microscopic tubules that provide the pathway for the ingress of acids and egress of mineral. As the dentinoenamel junction (DEJ) possesses the least resistance to caries attack, it allows for rapid lateral spreading once caries has penetrated the enamel. Because of this characteristic feature, dentinal caries is 'V' shaped or cone shaped in cross-section and has a wide base at the DEJ and the apex directed pulpally.

Caries advances more rapidly in dentin than in enamel because dentin provides much less resistance to acid attack because of less mineralized content. Caries in dentin produces variety of responses including sensitivity, pain, demineralization and remineralization. Once bacterial invasion of dentin is near to the pulp, toxins and few bacteria enter the pulp resulting in inflammation of the pulpal tissue.

In slowly advancing caries vital pulp can repair demineralised dentin by remineralization of the intertubular dentin and by opposition of peritubular dentin.

ROOT CARIES

Recession of gingival margin is an inevitable reason for poor oral hygiene and loss of periodontal attachment, as age progresses. Gingival recession is a prerequisite for exposure of a root surface. It is commonly seen in older people. Bacteria seem to penetrate into the tissue at an earlier stage in root caries than in coronal caries. The cement-enamel junction is highly irregular and represents a particular bacterial retention site and majority of root caries lesions develops at this site. It is claimed that root surface caries may occur within a deep periodontal pocket and lesion may be hidden in the pocket. Like enamel lesions, root surface caries lesions may be classified as active or arrested. Root lesions are very vulnerable to mechanical damage and probing should be avoided. Early diagnosis of such lesions is important because active lesions may become arrested following improved plaque control, use of fluoride toothpaste, and care with diet.

Risk Factors for Root Caries

The integrity of the periodontium as age advances, on account of degenerative changes, starts declining. And also the efficiency of the oral hygiene exercise by the older people is poor. There are drastic changes in the salivary composition and flow rate this, in turn, affect natural cleansing effect and protective properties of the saliva. This, sometimes, may get influenced and precipitated by medication due to chronic systemic illnesses in older people. Hence all these factors might act as a risk factor directly or indirectly for development of root caries in older people.

The risk factors for root caries are given below:

1. Age
2. Gender
3. Fluoride exposure
4. Systemic illness
5. Medication
6. Oral hygiene
7. Diet
8. Salivary changes

However, the critical pH for root caries is closer to pH= 6 and it is more than the pH =5.5 for which is for enamel caries.

CONCLUSION

Dental caries is a multifactorial disease of bacterial origin. For caries to occur, three factors must be present simultaneously along with time factor. They are susceptible tooth surface, cariogenic bacteria and sucrose containing dietary factors. Caries is an infectious disease caused by cariogenic plaque formation on the tooth, which causes demineralization of the tooth. Dental caries is a complex multifactorial disease that cannot be controlled by restoration alone. Initial lesion undergoes many cycles of demineralization and remineralization as it is in constant daily battle between progression and regression. Not all initial lesions develop to cavities at the same rate. At the same time progression rates are not same for each site.

An individual is never free of dental caries as the process of enamel demineralization and remineralisation cycles constantly moves between net loss and net gain of mineral. It is only when the balance leans towards net loss for some time that clinically identifiable signs of the process become apparent. The long-term outcome of this cyclic process is determined by the composition and amount of plaque, sugar consumption frequency and timing, fluoride exposure, salivary flow and quality, enamel quality and individual immune response.

In summary, dental caries is a disease manifested as interplay between environmental, behavioral and genetic factors.

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REVIEW QUESTIONS

1. Define dental caries and discuss the early theories of caries aetiology.
2. Classify dental caries. Discuss each type of dental caries.
3. Discuss the role of plaque in dental caries.
4. Discuss the role of microbial agents responsible for caries.
5. Write short notes on:
   a. Keyes circle
   b. Root caries
   c. Buffering capacity of saliva
   d. Rampant caries
   e. Nursing caries
   f. Radiation caries
   g. Hidden caries
   h. Microbial flora of cariogenic plaque

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31 Diet and Dental Caries

Hiremath SS

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INTRODUCTION

There is a substantial evidence of relationship between diet and dental caries. Fermentable carbohydrates of dietary origin are a necessary component of the dental caries process. We know a great deal about malnutrition and general health and in turn there is a strong correlation between malnutrition and dental caries. Primary dentition caries has been associated with early childhood malnutrition. The classic study conducted in Vipeholm, Sweden during the late 1940s suggested that the timing of consumption and retentive nature of the carbohydrates were predictors of caries risk. Sugars are the preferred substrate.

FOOD

Food is a complex chemical mixture of organic and inorganic materials containing both diet and nutrients.

DIET

Diet is the total intake of substances that provide nutrition and energy. It may be dairy or milk group, meat or poultry group, vegetable or fruit group and bread or cereal group.

NUTRITION

Nutrition is a science of how the body utilises food to meet the requirements for development, growth, repairs and maintenance or as the science of food and its relationship to health.

COMPONENTS OF FOODS

Human food consists of: (i) carbohydrates, (ii) proteins, (iii) fats, (iv) vitamins, (v) minerals and (vi) water.

CLASSIFICATION OF CARBOHYDRATES

Carbohydrates that are of special interest and importance in nutrition are: (i) monosaccharides, (ii) disaccharides and (iii) polysaccharides.

Monosaccharides

Monosaccharides are the simplest carbohydrates and are classified according to the number of carbon atoms in the chain, e.g. glucose, fructose and galactose.

Disaccharides

Disaccharides consist of a linkage of two monosaccharide units. Disaccharides, in general, have a sweet taste, water soluble and are crystalline solids, e.g. sucrose, lactose and maltose.

Polysaccharides

Polysaccharides are complex carbohydrates made up of many (more than 10) monosaccharides linked together.

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Unlike sugars, these are tasteless. Some are used for storing energy and others perform structural functions, e.g. starch, glycogen and cellulose.

Sucrose is having highest cariogenicity followed by glucose, fructose, lactose and galactose. Glucose syrups and hydrogenated glucose syrups have less cariogenicity than sugars, whereas sugar substitutes like xylitol, sorbitol, mannitol (sugar alcohols), aspartame, saccharin and cyclamate are not cariogenic.

Based upon where the sugar molecules are located within the food items or drink structure, the classification of sugars is done. **Intrinsic sugars** are formed inside the cell structure of certain unprocessed food stuffs, the most important being whole fruits and vegetables (containing mainly fructose, glucose and sucrose) **extrinsic sugars**, by contrast, are located outside the molecules of foods and drinks. There are two types; milk extrinsic sugars and nonmilk extrinsic sugars. The extrinsic milk sugars include lactose found in dairy products such as milk and milk products. Nonmilk extrinsic sugars are found in table sugar, confectioneries, soft drinks, biscuits, honey or fruit juice. However, nonmilk extrinsic sugars are more cariogenic and play a vital role in the caries process.

EVIDENCE LINKING DIET AND DENTAL CARIES

The evidence linking diet and dental caries can be summarised under the following headings:

(i) Historical evidence
(ii) Epidemiological evidence
(iii) Experimental evidence

Historical Evidence

It was found that caries was present since about 5 million years in South Africa in hominids in Neolithics. Interestingly, dietary pattern was not known. Eskimos' skulls were free from caries.

Epidemiological Evidence

Tristan da Cunha study. Tristan da Cunha is a remote rocky island in south Atlantic region. Before 1930 and 1940 onwards study showed no evidence of dental caries in this region because of consumption of raw diet. But after volcanic eruption in 1964, people living in this area moved to other areas where they developed dental caries because of change in dietary habits.

During World War II. Due to sugar restriction (rationing) in World War II (1939–1944), dental caries reduced among civilians. At the same time, dental caries experience among army personnel was increased due to increase in sugar consumption as more quantity of ready-made food items were supplied during war time.

Hereditary fructose intolerance (HFI). Hereditary fructose intolerance (1956) is an autosomal recessive disorder of fructose metabolism. Patients having intolerance to fructose avoid fructose and fructose containing dietary factors, because consumption of fructose causes malaise, nausea, vomiting, sweating, cramps, tremors, convulsions, coma and finally death. Hence, dental caries experience among these patients is very low.

Experimental Evidence

Animal studies. Orland et al (1954) did a study on rats. He showed that germ-free rats fed on carbohydrates produced no caries. And also when rats were fed through stomach tube in the presence of cariogenic bacteria in the oral cavity, no dental caries were found.

Human studies.

Vipeholm study, 1954 (Gustaffsone et al Sweden):
This study was conducted in a mental institution in Sweden. Residents were adults and mentally retarded. Before starting this study, they were under normal diet. Later, they were divided into nine groups depending on the type of food consumed. Sucrose in solid forms (chocolate group, bread group and caramel group) were given in different frequency and quantity. And they were given in between meals. In caramel group, 24 toffees and 48 toffees were given to one of the groups.

Findings

1. Significant caries increase occurred when sucrose-containing snacks were taken between meals—***time factor.***
2. More the number of times sucrose was ingested more increase in caries—***frequency.***
3. Sticky forms of sucrose foods, which can retain high sugar levels, were more cariogenic than those cleaned rapidly—***consistency.***
4. Sucrose containing solid foods were more cariogenic than liquid types- ***form.***

Hopewood House study—Harris (1942–1967):
Study was conducted in New South Wales, Australia. Hopewood house is an orphan house containing children from birth to 12 years of age. These subjects were on lactovegetarian diet—rich in milk products and vegetables. The drinking water was having low amount of fluoride. Their oral hygiene practices were poor. Their diet mainly consisted of whole wheat, soyabeans and nuts. Cheese, sugar and refined carbohydrates were totally excluded. They were followed up to 13 years of age (Fig. 31.1).

Findings

1. Significant caries reduction was seen in spite of poor oral hygiene and low level of fluoride in drinking water.
2. When the children go out of this institution after study period was over at the end of 13 years and at later stage when they were exposed to normal diet like any other State schools (Australia) child, containing all kinds of sugars, the caries rate started increasing and the caries experience of children of Hopewood house study was almost similar to state school children (Fig. 31.1). Though the children were on lactovegetarian diet right from the birth, they did not have any special protection against dental caries when teeth were exposed to sugar.

Turku sugar study, Finland (Scheinin and Makinin) *1972 to 1974:*

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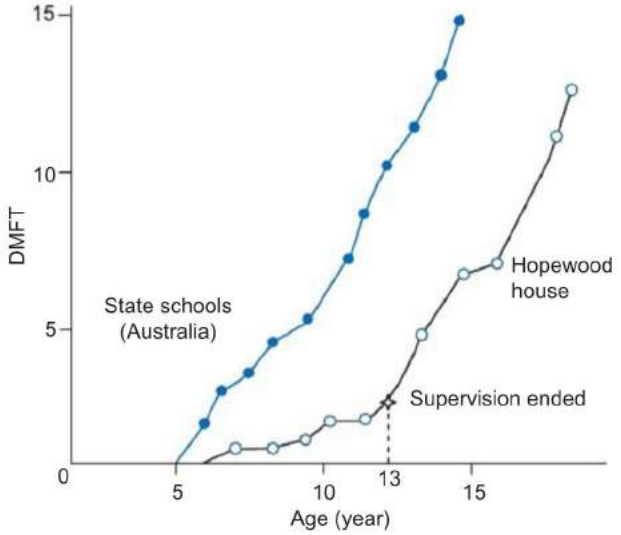


Figure 31.1 Caries experience (DMFT) in children in Hopewood House (with SE of means) and children in state school of New South Wales, Australia.

In this study about 125 subjects of all age groups were included and they were divided into three groups. Each group was given different types of diet.

Objectives: To find out the effect of diet (totally sucrose free) on dental caries increment,

- Sucrose was replaced by xylitol
- One group was given chewing gums containing sucrose
- Another group was given chewing gums containing fructose
- The third group was given chewing gums containing xylitol

Findings

1. Dramatic reduction in dental caries after 2 years among subjects of xylitol group.
2. Fructose group developed more caries than xylitol group.

Sucrose group developed more caries than fructose group.

Between meals chewing of xylitol was anticariogenic.

CARIOGENICITY OF SUCROSE

Sucrose is the arch criminal of dental caries (Newbrun, 1969), it continues to be the most common form of added sugar in the diet, even with continuation of the trend towards increased use of high fructose corn syrup in many industrialized countries. There does not appear to be any difference in the acidogenic potential or the ability to directly induce in situ enamel demineralization among the common sugars, sucrose, maltose, glucose and fructose. Lactose has less acidogenic potential than the other sugars and as a constituent of milk is not considered to be cariogenic mainly due to the protective factors in milk.

Sucrose induces the smooth surface lesion more than any other carbohydrates, especially when treated with *Streptococcus mutans*. Sucrose is the only carbohydrate diet degraded to glucans. Cariogenicity of sucrose does not relate to the ability to increase plaque, but ability of *Streptococcus mutans* to colonize smooth surface in the presence of sucrose. Glucans limit the diffusion of acids away from tooth surface (Fig. 31.2).

Table 31.1 Classic evidence from humans supporting the role of sugar in dental caries

Study	Main conclusions
1. **Vipeholm Study-** *Gustaffsone et al* (1954)	The more frequently sugar is consumed the greater the risk; sugar consumed between meals has much greater caries potential than when consumed during a meal
2. **Turku Sugar** Study-*Scheinin and Makinin (1972 to 1974)*	When sugars are almost completely replaced by non-fermentable sugar substitutes (xylitol), caries increment is dramatically reduced; fructose is less cariogenic than sucrose
3. **World War II-** Takeuchi (1961)	Caries decreased and increased with sugar consumption during and after the war, respectively
4. **Hopewood** House- Harris (1963)	Modern diet more cariogenic than vegetarian low sugar diet
5. **Tristan da Cunha** – Holloway et.al (1963)	Introduction of a modern diet including sugar and refined carbohydrates to this remote island greatly increased caries prevalence
6. **Hereditary Fructose Intolerance-** Marthler (1967)	Less caries in individuals that must avoid sucrose and fructose, but not other sugars and complex carbohydrate
7. **Experimental Caries** in Man	Incipient caries can be rapidly induced by frequent rinsing with high concentration sucrose solutions in the absence of oral hygiene
8. **Stephan Plaque pH Response** – Stefan (1940)	Demonstrated the relationship between sugar exposure resulting in the acidification of dental plaque and caries experience

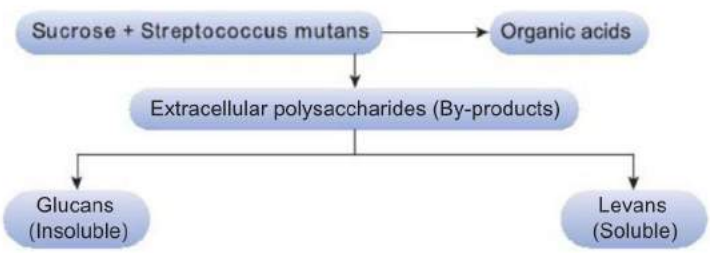


Figure 31.2 Cariogenicity of sucrose.

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Sucrose has been given special importance due to its involvement as a sole substrate in the synthesis of extracellular (water-soluble and water-insoluble) glucans mediated by microbial glycosyltransferase, which has been the subject of intense studies for many years.

Glucan can form a major component of the structural intermicrobial matrix of dental plaque (Guggenheim, 1970). It has been proposed that water-insoluble glucans enhance the ability of mutans streptococci to accumulate on smooth surfaces of teeth (Gibbons, 1984). Several studies have indicated that caries associated virulence of glucan may have more to do with an alteration in plaque ecology than effects on the accumulation on specific bacteria in plaque, whereby sucrose mediated synthesis of glucan increases the porosity of plaque permitting deeper penetration of dietary sugar into the biofilm and greater acid production immediately adjacent to the tooth surface.

STEPHAN CURVE (1940)

Stephan, by using antimony microelectrodes, recorded the pH values of dental plaques in situ before, during, and after a glucose rinse (Fig. 31.3). A typical pH response to plaque following exposure to a glucose rinse is obtained. These curves are often referred to as Stephan curves, and they have three main characteristics. Under resting conditions, pH of plaque is reasonably constant, 6.9-7.2. Following exposure to sugars, the pH drops very rapidly (in few minutes) to the low level (5.5 to 5.2— critical pH) and at this pH, the tooth surface is at risk . Later, slowly it returns to its original value over a period of 10-40 minutes, approximately This is referred as critical period(Fig. 31.3). During this critical period, the tooth mineral dissolves to buffer further acid at lower pH in the plaque-enamel interface and also results in mineral loss. Repeated fall of pH over a period of time leads to more and more mineral loss from the tooth surface and ultimately it presents in unfavourable way resulting in initiation of dental caries

During the period when the tooth mineral dissolves to buffer further acid at lower pH in the plaque-enamel surface and If the tooth buffering were not available, the plaque pH could drop to pH 3 or 4. Unfortunately, salivary buffers are ineffective at pH below 5. If pH drops to 3 or 4, the surface layer would be irreversibly lost. That is why, tooth acts as a buffer to maintain pH near to 5.

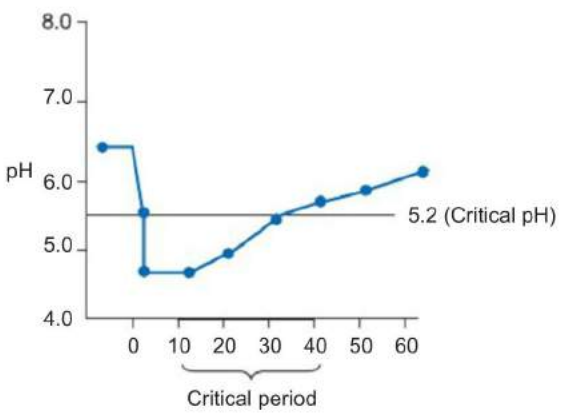


Figure 31.3 Stephan curve minutes after glucose.

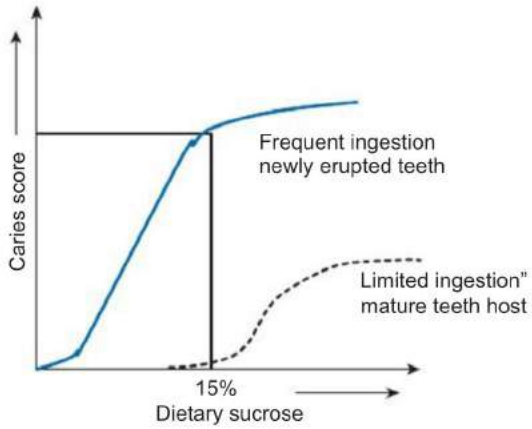


Figure 31.4 Ingestion of sucrose in relation to development of caries process.

Frequent ingestion of sucrose has a lot of influence in initiation and development of caries process in newly erupted teeth compared to matured older teeth (Fig. 31.4).

ORAL CLEARANCE OF CARBOHYDRATES I

Acid production in the plaque depends largely on retentive factors, and time and concentration of sugars in the saliva.

Clearance time for sugar is the time it takes to eliminate these either to levels present before eating or below 0.1%. Clearance time may be prolonged by retentive factors in dentition like malocclusion, cavities, improper restorations, crowns, bridges, orthodontic and prosthetic appliances, low salivary flow and high viscosity. Low sugar clearance is the risk factor for caries activity.

Time taken for clearance of various food items from the oral cavity is depicted in Table 31.2.

Although sucrose is recognized as an important factor in the aetiology and pathogenesis of dental caries, it was pointed out that sucrose is rarely consumed alone and that attention should be paid to the diverse effects of food combinations. For example sucrose/maize mixtures cause plaque pH to fall whereas milk/maize/sugar mixture raises it to alkaline levels, inefficient swallowing might delay carbohydrate clearance from the mouth and thus enhance the cariogenic potential of foods.

Over the years, numerous epidemiological and experimental studies have established the role of sugar in dental caries development. Carbohydrates constitute the largest

Table 31.2 Clearance of various food items from oral cavity

Food items	Times (in mins)
1. Fresh fruits and vegetables	5
2. Caramels, toffees, chocolates	20–40
3. Sugar chewing gum	15
4. Rice	8
5. Potatoes	9
6. Macaroni	11
7. Bread	15–20

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component of the diet, with children consuming as much as seven intakes a day, some of which are snacks rich in added sugars. Among the factors associated with risk of caries development the local effect of diet plays a fundamental role. The frequency of consumption of sugary foods may be as important as the total quantity but it does not clarify which of the two should be considered more important although it should be borne in mind that they are usually combined (Table 31.1).

When sucrose and starch are combined in food stuffs their cariogenicity rises because starch increases the period of time for which the food is in contact with the teeth. So, foods containing starch and sugar are more cariogenic than foods that contain only sugar. Children who eat fruits during main meals presented significantly lower mean dental carious surfaces than those who did not eat fruits. Eating fruits and vegetables five or more times a day is a protective factor against caries and, intake of cheese and nuts is also shown to be associated with less caries experience.

Cariogenicity of sucrose and its synthesis of glucose depend on high concentration of sugar. If sucrose is present in low concentration as in case of fruits and vegetables, it is directly metabolized to lactic acid instead of glucans. It means there is no formation of plaque matrix, i.e. cariogenic plaque. Along with this the fruits and vegetables stimulate increase in salivary flow, have less retention and results in better clearance from the oral cavity. Hence, very less caries or no caries activity takes place when diet consisting more of fresh fruits and vegetables.

Cariogenicity of sucrose is directly related to its concentration. However, sugar content beyond certain level does not increase caries substantially that is more than 15-20% of sugars. Foods and snacks with 15-20% sugars are highly cariogenic.

S-shaped Curve

Peak of dental caries is at 15% of sugar concentration. After this concentration, the curve flattens out indicating that dental caries does not increase substantially beyond certain level (Fig. 31.5).

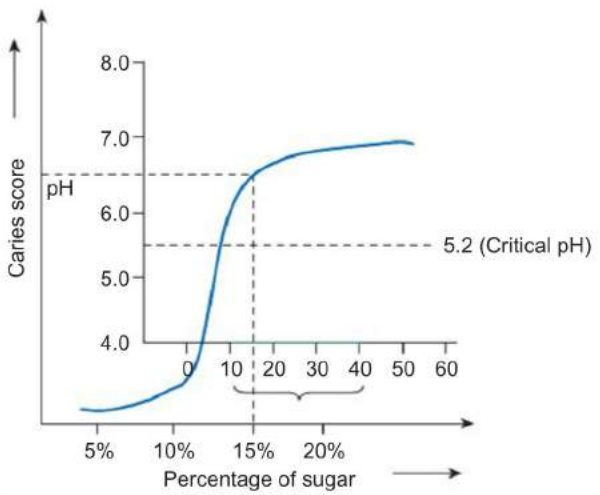


Figure 31.5 S-shaped curve relationship of caries to concentration of sugar.

PREVENTIVE DIETARY PROGRAMME

1. Exclude fermentable sugars from diet.
2. If child is fond of sweets, give them all at mealtime, not between the meals.
3. Include vegetables and fruits, nuts (pea nuts) and cheese as basic diet (increases in salivation).
4. Avoid solid and sticky sugary foods.
5. Reduce the number of sugar exposures.

DIETARY COUNSELLING

During the pre-eruptive periods of development of both deciduous and permanent teeth, foods exert a systemic (nutritional) effect on the formation of the dental matrix and its mineralization. However, during the post-eruptive period, when the deciduous or permanent teeth are fully erupted, foods exert a topical effect (local site contact on tooth surface).

When giving dietary counselling, some food choices and eating habits merit attention (Tables 31.3 and 31.4). These include:

1. Frequency of sugar consumption between meal-snacking,
2. Physical form and retentiveness of sugar-sweetened snacks on and between the teeth, and

Table 31.3 Cariogenicity of food (Stephan, 1996)

Food	Mean caries score
Sucrose	62.1
Milk/chocolate	34.1
Dates	32.7
10% sucrose solution	32.2
Grapes	24.1
Apples	19.1
Carrots	2.1
Oranges	0
Pea nuts	0

Table 31.4 Sugar content (g/100 g)

	Glucose	Fructose	Sucrose
Jam	22	23	05
Marmalade	16	14	30
Fresh fruits	03	05	03
Dried fruits	25	25	23
Ketchup	04	05	12
Salad	02	02	13
Cornflakes	02	01	23
Biscuits	0.2	0.1	21
Yoghurt-sweetened	02	01	08
Ice cream	01	01	13
Soft drink	01	01	08
Constant drink powder	00	00	71

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3. Amount of sugar added to food or beverages for sweetening.

A basic prerequisite for accomplishing dietary change is the advice that patient bears the responsibility for making the change. Minimal requirements for a successful dietary counselling service include:

1. Enrolling active patient involvement in planning, implementing, and evaluating the diet before and after counselling.
2. A simple initial screening that shows a typical 24-hour food intake (normally followed other days of the week) can disclose possible dietary inadequacies, excesses, or both that may exert a negative influence on an individual's dental health—a potential cariogenic diet.
3. Insisting on a series of follow-up visits to tailor the diet to patient's needs and likes, and to avoid if possible dislikes without jeopardizing the dental—oral health status.

TOOTH-FRIENDLY SNACK OR IDEAL SNACK

1. It should stimulate salivary flow.
2. It should have minimum retention on tooth.
3. It should have faster oral clearance rate, e.g. fibrous diet.
4. Snacks should be rich in proteins, minimum in carbohydrates and moderate in the quantity of fat.

SUGAR SUBSTITUTES

Sugar substitutes are less cariogenic or non-cariogenic. Sweeteners stimulate the flow of saliva, thereby they differ from dietary sugars that sweeteners have smaller role or no effect on bacterial glycolysis. Plaque pH usually decreases with sugar intake and raises with sweeteners and accounts for increase in flow of saliva. When plaque pH becomes alkaline, it mobilizes some of the calcium and phosphates and mobilizes for remineralization of the tooth surface and that is the reason, there could be shift from demineralization to remineralization. In those children, who are consuming sucrose containing snacks more frequently, it is ideal to replace the sucrose by sugar substitutes. Unfortunately in the present time, on account of different lifestyle, more and more people are adopting to the consumption of ready-made foodstuffs, which contain refined fermentable carbohydrates more commonly.

FUNCTIONS OF SUGAR IN FOOD TECHNOLOGY

Addition of sugars in food technology acts as

1. Sweeteners
2. Preservative
3. Texture modifier
4. Fermentation substrate
5. Flavouring and colouring agent
6. Bulking agent

CLASSIFICATION

Sweeteners/Sugar Substitutes

Sweeteners are of two types:

1. **Non-caloric sweeteners**
2. **Caloric sweeteners**

Non-caloric sweeteners. They provide no energy but provide intense sweet taste. They are not metabolised to acids. Disadvantages of non-caloric sweeteners are instability and lack of volume e.g. cyclamate, saccharin and aspartame.

Caloric sweeteners

They provide energy and sugars are cariogenic. However, sugar alcohols are non cariogenic

- Sugars—e.g. fructose, glucose, lactose and glucose syrup.
- Sugar alcohols—e.g. lycasin, sorbitol, xylitol and coupling sugar.

Caloric sweeteners are used in sugar free chewing gums, medicines, food products and toothpaste. They are all non-cariogenic. Among all of them sugar alcohol, xylitol is the most popular and widely used at present.

Sugar Alcohols

All sugar alcohols have been classified as hypoacidogenic or nonacidogenic. There is a reduced or virtually no extracellular polysaccharide production from sugar alcohol.

Xylitol. Xylitol is non-cariogenic/anticariogenic and stimulates salivation. It is non-acidogenic. It is a sugar alcohol having an acceptable sweetening taste, promotes remineralisation and approved as a sweetener in more than 45 countries. This is used mainly in chewing gums, ice creams, jams, cookies and soft drinks.

Xylitol stands out and is widely believed to have anticaries properties, which may render it more superior to other sugar alcohols for caries control. Xylitol is not fermented by oral microorganisms and it inhibits the growth of mutant streptococci and also it interferes with glycolysis when glucose is used as energy source.[7]

Sorbitol. This is a low cariogenic sugar substitute used mainly as sweetener in chewing gums, soft drinks, cookies and jams. It is not as sweet as sucrose.

Coupling sugar. These sugars are very effective sugar substitutes and anticariogenic. It exactly resembles sucrose. At present it is used widely in the making of variety of snacks in Japan. The disadvantage is that it is too expensive.

Saccharin. It is non-caloric and less cariogenic. It leaves some bitter taste later, and it is highly intense sweetener.

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DIFFICULTIES IN SUBSTITUTION OF SUCROSE

1. The sweetness of sweetener varies widely. If sweetness of sucrose is 1, then that of lactose is 0.2; whereas saccharine is 300 times, aspartame is 180. So if we replace sucrose, taste changes drastically.
2. Single sweetener is not able to replace or fulfill all roles of sucrose in different products.
3. For baking, sugar alcohols like xylitol and sorbitol are unsuitable. Xylitol and sorbitol must not be added before fermentation during process of making the bakery products (bread and cake).
4. Sweetening power of glucose, lactose and maltose syrups are insufficient to sweeten food products.
5. Saccharine leaves some bitter after taste.
6. They are expensive.

Summary of Sugar Substitutes

1. There is no perfect sugar substitute.
2. Non-caloric substitutes can be classified as non-cariogenic.
3. They may be used in beverages like coffee, tea.
4. Sugars like fructose, glucose cannot be recommended due to cariogenicity.
5. Sugar alcohols like xylitol, sorbitol, lycasin are low cariogenic or anticariogenic.
6. These can be used in chewing gum, medicines, and lozenges.
7. Most important goal of preventive dentistry including dietary advice must always be to reduce consumption of sweet products to a minimum.

CONCLUSION

Dental caries is a diet-related disease that continues to be a problem for certain dental patients. Frequent consumption of fermentable carbohydrates that have low oral clearance rates increases the risk of enamel caries. Highly acidogenic snack foods should be consumed at meal times to reduce the risk and between meal snacks should be non-acidogenic (e.g. xylitol products). Diet containing cheese may provide anticariogenic effect. Certain additives as well as sugar substitutes show great promise for the provision of between meal snack foods that reduce the risk of development of dental caries. Nonmilk extrinsic sugars (sucrose) are highly cario-genic.Frequency of eating or drinking nonmilk extrinsic sugar is important in caries development. However, frequency and time of intake are closely correlated.Intrinsic sugars as found in fresh fruits and vegetables and cooked staple starchy food such as rice and potato are of low cariogenicity. Milk extrinsic sugars, e.g. milk are virtually noncariogenic. Nonsugar sweeteners or sugar substitutes are noncariogenic. Xylitol possesses anti caries properties. Regular use of xylitol is more likely to reduce the caries inductive properties of dental plaque.

A professional team should thoroughly understand the relationship of diet to caries and consciously apply that kind of knowledge to educate and motivate the patients in general and also counsel the specific high-risk individuals.

REVIEW QUESTIONS

1. Discuss various studies on diet and dental caries.
2. Classify carbohydrates. Discuss carcinogenicity of sucrose.
3. Write short notes on:
   a. Stephan curve
   b. Tristan da Cunha study
   c. Hereditary fructose intolerance
   d. Hopewood House study
   e. Sugar substitutes
   f. Sugar alcohols

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Caries Risk Assessment

32

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INTRODUCTION

Dental caries is a chronic, transmissible, carbohydrate modified, local infection with saliva acting as an important regulator. The initiation, development and progression of dental caries are influenced by combination of a variety of factors like oral health status, aetiologic factors, preventive factors, modifying factors and other risk factors. Because of its multifactorial nature, the pattern and prevalence of dental caries is highly variable and unevenly distributed. The risk for caries development also varies significantly for different age groups, individuals, teeth and teeth surfaces. Hence, caries preventive measures should not only be tailored to the individual's risk, but also should target teeth and surfaces at risk.

RISK GROUP

Risk groups can be divided into two categories: (i) risk age group and (ii) other risk groups.

Risk Age Group

According to some recent studies, initiation of dental caries is age specific, especially in children and also in adults. The Prime risk period in children for initiation of caries seems to be during eruption of permanent molars and at the time when enamel is undergoing secondary maturation. In adults, root caries development is seen in the older age group, which could be attributed to a higher prevalence of exposed root surfaces.

Age 5–8 years. The risk of caries development in 5–8-year-old children is high owing to the eruption of first permanent molars. The enamel of erupting and newly erupted permanent teeth is considerably more susceptible to caries development until secondary maturation is completed, which is generally after more than two years of eruption.

Age 11–15 years. The risk of caries development in 11–15 year old children is high due to eruption of second permanent molar. Normally, second molar erupts at the age of 11–12 years and total eruption time ranging from 14–18 months. The proximal surfaces of newly erupted posterior teeth are usually at maximum risk for caries development. Therefore, 11–15 years olds have not only by far the highest number of intact tooth surfaces but also the more number of surfaces at risk.

Young adults and adults (19–22 years). The risk at this age group can be attributed to the erupting or erupted third molars without full chewing function and having highly susceptible fissure for caries on mesial surfaces. In addition, changes in lifestyle, oral hygiene habits and dietary practices due to peer pressure (towards good or bad habits) increases the risk for development of dental caries.

Older adults. Individuals in this group having multiple restorations with plaque-retentive margins and exposed root surfaces as a result of chronic periodontitis are susceptible for root caries development.

Other Risk Groups

Mothers with High Salivary Mutans Streptococci (MS)

Mothers are the prime source from whom MS is transmitted to their children as soon as first primary tooth erupts. The enamel of erupting and newly erupted primary teeth has voids until completion of secondary maturation, and hence is highly susceptible for caries development. The specific immune system is also immature, particularly the immunoglobulin in saliva among 1–3 year olds. In addition, if oral hygiene maintenance is poor, it favours the establishment of carious micro flora.

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Based on this, the expectant mothers and 1–3 years old children form the first priority age group.

- Obese individuals who snack frequently (sugary snacks)
- Individuals with systemic diseases who are on regular medications (affecting salivary function)
- Pregnant women and lactating mothers
- Individuals with impaired salivary functions or immune response
- Persons undergoing radiation therapy for malignancies of head and neck region

Key Risk Teeth and Surfaces

The risk for caries development is different for different teeth and surfaces owing to many factors. Also the risk varies with time and a particular tooth or surface may become highly susceptible at a particular point of time.

Among the teeth, the molars are the first permanent teeth to erupt into oral cavity and have the widest approximal surfaces, thus increasing their risk for dental caries. On the contrary, the mandibular incisors are least susceptible or at low risk for dental caries. Among the surfaces, the fissures of the molars and approximal surfaces from the distal aspect of first molars to the mesial aspect of second molars are at high risk for caries. The wide mesial surfaces of the first molars become exposed to cariogenic micro flora when the second premolars erupt. In the primary dentition, the approximal surfaces are highly susceptible.

In general, all newly erupted teeth are more or less deficient in mineral content, and thus are more susceptible for caries as compared to after some years of post-eruptive maturation.

FACTORS RELEVANT FOR ASSESSMENT OF CARIES RISK

Factors relevant to caries risk are depicted in Table 32.1. The relevant histories regarding following factors are

Table 32.1 Factors relevant to caries risk assessment

Low Risk	High Risk
1. *Social component*	1. *Social component*
• Middle class	• Socially deprived
• Low caries in siblings	• High caries in siblings
• Dentally aware	• Low knowledge about dental disease
• Regular attender	• Irregular attender
• High dental aspirations	• Low dental aspirations
2. No medical problem	2. Medically compromised
3. Normal salivary flow	3. Xerostomia
4. No long-term medication	4. Long-term cariogenic medicine
5. *Dietary habits*	• Frequent sugar intake
• Infrequent sugar intake	• Frequent intake of high sugar snacks
• Low sugar snacks intake	• Intake of sugar in between meals
• Intake of sugar at meals	• Non-fluoride areas
6. *Fluorides*	• No fluoride supplements
• Fluoridated area	• No fluoride toothpaste and mouth rinses
• Fluoride supplements used	5. Infrequent ineffective cleaning
• Fluoride toothpaste and mouth rinses	6. Poor oral hygiene status
7. Frequent effective cleaning after every meal	7. Low salivary flow rate (xerostomia)
8. Good oral hygiene status	8. Low buffering capacity of saliva
9. High buffering capacity of saliva	9. High *S. mutans* and *Lactobacillus* counts
10. Low *S. mutans* and *Lactobacillus* counts	• Frequently found new lesions
11. *Clinical evidence*	• Premature extractions
• No new lesions	• Anterior caries or restorations
• No extractions for caries	• Multiple restorations
• Sound anterior teeth	• History of repeated restorations
• No or few restorations	• Multiband orthodontics and partial dentures
• Restorations inserted years ago	
• No appliances	

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important and useful in assessing caries risk among different groups of people. The factors are: (i) social aspect, (ii) medical history, (iii) dietary habits, (iv) use of fluorides, (v) plaque control measures and (vi) saliva.

CLINICAL EVIDENCE

The best predictor of caries risk are clinical findings. Subjects with the following characteristics are considered to be at high risk:

1. Multiple new carious lesions
2. History of premature extraction for caries
3. Several restorations
4. Caries or restorations in anterior teeth
5. History of secondary caries or frequent replacement of restorations

IDENTIFYING RELEVANT RISK FACTORS

Though determination of risk status of a patient takes a short time, explaining the cause of the risk usually takes a long time. It is definitely worth spending long time because it might help either the patient or the dentist to modify some of the risk factors, in turn slowing down the disease progression. Removal of plaque from the tooth surface that is developing a white spot lesion is a good example of this. For some patients, frequent consumption of particular drink, snack or eatables may be of significance to their caries risk, and modification of this factor may be essential to change this risk.

Certain risk factors such as dry mouth or social deprivation are difficult to modify. A patient with Sjogren's syndrome may always be at a high risk and always have to make strenuous efforts for prevention. It is almost impossible to modify or elevate social deprivation in any particular patient or group of people. However, social factors can change over time, sometimes for better and sometimes for worst. Enormous research effort and understanding has been put into risk assessment and yielded much of use to the practitioner. However, to define one factor of over-riding importance in this multifactorial disease seems of little concern. Similarly, those who ask for weightages to be given to various risk factors, to delineate their importance, seem to have missed the point. For instance, social deprivation is an important risk indicator but not all socially deprived people are at high risk—a patient with a dry mouth may be at high risk despite very rich status.

CARIES RISK ASSESSMENT TOOLS

Caries risk assessment procedures used in dental practice usually has adequate data to accurately estimate a person's susceptibility to dental caries and allow for preventive measures. Caries-risk assessment models currently involve a combination of factors including diet, fluoride exposure, a susceptible host and microflora along with demographic factors such as social, cultural and behavioural factors. These tools can be used by dental professionals in order to

- Identify high risk individuals.
- Provide and justify the services and quality of care with outcome assessment.

The following are the various tools for caries risk assessment.

Caries Risk Assessment Tool (CAT) by American Association of Pediatric Dentistry (AAPD)

This tool includes 3 factors: biological, protective and clinical findings. Based on the age of the patient, appropriate form can be used. The factors included for caries risk assessment for 0-3 years have been shown in the following.

Biological	Protective	Clinical Findings
Mother/primary caregiver has active cavities	Child receives optimally-fluoridated drinking water or fluoride supplements	Child has white spot lesions or enamel defects
Parent/caregiver has low socioeconomic status	Child has teeth brushed daily with fluoridated toothpaste	Child has visible cavities or fillings
Child has >3 between meal sugar-containing snacks or beverages per day	Child receives topical fluoride from health professional	Child has plaque on teeth
Child is put to bed with a bottle containing natural or added sugar	Child has dental home/ regular dental care	
Child has special health care needs		
Child is a recent immigrant		

Caries Risk Assessment by American Dental Association (ADA)

This tool classifies the patient into 3 categories namely low, moderate and high risk based on domains that include: contributing conditions, general health conditions and clinical conditions. The factors considered under each domain are listed below:

Contributing Conditions	General Health Conditions	Clinical Conditions
Fluoride exposure	Special health care needs	Cavitated or non-cavitated carious lesions or restorations
Sugary foods or drinks	Chemo/radiation therapy	Teeth missing due to caries in past 36 months
Caries experience of mother, caregiver and/or other siblings	Eating disorders	Visible plaque
Dental home	Medications that reduce salivary flow	Unusual tooth morphology
	Drug / alcohol abuse	Interproximal restorations

Continued

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Contributing Conditions	General Health Conditions	Clinical Conditions
		Exposed root surfaces
		Restorations with overhangs or open margins
		Dental / orthodontic appliances
		Severe dry mouth

Caries Management by Risk Assessment (CAMBRA)

CAMBRA is an evidence-based approach to preventing and treating caries at an early stage by identifying the cause of dental caries. For the diagnosis of caries risk, patient interview and clinical examination are conducted to collect information on disease indicators like visible cavities, white spots etc., biological predisposing factors like mutans streptococcus and lactobacilli counts, visible plaque, deep pits and fissures etc and protective factors like living in fluoridated community, use of fluoridated toothpaste, mouthrinse or varnish etc. The individuals are classified based on their caries risk into four categories namely: low, moderate, high and extreme high.

Caries Risk Assessment Using Cariogram

Cariogram is a computer-based educational interactive programme, which graphically depicts the 'chance' for the promotion of a new carious lesion in the near future and can be used for both patient education and in clinical setting. The Cariogram is a pie circle diagram, which is divided into five sectors with five different colours mainly: *green, dark blue, red, light blue, yellow* indicating the different factors related to dental caries.

Green: An estimation of the 'actual chance to avoid new cavities'. The green sector is 'what is left' when the other factors have taken their share.

Dark blue: 'Diet' is based on a combination of food contents and frequency of intake.

Red: 'Bacteria' is based on a combination of the amount of plaque and mutans streptococci.

Light blue: 'Susceptibility' is based on a combination of fluoride programme, saliva secretion and saliva buffer capacity.

Yellow: 'Circumstances' is based on a combination of past caries experience and related diseases.

A larger green sector indicates better chance of avoiding dental caries in the future.

Smaller green sector means low chance of avoiding caries and hence high caries risk.

For detailed explaination of Cariogram refer to Chapter 34.

CARIES DIAGNOSIS AND LESION DETECTION

Diagnosis implies deciding whether a lesion is active, progressing rapidly or slowly, or whether the lesion is already arrested. Without this knowledge, logical decision about treatment is impossible, e.g. an active white spot lesion requires preventive treatment, whereas no treatment is required for an arrested lesion.

Importance of Early Diagnosis

It is important to diagnose early carious lesion (white spot lesion) as soon as possible, preferably before the surface of the tooth has cavitated. Such pre-cavitated or non-cavitated carious lesions are significantly more prevalent than cavitated carious lesions. Pre-cavitated carious pits and fissures are the most prevalent type in children. Second, *pre-cavitated carious pits and fissures are three times more likely to be restored compared to sound tooth surface.* However, findings of many studies indicate that significant proportion of fissures should be sealed and only fewer fissures should be restored than present levels. In fact, given the disease severity presently and in the next century to come, *sealants and micro restorations could well become the major form of therapeutic management of dental caries.*

While large proportions of pre-cavitated carious lesions are smooth surface lesions in children which regress or progress slowly during one-year period. Whereas the pattern of progression of lesion in early life of infants and young children may be progressed to cavitation between the ages of 2.5 and 3.5 years. However, in the fluoridated area incipient caries lesion might remain unchanged for a couple of years and rarely progresses to cavitation. Thus, it is very appropriate that detection of pre-cavitated or non-cavitated carious lesions becomes very important to manage and monitor the carious activity in the preventive strategy for appropriate patient care.

Prerequisites for early diagnosis. Caries diagnosis requires:

1. Good lighting
2. Clean teeth (free from deposits)
3. A three-in-one syringe so that tooth can be viewed both wet and dry
4. Sharp eyes
5. Blunt explorer
6. Reproducible bitewing radiographs

CONCLUSION

A combination of factors like aetiological factors, prevalence and incidence of dental caries, external and internal modifying risk indicators, risk factors, protective factors etc may be used to assess an individual's caries risk as or high. It is not sufficient if caries preventive measures are tailored to predicted individual risk but it should also target the key teeth and surfaces at risk.

No single variable has proven to be successful in predicting caries development for the majority of the population. Most variables that have been investigated are related to

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CONCLUSION—cont'd

the classic caries model: host, microflora and diet. The most relevant of these models for predicting subjects, who are likely to experience an increase in disease, are those based on longitudinal study data.

Assessment of caries risk is an important part of contemporary dental practice. Such assessment in everyday practice is important as it makes economic sense to target preventive treatments at the appropriate risk groups. Dental care is not a onetime affair that could be provided in a single appointment, but is an ongoing and continuous process. Caries risk assessment could be used to some extent to schedule recall intervals.

REVIEW QUESTIONS

1. Discuss the factors relevant to caries risk assessment.
2. Risk groups for dental caries.
3. Clinical evidence for identification of risk groups for dental caries.
4. Identification of relevant risk factors for dental caries.
5. Cariogram.

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33 Caries Activity Tests

Hiremath SS

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INTRODUCTION

Dental caries is a transmissible local infection induced by the effect of *s.mutans* on carbohydrates with saliva as a critical regulator. Clinical examination and findings will determine the diagnosis of dental caries. The activity and severity of the dental caries is described in terms of primary and secondary caries, white spot lesions (initial caries), cavitated lesions, arrested caries and root caries.

With the better understanding of multifactorial aetiology of dental caries, today, the disease is not only consideredas treatable but also preventable infection to the most aspects. Aetiological factors can be evaluated before the appearance of clinical signs and symptoms as well as in cases with already existing lesions and fillings. Appropriate measures taken subsequently can reduce the risk factors, which are responsible for future problems.

It is well known that certain individuals develop much more caries than others do. It is because of more risk factors present in some individuals. Hence, it is advisable to have caries risk assessment as well as caries activity evaluation of individual patients with regard to management of caries among high-risk groups. Caries activity tests are valuable adjunct for patient's motivation in plaque control programmes, but there is no ideal test available yet.

CARIES ACTIVITY TESTS

Unfortunately, no single test can fully explain or predict the dental caries owing to its multifactorial and complex aetiology. Using the term "caries activity test" may be misleading since it gives information on a particularly selected factors, which are important in the carious process. Laboratory tests should accurately reflect on the three overlapping circles presented by keys; (i) **the bacterial challenge**, (ii) **the sugar content of the diet** and (iii) **tooth and host resistance** (susceptibility) with remineralisation potential along with being simple, inexpensive and rapid. Considering these requirements, the following set of test might be useful:

- Bacterial challenge—Mutans streptococcai evaluation acting as relative risk indicator
- Diet—Lactobacilli evaluation for indication of dietary sugar content
- Remineralisation potential—Biological repair potential through salivary flow rate and buffer capacity
- Host susceptibility—Caries experience as past activity indicator.

There are a number of caries activity tests available. These are

i. lactobacillus test,
ii. Snyder test,
iii. reductase test,
iv. buffer capacity test,
v. Fosdick calcium dissolution test,
vi. plaque-toothpick method,
vii. saliva-tongue blade method,
viii. *Streptococcus mutans* adherence test,
ix. *Streptococcus mutans* dip-slide method, and
x. *Streptococcus mutans* replicate technique.

Commonly used caries activity tests are discussed in the following. However, tests (viii to x) are discussed under mutans group of streptococci screening tests.

Lactobacillus Test (Hadley—1933)

Lactobacillus test is used for estimation of *Lactobacillus* colonies appeared on LBS agar (Rogosa) after inoculation with a sample of saliva.

Collection of saliva involves chewing on paraffin wax before breakfast and then collected into a bottle. The specimen will be subjected to vortex mixer to mix it. The dilution of 1:10 and 1:100 are prepared by mixing with sterile salt solution. Using a bent glsdd rod 0.4 ml of 1:100 diluted saliva is spread on the surface of agar plate. The labeled plates are then incubated for 3–4 days at 37°C. Then, the numbers of colonies are counted using Quebec counter (Table 33.1).

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Table 33.1 Lactobacillus test

No. of Lactobacillus per ML of Saliva	Caries Activity
0–1000	Little or none
1000–5000	Slight
5000–10000	Moderate
> 10000	Marked

Limitations
- Not simple as counting colonies can be tedious.
- Needs professional training.
- Requires complex equipment and hence costly.
- The results are not available for several day.
- *Lactobacillus* count varies in the same individual.

For example, eating cheese can raise the *Lactobacillus* count in the patient who has less caries activity. The intake of dietary carbohydrates highly influences the levels of Lactobacillus, which reflects the amount of bacterial substrate and indicats an acid environment within the oral cavity. The lactobacilli has lower prevalence compared to mutans streptococci.

Alternatively, undiluted paraffin-stimulated saliva is poured over a plastic slide that is coated with LBS agar. The slide is placed in a sterile tube and incubated at 37°C for 4 days. Then the colony density instead of counting is compared with a model chart and classified as about 1000, 10000, 100000 or 1000000 aciduring organisms for ml of saliva.

This new method is simple, cost-effective, and easy to read the results and offers a practical office test.

Snyder Test

The rapidity of acid formation is measured by Snyder test by inoculating stimulating saliva into glucose agar with pH adjusted to 4.7 to 5. Bromocresol green acts as color indicator (Table 33.2).

Saliva is collected before breakfast by having the subject chew paraffin. Snyder glucose agar is melted in a tube and then cooled to 50°C. The saliva specimen is subjected to 3 minutes of vigorous shaking. Then 0.2 ml of saliva is pipetted into the tube of agar and mixed immediately by rotating the tube. Following solidification of agar in the tube, it is incubated at 37°C. The change in colour by the indicator is observed after 24, 48 and 72 hours of incubation (Table 33.2).

Table 33.2 Snyder test

	Time (hours)		
	24	48	72
• Colour	• Yellow	• Yellow	• Yellow
• Caries activity	• Marked	• Definite	• Limited
• Colour	• Green	• Green	• Green
• Caries activity	• Continue test	• Continue test	• Inactive

Advantages
- Simple
- Takes 24 to 48 hours and required only simple equipment. Some training is needed and the cost is moderate
- Correlation with clinical trials

Reductase Test

Reductase test measures the rate at which an indicator diazo resorcinol, changes color from blue to red to colourless or leukoform on reduction by mixed salivary flora.

Saliva is collected before breakfast having subject chew paraffin and expectorating directly into the collection tube. (The activity of enzyme reductase is measured by this test. This enzyme is involved in formation of products dangerous to the tooth surface through some very definite and limiting reactions.)

When the saliva reaches the calibration mark (5 ml,) the reagent cap is replaced. The sample is mixed with a fixed amount of diazo resorcinol, the reagent upon which the reductase enzyme is to react. The change in colour after 30 seconds and after 15 minutes is taken as a measure of caries activity (Table 33.3).

Advantages
- Good correlation with clinical experience.
- Measure of oral hygiene status of an individual.
- Caries-free adults exhibit low or negative scores on reductase test.

Buffer Capacity Test

The test measures the number of milliliters of acid required to lower the pH of the saliva through an arbitrary pH interval, such as from pH 7 to 6, or amount of acid or base necessary to bring color indicators to their end point. The pH meter or color indicators are used to quantify the buffer capacity.

Ten ml of stimulated saliva is collected at least one hour after eating; of which 5 ml is measured into a beaker. After adjusting the pH meter to room temperature, the pH of saliva is adjusted to 7 by addition of lactic acid or base. Re-recording of lactic acid level in the measuring cylinder is made. Lactic acid is then added to the sample until a pH of 6 is reached. The number of ml of lactic acid needed to reduce pH from 7 to 6 is a measure of buffer capacity. This

Table 33.3 Reductase test

Colour	Time	Scores	Caries Activity
Blue	15 minutes	1	Non conducive
Orchid	15 minutes	2	Slightly conducive
Red	15 minutes	3	Moderately conducive
Red	Immediately	4	Highly conducive
Pink or white	Immediately	5	Extremely conducive

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number can be converted to milliequiva-lents (mEq) per litre.

Advantages
- The buffering capacity of saliva and caries activity are in inverse relationship according to this test.
- Frequently lower acid-buffering capacity is seen in the saliva of individuals with considerable number of carious lesions compared to those who are relatively cries-free.

Disadvantage
- This test, however, does not adequately correlate with the caries activity.

Fosdick Calcium Dissolution Test

The test measures milligrams of powdered enamel dissolved in 4 hours by the acid produced by mixing patient's saliva with glucose and powdered enamel.

Calcium content is analyzed for part of saliva derived from 25 ml of gum stimulated saliva. The rest is placed in a sealed sterile tube with about 0.1 g of powdered enamel and shaken for 4 hours at body temperature. Analysis of calcium content is repeated again. If paraffin is used to stimulate saliva, a concentration of about 5% glucose is added. The amount of enamel dissolution increases with the increase in caries activity.

Limitations
- Not simple
- Costly equipment
- High cost
- Require trained personnel

MUTANS GROUP OF STREPTOCOCCI SCREENING TESTS

Plaque-Toothpick Method

Plaque samples are collected from the gingival third of buccal tooth surfaces (one from each quadrant) and placed in Ringer's solution. The sample is shaken until homogenized. Then, the plaque suspension is streaked across a mitis-salivarius agar plate. Incubated at 37°C for 72 hours, the cultures are examined under a low-power microscope and the total colonies in 10 fields are recorded (Table 33.4).

This test is an attempt to semi-quantitatively screen the dental plaque for a specific group of caries inducing streptococci, *Streptococcus mutans*.

Table 33.4 Plaque-toothpick method

Grade	Colonies/10 Fields
1	None
2	<8
3	>8

Saliva/Tongue Blade Method

Saliva/tongue blade method estimates the numbers of *S. mutans* in mixed paraffin-stimulated saliva when cultured on mitis-salivarius bacitracin (MSB) agar.

The subjects displace plaque microorganisms by chewing paraffin for one minute, thereby increasing the proportions of plaque microorganisms in the saliva. The subjects are given a sterile tongue blade, which they rotate in their mouth 10 times, so that both sides of the tongue blade are thoroughly inoculated by the subject's flora. The tongue blade is withdrawing through closed lips to remove excess of saliva. Both sides of the tongue blade are then pressed onto an MSB agar in petri dish, and then incubated at 37°C for 48 hours.

S. mutans Adherence Method

This test is developed for use with a large number of school children and avoids necessary collection of saliva.

The ability of *S. mutans* in salivary samples to adhere to glass surfaces when grown in sucrose-containing broth is categorized by this test.

Unstimulated (0.1 ml) saliva is inoculated in MSB broth. Inoculated tubes are set at 6° angle and incubated at 37°C for 24 hours. After growth has been observed, the supernatant medium is removed, and the cells adhering to the glass surface are examined macroscopically and are scored as:

– No growth expressed
+ A few deposits ranging from 1–10 × 10^4 CFU/ml
++ Scattered deposits of small size
+++ > 20 × 10^4 CFU/ml deposits

Advantages
- Simple
- Used in epidemiologicalstudies and preventive practices

S. mutans Dip-slide Method

These tests (Dentocult SM, Orion Diagnostica, Caries—Screen SM, Apo Diagnostics) classify salivary samples according to the estimates of *S. mutans* colonies growing on modified mitis-salivarius agar.

Dentocult SM: The subject chews the paraffin wax, and stimulated saliva is collected for 5 minutes. The saliva is poured over a agar-coated slide, totally wetting the surface, and the excess is allowed to drain off. After the slide dries for 10-15 minutes, the bacitracin discs are placed in the middle of the inoculated agar about 1 cm from each other. A carbon dioxide tablet is inserted in the tube containing the slide, which is incubated for 48 hours.

A zone of inhibition of 10-20 mm in diameter is formed around each disc. If present, *S. mutans* appears as small blue colonies growing within the zone of inhibition.

The colony density is compared with a model chart and classified as:

0 Negligible
1 < 1,00,000
2 1,00,000-10,00,000
3 >10,00,000 *S. mutans* CFU/ml

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S. mutans Replicate Technique

This method localizes *S. mutans* colonies on tooth surfaces, using a solid impression matrix comprised primarily of sucrose and a commercial gum base.

An imprint of the tooth surfaces to be sampled is obtained by pressing the matrix against it, after which the matrix is washed for several seconds in water to remove non-adherent cells and saliva. The matrices are placed in the liquid broth, incubated at 37°C, then removed and examined directly for overgrowth of *S. mutans* colonies at specific sites (e.g. occlusal and root surfaces).

USES

Caries activity tests have several uses for both clinicians as well as research workers.

For Clinician

1. To determine the need for caries control measures
2. As a patient co-operation indicator
3. As an aid in timing of recall appointments
4. As a guide to insertion of expensive restorations
5. To aid in determining the prognosis
6. As a precautionary signal to the orthodontist in placing bands

For Research Worker

1. As an aid in the selection of patients for caries research
2. To help in the screening of potential therapeutic agents
3. To serve as an indicator of periods of exacerbation and remission

Snyder has suggested that a suitable caries activity test should

1. Have a sound theoretical basis
2. Show maximum correlation with clinical status
3. Be accurate with duplication of results
4. Be simple
5. Be inexpensive
6. Take little time

CONCLUSION

Caries is a transmissible local infection involving aciduric microorganisms, like mutans streptococci and lactobacilli. With the knowledge of factors such as microbial challenge, intake of refined fermentable carbohydrates and the hosts' capacity of self-repair, dental caries can be prevented, arrested or sometimes reversed.

Caries risk assessment strategies can be applied for populations, larger or smaller groups or at individual levels. There is no single test that can accurately reflect the complex caries activity. Although, caries activity tests of mutans streptococci and lactobacilli show strong correlation with caries in epidemiological studies, they are generally of limited value for risk screening purposes in communities with a low prevalence of caries. On the contrary, predictive power and the value of the microbial tests are increased among the groups of individuals with higher caries incidence such as medically compromised patients, low socioeconomic status and residents of low fluoride areas.

Negative or very low count of mutans streptococci and lactobacilli are highly predictive for subjects at low risk of getting caries. Past caries prevalence is the most powerful single predictor on a population basis. Microbiological tests should be regarded as monitors of oral ecology. Any increase in the challenge factors or decrease in defence, protective and repairing factors at any time should be considered as a warning sign.

REVIEW QUESTIONS

1. Discuss various caries activity tests.
2. Write notes on:
   a. Lactobacillus test
   b. Snyder's test
   c. Streptococci screening tests
   d. Uses of caries activity tests
   e. Caries susceptibility tests

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34 Cariogram

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CHAPTER OUTLINE

Cariogram—The Five Sectors 294
"Chance to Avoid Caries" 295
Principles of Caries Risk Estimation Based on "Cariogram" Concept 295
Using the Cariogram for Evaluation of Caries Risk 298

Dental caries is one of the most common global dental diseases. Although it is directly caused by bacteria on the teeth, to a large extent it is considered to be multifactorial in etiology. Cariogram is a new method in which it illustrates the interaction between various related factors causing dental caries. Cariogram thus is an educational interactive programme, which has been developed for understanding the various multifactorial nature of caries in a simple way and acts as a guide to estimate the caries risk. Cariogram can be used in the clinical setting and also for education purpose. By explaining the caries risk graphically, the cariogram depicts the 'chance' for promotion of a new carious lesion in the near future. It might illustrate to what extent various factors might affect this chance.

A programme was constructed and launched officially in November 1997 by Professor Douglas Bratthall at the Faculty of Odontology at Malmö University College in Sweden, in Swedish version after extensive trial. The theory of assessing the caries risk is easy and uncomplicated, but the main concept behind assessing caries risk is to identify persons with high risk and to initiate the appropriate preventive procedures at correct time so that one can avoid dental caries in the future. It is also important to decide where one should use 'risk model' and 'prediction model'. In case of identifying disease risk and to initiating preventive treatment, one can opt for risk model where this model mainly concentrate on risk indicators like bacterial load I, dietary habits, food impaction areas etc. If one is interested only in identifying who is at greater risk can use prediction model where this model uses risk predictors like past disease experience, treatments, number of teeth involved etc. There is no such models and theoretical tool with which one can exactly calculate the Caries Risk.

It is just impossible to state that whether any patient will develop cavities or not during the coming next year with hundred percent certainty. On the other hand, based on the available information it may be possible to say that patients might develop several cavities during the coming years.

CARIOGRAM—THE FIVE SECTORS

The Cariogram is a pie circle diagram, which is divided into 5 sectors with 5 different colours mainly: ***green, dark blue, red, light blue, yellow*** indicating the different factors related to dental caries (Fig. 34.1).

Green: It is an inference of the 'actual chance to evade new caries in near future; provided the other sectors remains same'. The area of green sector is decided at the end by the software after all the other sectors are filled.

Dark blue: This sector denotes Diet where diet contents and frequency is considered.

Red: The bacterial load(Mutans streptococcus and Lactobacillus) in saliva and amount of plaque on teeth decides this sector.

Light blue: Is decided by amalgamation of fluoride usage, amount of saliva secretion and buffering capacity of saliva.

Yellow: Indicate 'Circumstances', which influences dental caries prevalence like past caries experience and related diseases.

Interpretation of caries risk is mainly decided by measuring the green sector. Greater the share of Green

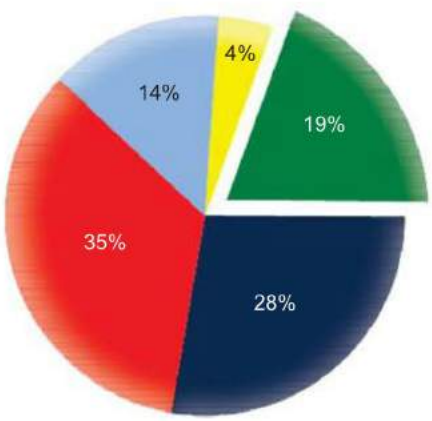


Figure 34.1 The cariogram.

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sector in Cariogram more chance of avoiding caries in near future. Smaller the share of green sector means higher the risk of getting new caries in near future. It is opposite in other sectors, i.e. smaller the sectors lesser susceptibility to caries, larger the sector greater the risk of getting caries.

Aims of Cariogram

It illustrates:

- The interaction of caries-related factors
- The chance to avoid new caries
- Graphical expression of caries risk
- Recommends preventive action for target group
- Used in the clinical set-up
- Mainly used for the education programme

For high caries risk group, targeted preventive action can be directed so that occurrence of cavities could be avoided.

For planning tailored preventive program for the high-risk individual, it is very much necessary that caries risk assessment tool should be precise so that risk factors could be targeted as soon as possible and avoiding new caries in high-risk individual.

Caries Risk

Risk is the likelihood that some detrimental incident will occur. In general, risk is defined as a likelihood of a surplus incident or detrimental incident happening in a specified period of time. In general, caries risk is defined as 'an individual might get new caries in near future provided the detrimental factors remain constant for the specified period of time'. Thus, 'Caries Risk' is the probability that an individual might get caries in near future.

Factors considered in the estimation of caries risk. These factors are divided into two groups (Table 34.1):

1. Those factors involved immediately in the caries process are grouped either as "defence" or "attack" mechanisms at the location of development of caries lesion. The cariogenic dental plaque, the presence of various types of specific microorganisms in the plaque and cariogenic diet can be included in this attack group. On the other hand, salivary protective factors and the exposure to fluoride can be included in the defence group. These are the main key factors deciding whether caries will occur or not at the specific tooth surface they are interacting.
2. There are some factors, which are concerned with the caries occurrence, without actually participating in the development of lesion like previous caries experience and socioeconomic factors. Such factors are generally designated as caries risk indicators; but, however, they do not actually participate in the development of caries.

"CHANCE TO AVOID CARIES"

The "chance to avoid caries" (green sector) means when there is a high caries risk there will be low chance of avoiding caries, which is indicated in the form of small green sector and it is vice versa when there is low caries risk high chance to avoid caries with large green sector.

Caries Risk	Chance to Avoid Caries	Cariogram
High risk =	Low chance =	Small green sector
Low risk =	High chance =	Large green sector

Cariogram is a computer application, which evaluates risk of new dental caries occurrence. It provides tailored caries risk summery as a pie diagram by taking consideration of various caries causing risk factors.

It creates an individual future "risk scenario" based on the given scores and of nine factors/parameters of direct relevance to caries, entered in the Cardiogram. The factors are: **caries experience, related disease, diet content and frequency, plaque amount, mutans streptococci level, fluoride program, saliva secretion and buffering capacity**.

According to the weighted formula, after all data of relevance for caries are collected from individuals, scored and entered in the Cariogram, the program presents a pie diagram with the following sectors: bacteria, diet, susceptibility and circumstances. The caries risk is expressed in the sector "chance of avoiding caries". When the chance of avoiding caries is high, the caries risk is small and vice versa. The chance varies on a scale from 0 to 100% – chance from 0 to 20% means that the individual has high caries risk, from 21 to 80% medium risk and from 81-100% low risk for future caries development.

PRINCIPLES OF CARIES RISK ESTIMATION BASED ON "CARIOGRAM" CONCEPT

To express caries risk as "percentage of chance to avoid cavities", one has to choose 'Cariogram model' as it demonstrate caries risk as a pie diagram with percentage.

Lower the percentage higher the risk; for example, 5% indicates high risk of getting new caries. In contrast, higher the percentage lower the risk. For example, 90% indicates individual is at lower risk of getting caries in near future.

Factors which has been considered while assessing caries risk using Cariogram:

The chance of avoiding new caries range from 0% to 100% i.e. it will not exceed 100% or in negative.

Apart from considering diet, bacteria and susceptibility, it also considers circumstances.

In addition to afore mentioned item, it is also possible to adjust caries risk prediction by adding "clinical feeling".

Fundamentally, Cariogram is built on the bases of first group of factors such as bacteria, saliva, plaque and fluoride exposure including circumstances such as past caries experience and general diseases. However, it seems to be neglecting the secondary group of factors such as socio-economic status, level of education etc. But they are the reflectors of oral hygiene and diet, which are well thought-out in Cariogram efficiently. Hence, it can be said secondary factors are addressed satisfactorily.

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Table 34.1 Factors related to caries according to programme

Factors	Explanation	Required data DMFT, DMFS and new caries
Caries experience	Dental caries experience in past, all dental carious lesions, restorations, and lost teeth due to dental caries, if there is a history of new cavities in preceding year should be scored 3, even number of restorations are minimal.	experience in the past 1 year
General systemic diseases/conditions	Any disease or condition associated with caries	Past medical history including use of medications
Diet (content)	Assessment of cariogenicity of various foods, in particular fermentable carbohydrate content	Diet chart/diet history including lactobacillus count
Diet (frequency)	Assessment of number of main meals and snacks per 24 hours and meal for normal day	Data from the questionnaire of 24-hour recall or dietary recall of 3 days
Plaque	Estimation of plaque according to Silness and Loe plaque Index	Plaque Index
Mutans streptococci	Estimation of mutans streptococci levels in saliva using *Strep. mutans* test	Strep mutans test or any other appropriate similar test
Fluoride	Estimation of extent of fluoride available intraorally over the coming period of time	Type and duration of exposure to fluoride
Salivary secretion	Estimation of amount of saliva expressing as ml/min	Stimulated salivary test— salivary secretion rate
Salivary buffer	Capacity of saliva to buffer acids is estimated (using Dentobuff test)	Dentobuff test or any other appropriate similar test

Tooth surface area is the one, which is exposed to the caries causing factors, which in turn depends on the dose, frequency and duration of exposure. Hence, each factors have to be evaluated based on these point. For example, diet analysis should not be based on a single day diet chart, instead it should include one week diet history where it considers five regular days diet and two week-end days diet patterns.

Relative Impact of Factors—Weights

Factors that are considered in the Cariogram are weighed differently. For instance, factors, which are increasing the caries risk like pH of saliva, amount of saliva and bacterial count, will have stronger impact on than the less important factors like past caries experience, general diseases etc. while assessing the probability of a chance to avoid new cavities. The factors are also evaluated in relation to each other. Hence, particulars have special weight in different circumstance and combination of these factors is vast.

The weights are assigned based on an in-depth search of the scientific literature and also through scientific evaluation of the previous findings and publications. Anyhow it should be cautiously noted that there is no evidence for actual scientific findings and at the same time any scientific studies available assessing all the responsible factors at the same time applicable for different geographical areas and different age groups.

This kind of processing of evaluation of Cariogram, which depicts a graphical picture of interaction of the patients' risk factor for developing dental caries in the future, is called as **Cariography**.

At the same time it expresses to what extent different aetiological factors of dental caries may affect risk of caries for that particular individual. However, a caries risk profile can be illustrated based on an overall risk scenario and weighted interpretation of information available. This information is fed later into the computer and in turn programme calculates the risk of caries.

The individuals caries risk assessment is presented graphically as circle with five different colored sectors with different size denoting particular risk factors. Though it does not mentions number of cavities that could occur and won't replace professional inference regarding dental caries risk, but it could be used as investigative tool that may aid in decision-making.

Cariogram: Explanation for the Different Scores (Tables 34.2–34.11)

Table 34.2 Caries experience

Score	Note
0 - Absence of dental caries and fillings	There is absence of dental caries, earlier restorations, no caries or missing teeth due to dental caries.
1 - Better than normal	Better status than normal for particular age group
2 - Normal for particular age group	Normal status for that particular age group
3 - Worse than normal	Several new caries-lesions develop in the previous year, hence, it is a worse status than normal for that age group

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Table 34.3 General diseases/condition

Score	Note
0 – absence of disease	Absence of general diseases, which are related to dental caries. Individuals is seems to be healthy
1 – Diseases or conditions are minimal	Carious process getting influenced indirectly by general disease or condition and which can contribute for higher caries risk
2 - Severe degree	Chronic patient who is immobilized or who may need continuous medication

Table 34.4 Diet (contents)

Score	Note
0 - Very low fermentable carbohydrate	'Good' diet from the caries point of view, which has very low fermentable carbohydrate and also low lactobacillus class needed to support a zero
1 - Low fermentable carbohydrate, ('non-cariogenic' diet)	Appropriate diet from a caries point of view having non-cariogenic and low fermentable carbohydrate. Caries inducing sugars are on a low level
2 - Moderate fermentable carbohydrate	Diet with relatively high content of sugars and having moderate fermentable carbohydrate content
3 - High fermentable carbohydrate (inappropriate diet)	High intake of sugar or other caries inducing carbohydrates

Table 34.5 Diet (frequency)

Score	Note
0 - Maximum number of meals per day—three, including snacks	Maximum of 3 meals per day (very low frequency of diet intake)
1 - Maximum five meals per day	Maximum of 5 times per day (low frequency of diet intake)
2 - Maximum seven meals per day	Maximum of 7 times per day (high frequency of diet intake)
3 - More than seven meals per day	A mean of more than 7 times per day (very high frequency of diet intake)

Table 34.6 Plaque (amount)

Score	Note
0 – oral hygiene is extremely good, score of Plaque Index (PI<0.4)	Absence of plaque, no plaque on any teeth surfaces. Good oral hygiene maintainer cleaning teeth using brush and interdental cleaning aids.

Table 34.6 Plaque (amount)—cont'd

Score	Note
01– oral hygiene is good, score of Plaque Index (PI=0.4-1.0)	Minimal plaque present in gingival third and adjacent tooth area. For appreciating plaque, disclosing solution or running probe on tooth surface is needed.
Oral hygiene is less than good, score of Plaque Index (PI=1.1-2.0)	Accumulation of soft deposit is moderate, it can be even appreciated with naked eye.
Oral hygiene is poor, score of Plaque Index (PI >2.0)	There is a profuse soft deposit around tooth and within the gingival pocket. There is difficulty in maintaining oral hygiene and patient may not be interested in cleaning teeth.

Table 34.7 Mutans streptococci

Score	Note
0 – Mutans streptococci class 0	There is very minimal or zero amount of mutans streptococci in saliva (colonization of tooth surface by streptococci is 5%)
1 – Mutans streptococci class 1	Low level of mutans streptococci in saliva (there would be 20% of the tooth surface colonized by the bacteria.)
2 – Mutans streptococci class 2	Saliva having high amount of mutans streptococci in saliva. (tooth surfaces colonized by mutans streptococci is about 60%)
03– Mutans streptococci class 3	High level of mutans streptococci count in the saliva. (tooth surfaces covered by bacteria is >80%)

Table 34.8 Fluoride programme

Score	Note
0 – individual receiving maximum fluoride exposure.	Individual using fluoridated toothpaste along with additional fluoride measures such as fluoride rinse, and professional fluoride application.
1- infrequent use of additional fluoride measures	Individual using fluoridated toothpaste along with additional fluoride measures such as fluoride rinse and professional fluoride application infrequently.
2 – use of fluoride toothpaste only.	Use of only fluoridated toothpaste and absence other fluoride supplements.
3- complete absence of fluoride use.	Evading fluoride use, not using fluoridated toothpaste nor any fluoride measures.

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Table 34.9 Saliva secretion (amount)

Score	Note
0- saliva secretion is in normal range.	Secretion of saliva is normal. (stimulated saliva >1.1ml/minute)
1- Minimal, stimulated saliva 0.9-1.1 ml/minute	Minimal secretion of stimulated saliva, 0.9-1,1ml/minute.
2- Minimal, 0.5-0.9 ml of saliva/minute	Stimulated saliva secretion ranging from 0.5-0.9 ml/minute.
3- Very minimal, (xerostomia) <0.5ml of saliva/minute	Individual with dry mouth, very minimal secretion of saliva per minute.

Table 34.10 Saliva buffer capacity

Score	Note
0- Satisfactory, Dentobuff blue.	Satisfactory buffering capacity of saliva (pH>6.0)
1- Decreased, Dentobuff green	Saliva buffer capacity less than satisfactory (pH 4.5-5.5).
2- minimal, Dentobuff yellow	Buffering capacity of saliva is low (pH<4.0)

Clinical Judgment

Table 34.11 Dental examiners opinion ('Clinical feeling')

Score	Note
0- clinician appreciating more positive clinical finding than Cariogram's assessment.	The caries situation in general, including socioeconomic status, gives more positive view than what Cariogram has been analyzed. This improves the chance to avoid new caries of the patient by making green sector bigger.
1 – Examiner's judgment is in line with Cariogram's assrssment.	The caries situation in general, including socioeconomic status, gives same impression what Cariogram has been analyzed. There is no other basis for an examiner to alter the Cariogram's assessment.
2- high caries risk than the Cariogram's assessment.	The general impression caries situation appears to be an increased risk. There is a probability of decreasing the chance of avoiding new caries and dental examiner would like to reduce green sector.
3- very high caries risk. Examiner is confirmed that new caries will appear, irrespective of Cariogram's assessment.	In near future irrespective of Cariogram's analysis. Thus, eximiner takes precedence of the Carigram's assessment and it is confirmed that cavity will appear.

USING THE CARIOGRAM FOR EVALUATION OF CARIES RISK (Fig. 34.2)

- Chance—to avoid new cavities in the near future **(Green)**
- Chance – to avoid new caries in near future. (Green)
- Diet—frequency of eating as well as contents of diet **(Dark blue)**
- Diet – frequency and contents of meals. (Dark blue)
- Bacteria—plaque amount as well as types of bacteria **(Red)**
- Bacteria – amount of plaque and strains of bacteria (Red)
- Susceptibility—tooth resistance (fluorides) and saliva characteristics **(Light blue)**
- Susceptibility – resistance of tooth (fluoride exposure) and saliva parameters (Light blue)
- Circumstances—combination of past caries experience and related diseases. **(Yellow)**
- Circumstances – amalgamation of past caries exposure and related general diseases. (Yellow)

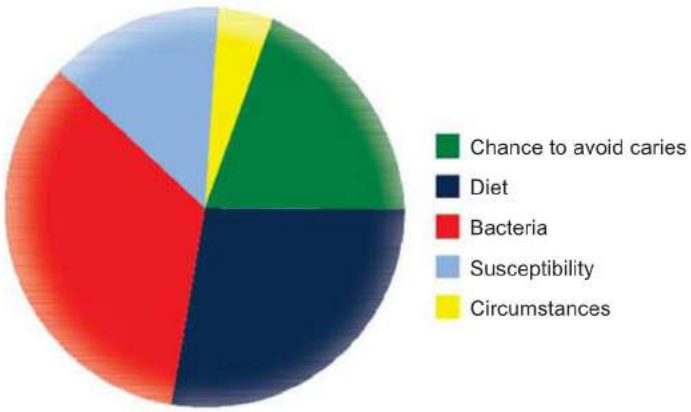


Figure 34.2 Cariogram indicating the components participating in the dental disease process.

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CONCLUSION

Dental caries is a multifactorial disease with several well known components participating in the disease process, like diet, bacteria, saliva and fluoride exposure.

Multiple factors contribute to a person's risk for caries, including: Environmental factors, such as diet, oral hygiene, fluoride exposure, and the level of colonization of cariogenic bacteria; and Host factors, such as salivary flow, salivary buffering capacity, position of teeth relative to each other, surface characteristics of tooth enamel, and depth of occlusal fissures on posterior teeth.

The cariogram is a method to facilitate the interpretation of such data by making up the risk profile of an individual and also to predict caries development in a statistically significant way. Thus cariogram expresses only caries risk, but the problems such as fracture of teeth or fillings, discoloration, etc. will not be taken into account, which may necessitate going for new fillings.

REVIEW QUESTIONS

1. What is cariogram?
2. What are the factors considered in the estimation of caries risk?
3. What are the principles of caries risk estimation?
4. "Chance to avoid caries"—what does it mean?
5. Discuss relative impact of factors with corresponding weights in cariogram.
6. Write about the evaluation of caries risk using cariogram.

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35 Dental Caries Vaccine

Hiremath SS

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INTRODUCTION

Dental caries remains one of the most widespread diseases of mankind. Advances in prophylactic measures to deal with this disease have significantly reduced the overall caries rate in developed countries. However, in developing countries dental caries trend is increasing. Being poor is clearly a risk factor for increased decay. More than one-third of the poor children in age group 2 to 9 years have untreated decayed primary teeth.

In developing countries, dental caries is often at epidemic proportions, especially among disadvantaged population. This high caries rate continues among the less economically advantaged in the face of efforts to introduce fluoride at an early age. Thus, more effective public health measures are needed to address this worldwide problem.

Landmark experiments in the 1960s established that mutans streptococci are the primary aetiologic agents of this disease, and that infection is transmissible. A strong association exists between the level of colonisation with mutans streptococci and dental caries although other organisms, such as lactobacilli, have also been implicated in this disease.

Other factors also influence mutans streptococcal colonisation. If the environment strongly favours mutans colonisation, e.g. if high maternal infection levels are combined with high dietary sucrose levels, this so-called window of infection shifts to an earlier age.

Dental caries, the disease that causes tooth decay, is infectious, and the mutans streptococci bacteria have long been identified as the primary disease-causing agents. Most treatments are now aimed at either elimination of this bacterium or suppression of its virulence. Thanks to numerous scientific advances, tooth decay is not as rampant as it once was, but it is still five times more common in children than asthma and seven times more common than hay fever.

Many independent studies have confirmed the observation made by Clark in 1924 that higher numbers of *S. mutans* are found at carious tooth sites compared to sound ones. A clearer picture of the involvement of *S. mutans* in the initiation of caries comes from the longitudinal studies, which have concentrated upon particular caries prone sites. It has thus been demonstrated that specific sites on teeth, which have a high *S. mutans* level at a particular time, mere presence of *S. mutans*, however, even at high levels, in no way guarantee that caries will occur. Other factors, including diet, tooth resistance and antimicrobial properties of saliva, all affect the outcome and hence make it impossible to demonstrate an absolute cause-and-effect relationship between *S. mutans* and caries similar in most infectious diseases.

Support for aetiological role of *S. mutans* has come from a number of laboratories, It is also important not to lose sight of the fact that bacteria other than *S. mutans* may be associated with caries; the lactobacilli in particular are commonly found to increase in numbers in the developing lesion although they attain much lower levels than those of *S. mutans*. It is also possible that relative importance of different bacteria varies with the site of disease. For example, *Streptococcus sobrinus* may more frequently be associated with caries on smooth surfaces while *Actinomyces* have been proposed as major agents in root surface caries. Although more recent studies implicate *S. mutans* more strongly in the latter.

Almost all recent research is focused on *S. mutans*, there is long-term potential for multivalent vaccines with a wider spectrum of activity. For progress to be made in a rational way, however, logic demands that initial efforts at the development of a vaccine should be based on the most significant organism and this is undoubtedly *S. mutans*.

Clearly, a high degree of protection is to be desired, from all possible methods including use of vaccines. But immunisation should be considered alongside other available preventive measures, none of which is completely effective on its own.

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PROSPECTS FOR VACCINATION AGAINST DENTAL CARIES

First report of a successful experimental dental caries vaccine appeared in 1969. Since that time, much effort in laboratories around the world has been devoted to research. At times some authors may have given the impression that wide-scale introduction of a vaccine is imminent and that few problems remain to be resolved. Others have been more cautious in their predictions, and there are also those who have a longstanding antipathy to the concern of a vaccine.

It should also be remembered that vaccines against other diseases are seldom, if ever, 100% effective and yet have proved of enormous public health value. Furthermore, problems of developing a vaccine against a disease with complex aetiology are by no means unique to dental caries. Similar problems of inducing protection against a range of challenging organisms (which may also be individually capable of variation) are faced by workers attempting to develop the new generation of vaccines for diseases such as pneumonia, meningitis, gonorrhoea, influenza and malaria. Progress in these areas is dependent upon detailed knowledge of the pathogens, both in the field and in the laboratory, utilizing the latest techniques of biochemistry, immunology and genetics.

Which Type of *S. mutans* is Most Important?

Mutans group of streptococci is a heterogeneous collection of organisms, which can be subdivided into at least six distinct species. Strains recognised as *S. mutans* were first subdivided by a serological method based upon differences in surface polysaccharides. However, later studies on DNA and protein composition have led to recognition of the separate species. It is now clear that the one species important in promoting caries in humans are *S. mutans* (containing strains of serotypes *c, e,* and *f*), and possibly *S. sobrinus* (serotypes *d* and *g*). The others, *S. cricetus* (serotype *a*), *S. rattus* (serotype *b*), *S. ferus* (serotype *c*) and *S. macacae* (serotype *c*) are only very rarely or never isolated from human dental plaque. Surveys from more than a dozen countries have shown that of the species found in humans, by far the most common is *S. mutans,* which occurs in about 90% of plaque samples known to contain mutans group streptococci. Many individuals also carry *S. sobrinus* either alone or in combination with *S. mutans.* But *S. sobrinus* has been found to be carried by between only 5% and 35% of individuals in the different surveys.

Wall Associated Proteins

Two purified proteins from the surface of *S. mutans* serotype *c* are currently being suggested for use as dental caries vaccines. Antigen I/II described by Lehner and his colleagues, has given protection in rhesus monkeys. Antigen I/II is known to be identical with antigen B, but failed to give reproducible protection. This antigen, however, shows some promise as the basis for a human caries vaccine and has the advantage of being found in all serotypes of *S. mutans* and *S. sobrinus* (as well as other oral streptococci); it could therefore give wide-ranging protection.

The other wall-associated protein of interest is antigen. A first discovered at the Royal College of Surgeons dental research unit (UK), and later reported to reduce caries dramatically both in monkeys and in rats. The protection of immunised monkeys has been maintained now for over 6 years. Antigen A is quite distinct from the known HCRA of *Streptococcus mutans* and has been put through the extensive toxicological tests required of new therapeutic agents at the Welcome Research Laboratories. When the antigen was injected into adult volunteers, local skin reaction was assessed as mild as acceptable as other widely used vaccines.

ROUTE OF ADMINISTRATION OF VACCINE

Mucosal Immunity

Mucosal applications of dental caries vaccines have been sought since secretory IgA is the principal immune component of major and minor salivary gland secretions and thus would be considered to be the primary effector of adaptive immunity in the salivary milieu. Given the natural history of mutans streptococcal infection described earlier, immunisation would presumably need to be initiated early in childhood to interfere with mutans streptococcal colonisation. The oral immune environment undergoes rapid, early development. Although secretory IgA antibody in saliva and other secretions is essentially absent at birth, mature SIgA, i.e. dimeric IgA with a bound secretory component, is the principal salivary immunoglobulin secreted in individuals by one month of age.

Children respond at different rates following infection, a condition which may be partly the result of the extent of infection (antigen dose) or age at the time of infection (maturation of immune response). Even siblings may differ in amounts or kinds of IgA antibody specificities appearing in their saliva. These variations may stem from differences either in the inherent ability of the child to respond or in the characteristics of genetically different strains of mutans streptococci (thus potentially differing antigenic challenge) ultimately colonising the child. The rate, specificity, and/ or extent of the mucosal immune response to previous encounters with the organism may also contribute to the success or failure of permanent colonisation. Thus, evidence from salivary IgA responses to commensal oral microbiota indicates that the mucosal immune system is relatively well developed by the period during which children typically become infected with mutans streptococci. Most children apparently respond immunologically to transient infection or ongoing colonisation with mutans streptococci in early childhood. Although distribution and specificity of children's responses are not identical, antibody to a few major antigens predominates. Analysis of these data suggests the possibility that such responses could be protective if induced prior to critical colonization events.

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EFFECTIVE MOLECULAR TARGETS FOR DENTAL CARIES VACCINE

Several stages in molecular pathogenesis of dental caries are susceptible to immune intervention. Microorganisms can be cleared from the oral cavity by antibody-mediated aggregation while still in the salivary phase, prior to colonisation. Antibody could also block the receptors necessary for colonization (e.g. adhesins) or accumulation (e.g. glucan-binding domains of GBPs and GTF), or inactivate GTF enzymes responsible for glucan formation. Modification of metabolically important functions may also be targeted. In addition, the antimicrobial activity of salivary IgA antibody may be enhanced or redirected by synergism with innate components of immunity, such as mucin or lactoferrin. Most of recent experimental effort has been directed towards components like adhesins, GTFs and GBPs as vaccine targets.

Adhesins

Adhesins from two principal human pathogens, *Streptococcus mutans* (variously identified as antigen I/ II, PAc, or P1) and *Streptococcus sobrinus* (SpaA or PAg), have been purified. However, despite homology between the two mutans streptococcal adhesins, each appears to bind to separate components in the pellicle. Immunological approaches support the adhesin-related function of the AgI/II family of proteins and their repeating regions. Numerous immunisation approaches have shown that active immunisation (with intact antigen) or passive immunization with monoclonal or transgenic to putative salivary-binding domain epitopes within this component can protect rodents, primates or humans from dental caries caused by *S. mutans*.

Glucosyltransferases (GTFs)

Mutans streptococci that have lost the ability to make glucan through natural or induced mutations in GTF genes do not produce significant disease in animal models. Growth of mutans streptococci in the presence of antibody to GTF significantly diminishes the amount of biofilm on glass surfaces. Thus, it was not surprising that immunization studies using intact GTF vaccines successfully protected animals infected with *S. mutans*. Passive administration of antibody to GTF in the diet was also protective. GTF is an interesting protein in that it does several things. This enzyme cleaves the bond between the glucose and fructose moieties in sucrose. Activated glucose is then transferred to a growing glucan polymer. GTFs from the two major cariogenic streptococcal species in humans, *S. mutans* and *S. sobrinus*, have very similar sequences in these functional domains, immunization with GTF protein or subunit vaccines from one species can induce a measure of protection for the other species. Thus, the presence of antibody to GTF in the oral cavity, prior to infection, can significantly influence the disease outcome, presumably by interference with one or more of the functional activities of the enzyme.

In addition, ability of GTF from initially colonizing *S. mutans* to synthesise water-insoluble glucan has been correlated with caries incidence in young children.

Glucan-binding Proteins

The ability of mutans streptococci to bind to glucan is presumed to be mediated, at least in part, by cell wall-associated glucan-binding proteins (GBP). Many proteins with glucan binding properties have been identified in *Streptococcus mutans* and *Streptococcus sobrinus*. Each glucan-binding protein has the ability to bind a 1,6 glucan although other glucan linkages potentially may impart higher binding constants. *S. mutans* secretes at least three distinct proteins with glucan-binding activity.

Protection can be achieved by either subcutaneous injection of GbpB in the salivary gland region or by mucosal application by the intranasal route. Saliva samples from young children often contain IgA antibody to GbpB, indicating that initial infection with *S. mutans* can lead to natural induction of immunity to this protein.

SYNTHETIC PEPTIDE VACCINES

Subcutaneous immunisation with a synthetic peptide derived from alanine-rich region of Ag I/II from *S. mutans* has induced higher levels of serum IgG antibody reactive with recombinant Ag I/II than a synthetic peptide derived from proline-rich region. Intranasal immunisation with PAcA, coupled to cholera toxin B subunit, has suppressed colonisation of mouse teeth by *S. mutans*. *Fusion* proteins containing PAcA have also inhibited sucrose-independent adhesion of *S. mutans* to saliva-coated hydroxyapatite beads. Combining epitopes from adhesins and GTFs into one construct and enhancing the immune response with additional sequences (e.g. cholera toxin subunits) could theoretically increase, and possibly extend the protective effect of these subunit vaccines. Some recombinant protein approaches, described in the following, have used this design.

Recombinant Vaccines/Attenuated Expression Vectors

Recombinant approaches afford expression of larger portions of functional domains than can be accommodated by synthetic peptides. Attenuated mutant vectors such as *Salmonella*, which contain plasmids expressing recombinant peptides, can target the vaccine to appropriate inductive lymphoid tissue for mucosal responses.

Conjugate Vaccines

Another vaccine approach, which may intercept more than one aspect of mutans streptococcal molecular pathogenesis, is the chemical conjugation of functionally associated protein/peptide components with bacterial polysaccharides. Added to the value of including multiple targets within the vaccine is that conjugation of protein with polysaccharide enhances the immunogenicity of the T-cell independent polysaccharide entity. Subcutaneous injection with conjugate-induced systemic IgM and IgG antibody responses to both peptide and polysaccharide, which could be boosted upon subsequent injection.

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Route of Administration of Vaccine

The choice of a route of immunisation is directly linked to the type of antibody response desired for protection, and here again there is a divergence of opinion between research groups working with rodents and those having primates as their experimental models. Two main types of antibody response are: (i) circulating antibody induced by systemic injection (predominantly of IgG class), which enters the oral cavity by way of gingival crevice and (ii) a secretory Ig A antibody, which is produced by salivary glands. A third possible approach inducing local synthesis of IgG antibody in the gingivae has also been recently reported in the monkeys.

Successful attempts at immunising monkeys against caries have all used *subcutaneous injections* into limbs designed to induce high levels of circulating antibodies. Strategies of oral immunisation intended to induce secretory antibody in saliva have been successful in rats but not in monkeys. One report of induction of a response in human volunteers who swallowed capsules of *Streptococcus mutans* has appeared, but two independent studies have failed to corroborate this. Although there is an extremely active field of research into oral immunisation, the results available to date indicate that there is no immediate prospect of an orally administered caries vaccine becoming feasible in the near future. Passive immunisation, in which subjects are treated topically with monoclonal or polyclonal antibodies previously raised against *Streptococcus mutans* antigens in animals, has been reported to be protective in experimental animals. This approach, however, will requires considerable research to determine frequency and levels of dosage needed and is very likely to be very expensive. Both oral vaccine and passive immunisation have been suggested as being possibly safer than injected vaccine with its resultant high levels of circulating antibodies. However, with a suitably chosen nonreactogenic composition and injected caries vaccine should be no less acceptable than other vaccines in current use; indeed one based on a purified protein should be considerably better tolerated than most existing whole cell vaccines. The precise timing and number of injections, which might ultimately be required in children, cannot yet be determined. Although much can be learned from animal models, it will be essential to acquire such baseline data from preliminary clinical trials in humans in order to determine the effect of such variables as age and prior exposure to *Streptococcus mutans* antigens.

RISK FACTORS

It has, however, been suggested to be heart cross-reactivity and although the significance of these observations has been questioned, the hint of suspicion indicates that this antigen must be regarded as unacceptable at present. There are various ways in which this might be overcome.

Adverse consequence of injecting a crude bacterial vaccine may be many and varied, but with streptococci concern is focused upon immunologically mediated tissue damage following exposure to streptococcal antigens. When animals are injected with whole *Streptococcus mutans* bacteria, they form antibodies, which react not only with the bacteria but also with heart tissues, possibly the myosin component. While significance of this is not yet understood, induced by the heart cross-reactive antigens (HCRA) will cause some damage to the heart. Presently HCRA problem must prevent the use of crude whole *S. mutans* vaccines, and any proposed vaccine must be demonstrably free of possible HCRA. The best way to ensure this is to use a vaccine, consisting of a single carefully defined and highly purified antigen (or mixture of antigens), which does not have any adverse properties associated with it. This can be done in two ways:

1. The first is to demonstrate the observed phenomena interpreted as heart cross-reactivity are artefacts of the technique used or have no pathogenic implications.
2. The second way of resolving the problem of HCRA is to hope that because the antigen concerned is large, it will be possible to separate a segment that is protective from the part responsible for heart cross-reactivity. This can be achieved: by cleaving the antigen into small fragments, by manipulating the gene so that a truncated product is synthesised or by making synthetic peptides which correspond to the protective part. But it may still be sometime before the desired aim of producing a useful protective antigen conclusively freed of heart cross-reactivity is achieved. There is also, of course, no guarantee that the protective and cross-reactive part of the molecule can be free from side effects.

PAST, PRESENT AND FUTURE HUMAN APPLICATIONS

Active Immunisation

Few clinical trials have been performed to examine the protective effects of active immunisation with dental caries vaccines containing defined antigens. However, several studies have shown that mucosal exposure of humans to immunisation with glucosyltransferases from *S. mutans* or *S. sobrinus* can lead to formation of salivary IgA antibody. Parotid salivary IgA antibody responses, primarily of the IgA2 subclass, were induced in five of seven subjects. Similarly, nasal immunisation with dehydrated liposomes containing this GTF preparation induced significant IgA1 antibody response in nasal washes. Parotid salivary antibody levels to GTF were of lower magnitude.

Passive Immune Approaches

Passive antibody administration has also been examined for effects on indigenous mutans streptococci. Mouth rinses containing bovine antibody to *S. mutans* cells led to modest short-term decreases in the numbers of indigenous mutans streptococci in saliva or dental plaque. Long-term effects on indigenous flora were observed after topical application of mouse monoclonal IgG or transgenic plant secretory S IgA/G antibody, each with specificity for Ag I/II.

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Future Prospects and Potential Impact

Given that dental caries usually develops slowly and can occur throughout life, it may be anticipated that immune protection would need to be similarly long lasting. While it is now clear that mucosal immune responses can persist and that memory is established if the primary stimulus is sufficient, relatively little is known about the parameters that govern memory in the mucosal immune system. Although current understanding holds that oral colonisation with mutans streptococci mainly occurs during a 'window of infectivity' at around 2 years of age after primary teeth begin to erupt, it is unclear whether further opportunities for colonisation exist, e.g. when children enter school and mix socially with a much larger group of their peers, or when the permanent teeth erupt. Two corollaries arise from such considerations: (i) that it would be necessary to immunise infants or young children in order to provide immune protection prior to initial colonisation with mutans streptococci; and (ii) that booster immunisation to recall responses might be desirable to forestall colonisation at later time points. As the transmission of mutans streptococci appears to be primarily from mother to infant, a third possibility is that young mothers might be immunised actively or passively with the objective of reducing their oral load of mutans streptococci (possibly in combination with conventional prophylaxis or other interventions), thereby diminishing the probability and extent of transmission to their infants. If the transferred bacteria are coated with maternal salivary antibodies, this would likely reduce their capacity to colonise the infant's mouth. It has been suggested that immunisation of young mothers to induce the generation of antibodies to mutans streptococci in breast-milk could be exploited to provide passive immunity against caries to their infants.

Need for an Anticaries Vaccine

Our understanding of the ontogeny of the mucosal immune response indicates that children at this age are competent to mount secretory responses to the proteins that have been suggested as vaccine components. A mucosally applied pediatric dental caries vaccine would be truly novel as the first nonreplicating vaccine applied by any mucosal route. Furthermore, the character of the pediatric response to a nasally applied caries vaccine would tell us about the potential for immunization by mucosal routes, not just for dental caries, but also for the many pathogens that cause disease in the gut or airways.

As dental caries fulfils the criteria of an infectious disease, the possibility of preventing it by vaccination has been pursued. The rationale is that the immunization with *S. mutans* should induce an immune response, which might prevent the organism from colonizing the tooth surface, thereby preventing decay. The vaccine could be given at the same time when the vaccines against diphtheria and tetanus are given. The immunity could be boosted at intervals thereafter to provide a lifelong protection.

CONCLUSION

Despite encouraging decline in dental caries observed in recent years in many populations, millions of children remain at risk of experiencing extensive tooth decay, and it is particularly distressing that many of those suffering will be amongst the least likely to obtain satisfactory treatment. We believe that along with established methods of caries prevention, caries vaccines have the potential of making a highly valuable contribution to disease control. As on today, however, no clinical trials in children have yet been approved by appropriate national authorities. It would take some years for the results of any such trials to become apparent, and there can be no guarantee that the successful outcome of experiments in animals will also be repeated in humans. In the meantime, basic research on the mode of action of caries vaccines and search for new, more effective, and possibly polyvalent vaccines must continue if we have to fully explore their potential for helping us in the struggle against dental caries.

REVIEW QUESTIONS

1. Write short notes on:
   a. Dental caries vaccine
   b. Future prospects and potential impact of caries vaccine
   c. Administration of caries vaccine
   d. Advantages and disadvantages of caries vaccine
   e. Risks of caries vaccine
   f. Current status of caries vaccine

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36 Fluorides

Hiremath SS

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INTRODUCTION

The burden of dental diseases and their economic impact is so massive that they challenge the capacity of health care services in both the developing and developed countries of the world. The treatment cost of dental diseases accounts to 5 – 10% of the total health care spending in the developed nations. Dental caries is not only widely prevalent but is also largely untreated, leaving the condition as one of the unmet needs of the community. About 5 billion people are affected by dental caries, majority of who belong to low-income underdeveloped/ developing countries.

In the recent decades, changing trends and patterns of occurrence of oral diseases have been observed. At one extreme, the western industrialized countries have a decline in dental caries and more number of children are becoming caries free and their number is increasing. The factors, which are considered for this reduction in caries, may be ascribed to changes in sugar consumption, improved oral hygiene and use of fluorides through systemic and topical route including fluorides in toothpaste, fluoride rinsing, and other school-based preventive programs.

At the other extreme, many of the developing countries show an increase in prevalence and severity of dental diseases, especially dental caries. This may be attributed to urbanization, which is now taking place at an explosive phase, rural immigrants adopting the behavior of modern society and changing their traditional dietary habits with less use of fluorides and virtually few or no preventive programs. Unfortunately, most of the caries is left untreated or children may have their teeth extracted due to lack of effective oral health services and preventive programs.

Fluoride is the most potent and effective substance yet developed for the prevention and treatment of caries. When successfully administered and made available to the target tissue either locally at the erupted tooth surface or pre-eruptively at the enamel organ, it is essential that at optimal concentration be available so that therapeutic effect can be achieved. Fluoride is also a double-edged sword. When fluoride is consumed at an optimal concentration, it renders caries-inhibitory benefit. A low sustained, ambient level of fluoride is also pivotal for the maintenance of structural integrity of the calcified tissues of teeth. However, toxic levels of fluoride can lead to dental fluorosis, skeletal fluorosis or other systemic problems.

Volumes of research have validated and confirmed the inverse relationship between fluoride level in drinking water and prevalence of dental caries. The optimal level of fluoride with the most caries-prevention benefit and the least risk of clinically significant fluorosis has been evaluated.

The 28th WHO assembly in 1975 approved the program and stressed the importance of optimizing the fluoride concentration in water supply. In 1978, the 31st World Health Assembly reaffirmed this support of fluoridation as inexpensive and effective management of oral diseases–both prophylactic and therapeutic. It has been suggested that if community water fluoridation is not feasible, suitable alternative strategies for the delivery of fluoride should be devised.

The repeated emphasis by WHO on community water fluoridation and other methods of using fluorides to prevent dental diseases is an indication that there is not and never has been any question about desirable health policy in these areas. The only question is how to implement it. Unfortunately, this aspect has either been totally neglected or side-lined in developing countries including India.

WATER FLUORIDATION

Water fluoridation has been included as one of the top ten public health achievements of the 20th century.

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Fluoridation is regarded as a primary public health measure for dental disease prevention because it is a potential health benefit conferred to all just by drinking water irrespective of age, sex, social class etc. Fluoridation may also be considered as a kind of fortification of drinking water.

History of Water Fluoridation

In **1901**, Dr Frederik Mckay of Colorado, USA accidentally discovered that many of his patients had permanent stain on their teeth and he called them as COLORADO STAIN and published in Dental Cosmos. When Mckay enquired with the local people, they simply referred them as "Colorado brown stains" and they were found most commonly among the local residents who lived there for a long time. They later referred them as "mottled enamel" in **1916**.

Later, he went for detailed examination of all the persons who were having this condition from different places and they were subjected for histological findings and examinations. In the meantime, to establish a geographical area of mottled enamel, Dr Mckay contacted GV Black in **1916**. After the detailed examination of mottled teeth from different places—histological findings were published as "endemic imperfections of enamel of teeth" in **1917**.

Later, Mckay established a contact at different places of USA to find out whether they did have mottled enamel affecting the people and wanted to establish a geographical area of mottled enamel and also to find out the probable aetiological factors for mottling of teeth. Interestingly, he noticed mottled enamel found among people who were born there, regardless of richness and poverty. Thus, he ruled out that diet was not an aetiological factor.

Throughout his study, he noticed that dental caries experience was very low among the mottled teeth. Contrary to the fact that mottled teeth are susceptible to dental caries, children who had been born elsewhere and brought to this area, when they were 2–3 years old, were not affected.

Dean continued the studies to establish the possible relationship between the severity of mottled enamel and the fluoride concentration in water supply. On 25 October **1928**, in association with Dr Frederick Mckay, he disseminated the information he gathered on mottled enamel through a publication in the epidemiology section of the American Public Health Association. In his report, he mentioned that in USA, there were 375 known areas, in 26 states where mottled enamel of varying degrees of severity were found. He also stated that occurrence of mottled enamel has been reduced at Oakley, Idaho, Bauxite, Arkansas and over, South Dakota, simply by changing the water supply which contained high concentration of fluoride, to one whose fluoride concentration did not exceed 1 ppm. This information was the most convincing evidence in support of the strong assumption that fluoride in the drinking water is the chief cause of mottled enamel. The publication of this information brought to successful and fruitful conclusion, McKay's search for the cause of the mottled enamel, which began in Colorado Springs in **1901** and lasted for almost 40 years.

In New Kensington, Pennsylvania, on 20 January **1931**, Churchill and Petrey, chemists using spectrographic analysis found that Bauxite water contained 13.7 ppm of fluoride.

In Arizona, husband and wife Dr Smiths in an experiment showed that mottled enamel occurred in rats fed with ordinary diet and water containing fluoride. Incisors of rats had similar stains of mottled enamel.

Subsequently, the US Public Health Department appointed Dr H Trendly Dean to peruse a full-time research on "mottled enamel" in **1931.** He was the first dental officer of the service to be given a non-clinical assignment.

Dean did the survey, collected the information from different places, different persons regarding water content of fluoride and mottling of teeth. He developed a "classification of mottling" in **1934**. Later, this classification was modified between **1936** and 1938 as Dean's index of fluorosis/Dean's index of mottled enamel to record quantitatively the severity of mottling of enamel in the community. He noticed that as fluoride concentration increased in water, severity of mottling increased (1936). Subsequently, he wanted to find out at which level fluoride began to affect the teeth and causing fluorosis or mottling and called it "minimum threshold of endemic fluorosis". He showed conclusively that severity of mottling increased with increasing fluoride concentration in the drinking water. Thereby, he formulated a hypothesis of minimum threshold of fluorosis and gave an indication that 1 ppm would not cause fluorosis in **1938.** To test this hypothesis he undertook "21 Cities Study".

Dean's 21 cities study. He conducted this study among 7257 children of the age group of 12–14 years from 21 cities of 4 states to find the possible association between increasing fluoride concentration in drinking water and degree of dental fluorosis (Fig. 36.1).

Results

1. As fluoride concentration increased from 0 ppm, there is decrease in caries experience.
2. Maximum reduction of caries occurred at 1 ppm. At this concentration fluoride caused only sporadic mildest forms of dental fluorosis of no practical aesthetic significance.

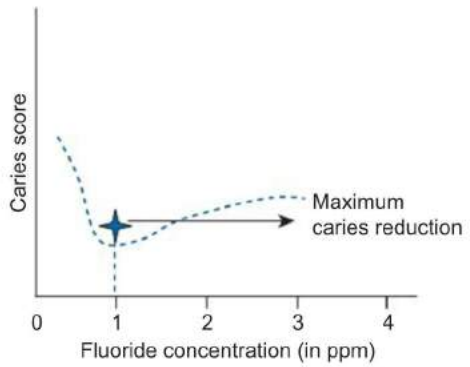


Figure 36.1 Graph showing the association between caries score and fluoride concentration.

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3. If fluoride level increases more than 1 ppm, there is no further reduction of dental caries but there could be chances of appearance of fluorosis.

Dental Caries Prevalence in Artificially Fluoridated Areas

Grand Rapids, Michigan vs Muskegon, Michigan (control). 1945—Grand Rapids whose water supply did not have fluoride was taken up for artificial fluoridation programme. The artificial fluoridation programme was based on the hypothesis that an upward adjustment of the fluoride level of public drinking-water supplies to 1 mg/l might exert anti-caries benefit to the community in the same fashion as the community would benefit in a naturally fluoridated area. Therefore, a community water fluoridation trial was conducted to test this hypothesis. Grand Rapids was the test city and Muskegon, a nearby city acted as the control study. The trial started on 25 Jan 1945. This is the first city in whole world to be fluoridated with optimal level of 1 ppm in water supply. Muskegon was taken as a control city without any fluoride, and with these two cities Aurora, another city was included, which had a natural water supply containing natural fluoride about 1.4 ppm (Fig. 36.2).

After 6.5 years, Arnold in 1953 studied the caries experience of 6-year-old children. The caries experience of Grand Rapids' children was half that of 6-year old Muskegon children. Later, Muskegon was also fluoridated in 1951. Results after 10 and 15 years of fluoridation showed that caries experience among 15-year-old children fell down from 12.4 DMFT in 1949 to 6.2 DMFT in 1959. There was reduction of caries up to about 50%. Caries experience were similar among children in Aurora compared to children of Grand Rapids.

New Burgh, New York vs Kingston (control) in USA. 1945—Kingston is about 35 miles away from New Burgh. The baseline studies were carried out in 1944–1945. After 20 years of fluoridation, in New Burgh the caries experience, which was 23.5% before, was reduced to about 13.9%. In Kingston, the caries experience was 23% in 1945, and it was 28.3% in 1955.

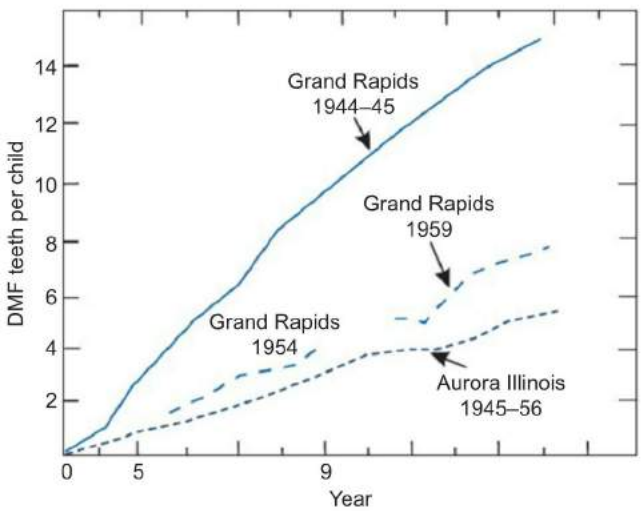


Figure 36.2 Caries experience in Grand Rapids Study.

Evanston, Oak Park study in USA. 1946—Evanston (Illinois) after 14 years of fluoridation results were published in 1967. In 1946, the DMFT was 11.6 and it was reduced to 5.95 in 1960. Hence, there is a caries reduction of 49%.

Brantford (Ontario) vs Sarnia (control), Stratford (another control with natural fluoride containing 1.3 ppm). June 1945 (Canadian study)—After 17 years of fluoridation, the caries experience of Brant-ford was similar to Stratford. There was a reduction of dental caries about 49–55%.

Similarly, studies were conducted at the same time in Netherlands, New Zealand, England and Israel. In Belgium, Holland, Luxemburg, Amsterdam similar results were found out in almost all the countries where fluorides were added (1 ppm).

To rule out all possible side effects of fluoride including toxicity, the detailed medical examinations were conducted and after 15 years of fluoridation programme, they found out that there were no side effects/unwanted effects or toxicity on human health. The detailed examinations were carried out including blood examination, height and weight of the person, infant mortality rate (IMR), stillbirth, maternal mortality rate (MMR), cardiovascular, neurological and haematological examinations.

In 1945, the US government, initially designed for 10 years, but later brought down to 5 years, gave permission to all the states wishing to add the fluoride to drinking water. In 1958, a WHO Expert Committee gave the conclusion that drinking-water containing about 1 ppm fluoride (1 mg/1) has a marked caries-preventive action. It also stated that there is no evidence that water containing this concentration of fluoride impairs general health. Interestingly, WHO on 22 July 1969 adopted a resolution to recommend its member states to introduce community water fluoridation.

Fifteen years after the introduction of the first artificial fluoridation program, the USA had nearly 50 million people benefitting from this public health measure. The implementation was further widened to include all major cities and by 2002, 46 out of 50 largest cities were fluoridated. with a total population covered of 171 million (68% of those on public water systems). Indeed, the United States appears to be attempting the target towards meeting its *Healthy people 2010* objective on community water fluoridation: 75% of people on public water systems to receive water that has the optimal level of fluoride recommended for preventing tooth decay, and, worldwide, around 350 million people to consume fluoridated water.

The history of water fluoridation can be divided into three periods.

The first period from 1901 to 1933 that focused on investigating causes of mottled enamel (Colorado brown stain, first reported by Frederick McKay).

The second period between 1933 and 1945 that focused on investigating the concentration of fluoride and clinical outcome-benefit and adverse effect. Attempted to study the relationship that might exist between fluoride concentrations, fluorosis and dental caries, and established that moderate levels of fluoride prevent dental caries.

The third period, from 1945 to the present was the implementation and expansion of community water

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fluoridation focused on adding fluoride to community water supplies.

PHYSIOLOGY AND CHEMISTRY OF FLUORIDE

Fluorine is said to have been discovered by the chemist Scheele in 1771, but not isolated until 1886 by Moissan. Ficinus reported his belief in the presence of fluoride in enamel and dentine in 1847 and Fremy found fluoride in fish bones, bone powders and bone ash in 1855.

Under the biological classification, fluoride is usually grouped with trace elements. Fluoride is ubiquitous in nature and is the 13th most abundant element in the earth's crust.

Fluorine is one of the elements in the halogen group. The atomic number of fluorine is 9. The maximum number of electrons that can be incorporated in the outermost orbit is 6. Hence, fluorine is highly reactive and wants to become stable by gaining one electron. The effective surface charge of fluoride ion is greater than that of any other element, owing to the small radius of the fluorine atom. As a consequence, fluorine is the most electronegative and reactive of all the elements. It reacts promptly with its surroundings and is rarely found in free or elemental state.

Sources of Fluoride

The principal source of fluoride ingested by humans is water but some fluoride is also derived from plants, marine animals and atmosphere (coal smoke and volcanic emissions). Most of the fluoride in water is due to its solvent action on rocks and minerals. The fluoride concentration in the ground water depends on the amount of minerals in soil containing fluoride, the temperature and pH of water.

The most commonly available solid fluoride in nature is in the form of compounds like fluorapatite, cryolite or fluorospar. Earth's crust contains 880 ppm of fluoride, rocks contain about 300-700 ppm, and this is leached out to the ground water and surface water. Deep well water contains high level of fluoride. Sea-water contains about 0.8 to 1.4 ppm of fluoride. In the atmosphere, it is widely distributed in the gaseous form from volcanic activity and coal burning.

Fluorides in Food

- Fish contains good amount of fluoride (19 ppm).
- Seafood (fish) when prepared with their bones may contain high quantities of fluoride.
- Tea leaves contain about 97 ppm of fluoride (0.82 mg per cup of tea).
- Whole potatoes—6.5 ppm.
- Vegetables, cereals and fruits—0.2-0.3 ppm.
- Average intake from all sources per day: **Adults—2.2-3.2 ppm, Children—1-1.2 ppm.**

Amount of fluoride ingested by water and from food depends on the fluoride concentration in the water, the size and age of the person. Milk contains very low amount of fluoride. The total oral intake by infants has been estimated from analysis of commercial infant food to be 0.32 mg/day at age 1–4 weeks and at the age of 4-6 months, it is estimated to rise up to 1.23 mg. These values of total amount would be higher if fluoridated water were used for diluting the food and lower, if whole human or cow's milk constituted a large part of the diet. In addition to food and water, fluoride may also be ingested intentionally as fluoride supplements or unintentionally from topical fluoride application (fluoride dentifrices, rinses and topical applications).

FLUORIDE HOMEOSTASIS

The dynamic equilibrium between fluoride uptake and fluoride excretion is fluoride homeostasis. It depends on absorption, deposition in different structures of the body and excretion of fluoride (Fig. 36.3).

Absorption of Fluoride

Fluoride is mainly absorbed via the gastrointestinal tract. Fluoride may also be inhaled from atmospheric air-borne fluoride. Maximum plasma concentration 0.15–0.25 ppm reaches within 60 minutes. Fluoride is generally ingested in a beverage in food or as a pharmaceutical preparation such as NaF tablets. The absorption of fluoride and entry to systemic circulation depend on various factors such as reactivity and chemical bonding properties of the fluoride containing minerals, its solubility, etc.

Once ingested, inorganic ionic fluoride is normally rapidly absorbed by the stomach and intestine. Because fluoride appears in the blood very rapidly, stomach is probably the major site of absorption. A small amount may also be absorbed through the oral tissues. Fluoride inhaled in vapours and dust can also contribute to body fluoride levels (absorption through lungs). Among sodium fluoride, solid calcium fluoride and bone meal, maximum absorption is noticed in case of sodium fluoride.

Fluoride uptake also depends on other factors viz. nutritional sources, dietary pattern, geographical factors such as altitude and renal activity. Studies have demonstrated that calcium inhibits the fluoride absorption. Diets rich in proteins have been shown to increase levels of fluoride in plasma. Impaired renal function can result in excess fluoride retention leading to higher plasma and salivary levels of fluoride. As fluoride is largely excreted through the renal tubules, any disturbance of renal function can enhance fluoride retention and result in increased levels of fluoride in plasma and saliva.

Fluoride in blood. The maximum plasma fluoride concentration is found within 30–60 minutes of ingestion of soluble fluoride. After the initial rapid increase the fluoride concentration declines for the next several hours reaching a normal level after 24 hours. In the plasma, fluoride is found in ionic and non-ionic forms. Fluoride exists in both ionic and bound forms in the plasma, the bound form being present in large quantity. The concentration of ionic fluoride in plasma depends on the concentration of fluoride in drinking water. The

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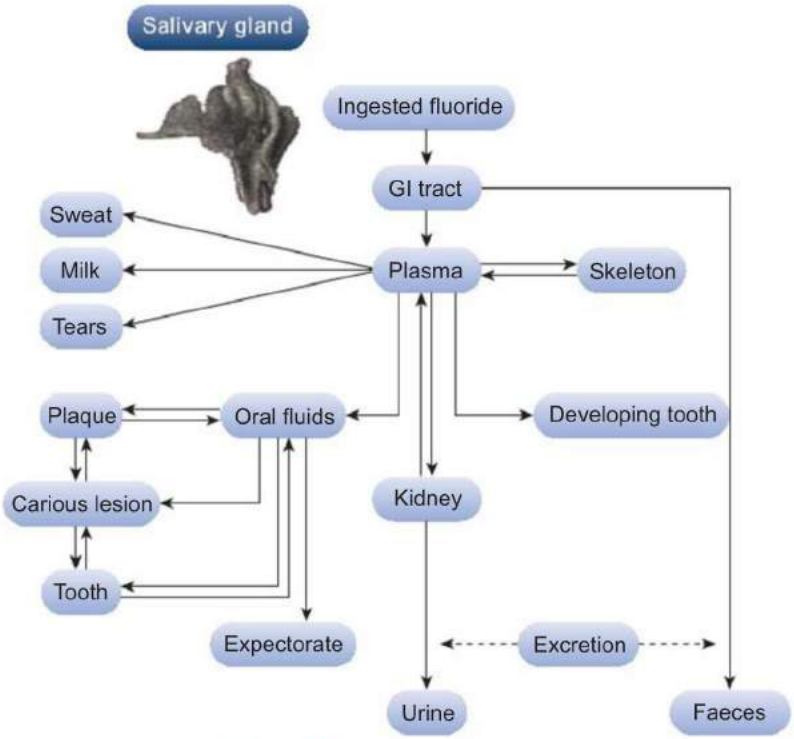


Figure 36.3 Fluoride homeostasis.

ionic form varies according to the concentration of fluoride in the drinking water and when the water contains 1.2 ppm of fluoride, the ionic fluoride in the plasma ranges from 0.25 ppm to 0.02 ppm. The higher levels are found in older individuals, probably because of slower skeletal growth.

Fluoride in saliva. Fluoride concentration in human saliva is less than those found in plasma ranging from 0.01 ppm to 0.05 ppm. Saliva-plasma fluoride ratio is 0.64 after single oral fluoride dose. Unstimulated saliva contains more fluoride than stimulated, but the rate of stimulation does not affect the concentration. The type of fluoride compound ingested also alters the extent of salivary response. Sodium fluoride, stannous fluoride and sodium monofluorophosphate all increase salivary fluoride levels more than aluminium fluoride or calcium fluoride (because of low solubility of aluminium and calcium salts).

Fluoride in milk. Fluoride levels in human milk are in the range of 0.02–0.05 ppm and are not significantly changed with changes in fluoride ingestion. Fluoride in cow's milk is found to be higher than in human milk and found to raise when animals are on a high fluoride diet.

Fluoride in mineralised tissues (Fig. 36.4). Fluoride is stored in the hard tissues of the body. The skeletal system and teeth serve as the storage sites for fluoride in the body. Fluoride concentration in bone and teeth build up with age slowly and related to the fluoride intake. Around 50% of excess dose of ingested fluoride is deposited in the bones. Approximately one-half of a dose of fluoride ingested in excess of normal is deposited and retained in the bones. The exact amount retained is dependent upon the amount of fluoride ingested and absorbed, the duration of fluoride exposure and the metabolic activity of the tissue involved. More rapidly growing bones (younger age) acquire fluoride at a more rapid rate. The quantity of fluoride accumulation by the skeletal system is closely related to the concentration of fluoride in the water. Skeletal systems continue to take up fluoride throughout the lifetime and increases in concentration with age. Fluoride is retained in the bones by chemical linkage through replacement of hydroxyl or bicarbonate groups bound within the bone by replacing hydroxyl or bicarbonate groups. The accumulation of large amounts of fluoride by bone also results in a decrease of citrate and increase in magnesium content.

Fluoride in dental tissues. Fluoride concentrations are relatively high in the earliest formed enamel. When the enamel is initially formed, the concentration of fluoride is relatively greater. Preferential accumulation then seems to occur at the transition/maturation interface. In this region, the organic matrix (mainly amelogenin) is breaking down rapidly and is removed with a concomitant increase in the tissue water content. Fluoride concentrations rise in the surface region during late maturation, when ameloblasts modulate between ruffled and smooth-ended morphologies. After eruption, little fluoride is taken up by completely mineralized sound enamel. Some fluoride is lost by wear. Surface uptake of fluoride by sound fully mineralised enamel is possible only when exposed to high concentrations of topical application or if the enamel becomes porous due to carious attack due to demineralization.

The fluoride concentration falls steeply from the pulpal surfaces to the enamel-dentin junction. The fluoride concentration is high in the surface region and falls

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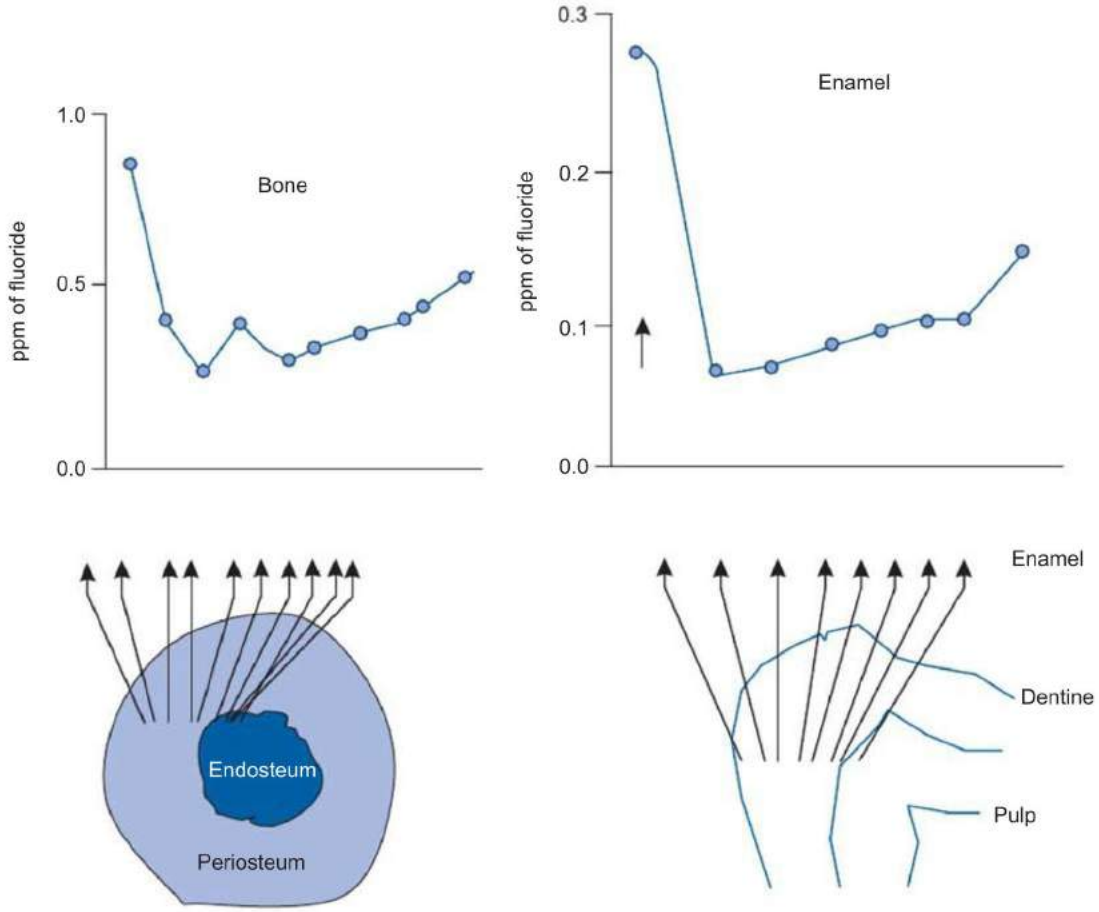


Figure 36.4 Concentration of fluoride in bone (human femur) and enamel (human molar).

to a plateau in the enamel interior. The fluoride concentration of different teeth in the same mouth as well as different areas of the same tooth also varies, but this is mainly the result of caries activity and enamel attrition rather than from developmental causes. However, newly erupted teeth have been found to contain more fluoride near the incisal edge possibly the incisal enamel as longer pre-eruptive stage.

Dentine, like cementum and bone, is a mesenchymal tissue. Unlike enamel, which are ectodermal, mesenchymal tissues have caliginous matrices and these are retained during the process of mineralisation. The apatite crystals are considerably smaller than those of enamel and are much less crystallised. Fluoride uptake in dentine is much greater owing to the increased surface area of the crystallites, the tubular structure and higher degree of tissue hydration. Dentine is also metabolically active and continues to grow throughout the life of the tooth and also because of greater porosity of dentine and the longer time during which they can acquire fluoride from tissue fluids (Fig. 36.5).

In the presence of fluoride, any change that increases the enamel porosity or allows deposition of mineral will result in an increased uptake of enamel fluoride. The wear or other abrasive forces remove some of the original surface, exposing enamel with lower fluoride concentration. The fluoride concentration in labial and buccal enamel surfaces of incisors, canines and premolars are higher near the biting edge in the young age

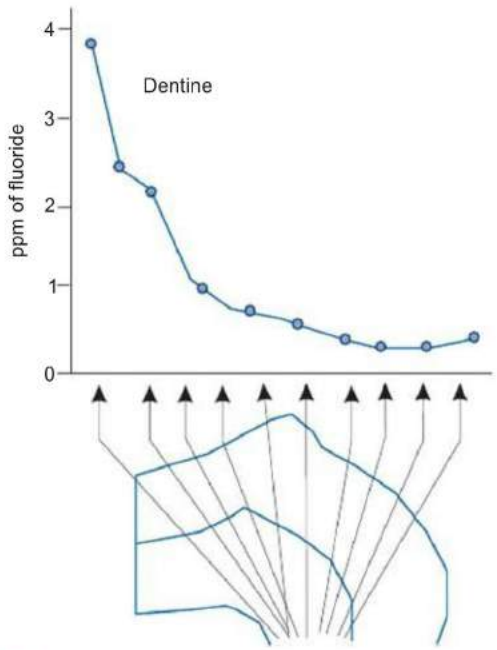


Figure 36.5 Concentration of fluoride in dentine (human molar).

group but will reduce with increasing age. The gingival area covered by the plaque contains more fluoride.

Cementum forms a thin layer on the surfaces of tooth roots. Like bone and dentin, it is a collagenous mesenchymal tissue. The small crystal size and poor crystallinity

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characteristic of mesenchymal tissues facilitates lower fluoride uptake in cementum compared with dental enamel.

Excretion of Fluoride

Excretion via kidney. The major portal of removal of fluoride is through renal excretion. Because ionic fluoride is not bound to plasma proteins, its concentration in the glomerular filtrate is undoubtedly the same as in plasma and water. On entering the renal tubules, fluoride ion will be reabsorbed and returned to the systemic circulation. The residue will be excreted in the urine. For adults, the normal renal clearance value of fluoride ranges from 30–50 ml/minute, whereas clearance rates of the other halogens, chloride, iodide and bromide, are usually less than 1 ml/minute.

Individuals, who are in active state of bone growth, excrete less fluoride than older individuals. The younger children will have lower urinary fluoride and greater fluoride storage, and approximately 30% of fluoride has been formed in the urine within 4 hours.

Excretion via faeces and sweat. Other routes of fluoride excretion are via sweat and faeces, but are of less quantitative importance. Faecal fluoride usually accounts for less than 10% of the amount ingested each day; i.e. more than 90% is typically absorbed. In temperate climates, excretion by sweating is usually negligible.

Fluoride Toxicity

Effects of different consumption concentrations of fluoride are depicted in Table 36.1.

FLUORIDE BIOMARKERS

The term biomarkers is used widely in life sciences. However, fluoride biomarkers are still obscure in a practical meaning regarding appropriate use, over exposure of fluorides and retention or deposition of fluoride in the organs.

Fluoride biomarkers are classified into three categories:

1. Contemporary markers (urine, plasma and saliva)
2. Recent markers (nail and hair)
3. Historic markers (bone and teeth)

Although bones are the major storage reservoirs of fluoride in the body, their use as biomarkers is limited due to difficulty in accessibility. Furthermore, as no correlation has been has been established between bone and enamel fluoride, teeth also cannot be considered as good biomarkers for fluoride.

Skeletal fluorosis and dental fluorosis are diseases related to fluoride ingestion. Bone is the largest storage site of fluoride in our body. Therefore, bone fluoride concentrations are considered biomarkers for total fluoride body burden (exposure). But there is a limitation on account of difficult accessibility, limits its use as biomarkers. However, no correlation was seen between bone and enamel Fluoride concentration or between bone and dentine Fluoride concentration in the human samples. Therefore, teeth are not good biomarkers for skeletal fluoride exposure in human when exposure is continued to optimal level of Fluoride in drinking water.

- Plasma and saliva fluoride concentration should be considered good biomarkers for total body burden of fluoride, especially if fasting plasma and fasting saliva are taken.
- Parotid duct saliva is a suitable biomarker of exposure to fluoride from the drinking water.
- Finger nails and toe nails can be used as biomarkers of chronic fluoride exposure from the diet.
- Urine was suitable biomarker of exposure to fluoride from dentifrice plus varnish, but not from dentifrice alone.
- Hair may be regarded as a useful material in evaluating prolonged exposure to fluorine compound.
- Bone surface is suitable biomarker for acute, sublethal fluoride exposure one day after fluoride administration.

Table 36.1 Effect of extra-ordinary fluoride intake in humans

Dose	Frequency	Effect
0	Daily for years	Increased susceptibility to dental caries
1–2 ppm	Daily for years	Reduced dental caries (greatest [1ppm in water] effect from pre-eruptive dose)
Toxic Effects		
3–15 ppm	Daily for years	Dental fluorosis of varying (2–10 ppm in water) severity and frequency (pre-eruptive dose only) reduced dental caries
20–80 ppm	Daily for eight or more years	Crippling dental fluorosis, gastrointestinal disturbances, dental fluorosis and increased dental caries
Acute Effects (lethal dose)		
250–1000 mg	One retained dose	Nausea, vomiting, abdominal pain
2.5–5 g (for children)	One retained dose	Probable death
5–10 g (for adult) (35–60 mg F/kg body wt)	One retained dose	Probable death

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Summary of Physiology and Chemistry of Fluoride

- Principal source of fluoride ingested is by drinking water and also by diet.
- Fluoride is absorbed from the stomach and intestinal tract.
- The peak level of fluoride in blood is found between 30–60 minutes after ingestion.
- Fluoride levels in saliva are about 65% of the blood levels.
- Skeletal system is the major site of fluoride accumulation followed by dental tissues.
- Most enamel fluoride is acquired before the eruption of tooth, and highest concentration is found in the outer layer of enamel, i.e. 30–50 microns.
- As permanent teeth have longer pre-eruptive maturation period, they have higher fluoride levels than deciduous teeth.
- Elimination of ingested fluoride is rapid primarily by kidney and 30% is excreted within 4 hours and remaining within 24 hours.
- Excess amount of fluoride, 2–3 ppm of fluoride may cause dental fluorosis and 8–20 ppm of fluoride may cause skeletal fluorosis.

MECHANISM OF ACTION OF FLUORIDE

Many studies have suggested that fluoride is capable of producing greater cariostatic effect than with currently used preparations. This is due to patients and practicing dentist may not utilise all the preparations available in the most effective manner. If the anticaries effect of fluoride has to be enhanced and maximised, the patient must be educated about various aspects of utilisation of fluorides.

Evidences suggest that fluoride provides anticaries effect in several ways and that under certain conditions several mechanisms may function simultaneously. With regard to development of caries, three fundamental requirements are bacteria, diet and susceptible enamel surface. There is enough evidence to show that fluoride can modify or eliminate these factors in each of the three areas. If one of the factors is modified in severity or intensity caries process would be slower, and if other factors are also modified simultaneously greater effect can be attained.

The cariostatic effect of fluorides can be explained by several mechanisms. Several mechanisms have been proposed to explain the cariostatic effect of fluoride. The cariostatic action of fluoride is therefore best described as multi-factorial. In relation to apatite crystal reactivity, two broad mechanisms operate. First, fluoride incorporated in the crystal can improve its resistance to acid. In particular, during remineralization or crystal maturation in the mouth, the outer surfaces of the crystals incorporate fluoride preferentially, converting the carbonate-containing apatite surface to a fluorapatite-like mineral, which is then much more resistant to any subsequent acid attack. When the dental mineral crystals are first formed, fluoride is incorporated, depending on the amount present in the fluid environment at each stage of maturation. This develop mentally incorporated fluoride is, however, distributed through the crystals at levels much lower than those found in fluorapatite. During the caries process, when some of the mineral dissolves, this incorporated fluoride can be released to assist in the inhibiting demineralization and promoting remineralization.

Second, the ionic fluoride in the aqueous fluid of the plaque and among the crystals within the enamel or dentin shifts the dernineralization/remineralization equilibrium toward mineralization, thus diminishing the damage to the tooth from a caries attack and contributing to the formation of acid-resistant crystals. That is, fluoride ions present in the fluid among the crystals can inhibit demineralization and enhance remineralization. Some investigators have attributed the effect of fluoride primarily to its incorporation into the solid, while others vouch for the beneficial influence of the ionic fluoride in the fluid surrounding the crystals. In essence, the two activities appear to be supplementary, both contributing to the protection of teeth against caries. Hence, the main mechanism by which fluoride increases the enamel resistance against caries may arise both from systemic and topical application of fluorides.

Anticaries Effects of Fluoride

Anticaries effects of fluoride are: **(1) fluoride and hydroxyapatite crystals, (2) fluoride and remineralisation of teeth, (3) fluoride and oral bacteria, (4) fluoride and enamel surface and (5) fluoride and morphology of teeth.**

Fluoride and hydroxyapatite crystals. Fluoride acts on the enamel crystals by two ways: (i) decreasing solubility and (ii) improving crystallinity.

(i) *Decreasing solubility:* When the tooth forms initially, it is made up of carbonated apatite crystals, which are most soluble in acid. Later on these carbonated apatite crystals are replaced by hydroxyapatite crystals, which are less soluble. If the tooth at this stage is exposed to fluoride, these hydroxyapatite crystals will get converted into fluoridated hydroxyl apatite, that later converts to fluorapatite which are least soluble (Fig. 36.6).

It has been proved that small amount of fluoride in an acid solution can have marked effect on hydroxyapatite solubility. Fluor-apatite forms on exposure to low

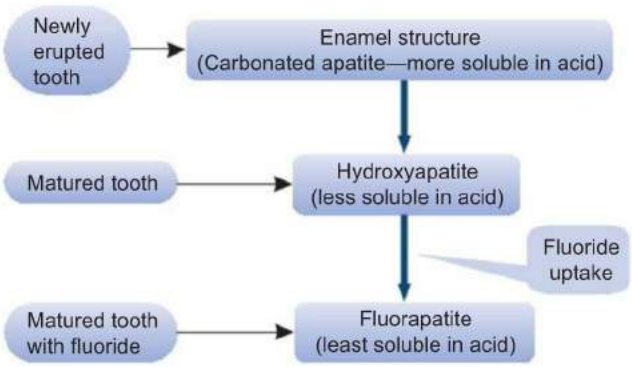


Figure 36.6 Different levels of enamel solubility in acids.

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concentration of fluoride. Fluorapatite acts as a membrane/ layer that regulate the rate of dissolution of hydroxyl apatite crystals.

(ii) *Improving crystallinity:* Hydroxyapatite crystals in dental enamel are typically small and contain several impurities. Radiographic analysis shows that presence of fluorine ion even in low concentrations effectively increases the crystallinity of hydroxyapatite. This is based on "Void theory".

Void theory concerns with association of the hydroxyl ion with calcium ions in the unit cell. Fluoride ions are able to fill up these occasional voids and replacing missing hydroxyl ions, thereby can effectively stabilise the crystal structure by providing additional and significantly stronger hydrogen bonds.

Fluoride and remineralization of teeth

Remineralization: Fluoride depresses demineralization and it enhances remineralisation (Fig. 36.7). Studies have shown that even a small amount of fluoride (0.03 ppm) can enhance remineralisation. Hydroxyapatite crystals when exposed to low concentrations of fluoride (e.g. dentifrices, fluoride mouth rinses) will form fluorapatite crystals. Although saliva is the natural remineralising solution, there is evidence that fluoride is more effective. Reversal of early carious lesion is frequently noticed, and these reversals are due to remineralisation on account of the use of anticaries agent, fluorides.

White spots are more rapidly remineralised by calcium phosphate containing fluoride than by 0.5% fluoride solution alone.

If hydroxyapatite crystals are exposed to high concentration of fluoride (professionally applied—NaF, SnF_2, APF), there is a formation of calcium fluoride. Later on, calcium fluoride further breaks down into calcium and fluoride. This fluoride is highly reactive and acts like commandos. They come back to the teeth and react with hydroxyapatite crystals and lead to the formation of fluoridated hydroxyapatite (FHA). Later, this fluoridated hydroxyapatite on exposure to fluoride for a longer period of time leads to formation of fluorapatite. Thus calcium fluoride acts like reservoir (Fig. 36.8).

Carious dissolution of enamel can be seen as a cyclic phenomenon consisting phases of demineralisation and re-precipitation that are determined by changes in the pH and ionic concentrations within the plaque and the lesion.

Presence of fluoride in dissolution medium significantly decreases enamel solubility by enhancing precipitation of hydroxyapatite and by preventing the formation of more soluble calcium phosphate.

Fluoride and oral bacteria. Saliva can serve as a source of fluoride for the plaque and therefore may affect both salivary and plaque organisms. Topical application of fluoride increases salivary fluoride levels more than ingested fluoride.

This is mainly by the topical application of fluoride. The fluoride has to be at high concentration to act as bactericidal (> 9000 ppm).

Fluoride can affect microorganisms in several ways: at low fluoride concentration it retards acid formation; at higher concentration it can have an effect on growth and metabolism; and at very high concentration it is bactericidal (lethal). Inhibition of bacterial growth and metabolism is related to the effect of fluoride on bacterial enzymes. The enzyme most sensitive to fluoride during the formation of acid is enolase and in the formation of polysaccharides is phosphoglucomutase (Fig. 36.9). The total

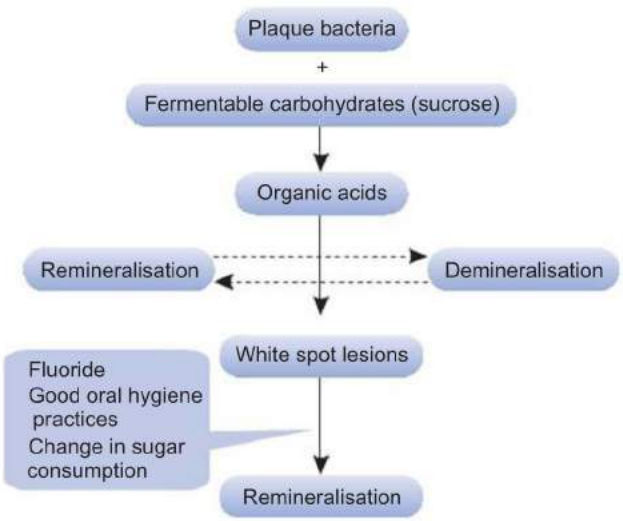


Figure 36.7 Effects of fluoride on demineralisation and remineralisation.

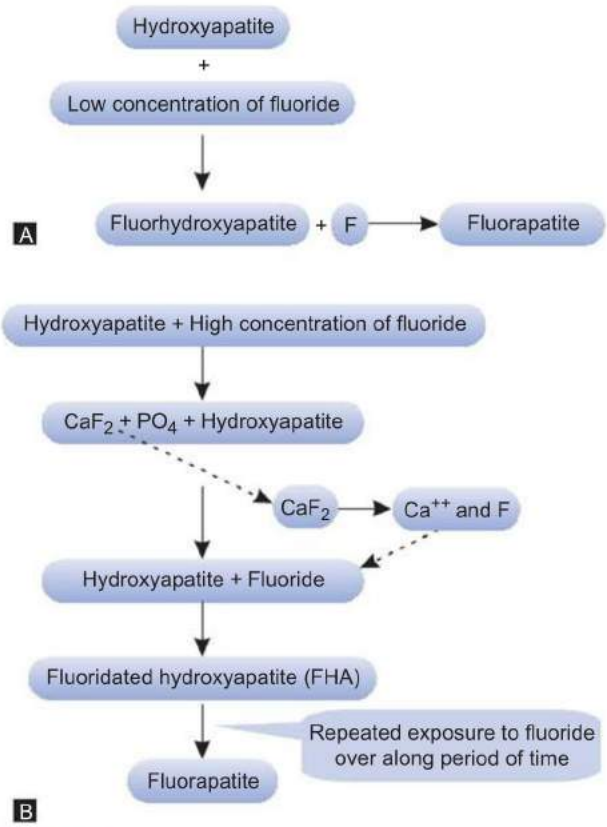


Figure 36.8 Diagram showing mechanism of formation of fluorapatite. (A) Low concentration of fluoride (B) high concentration of fluoride.

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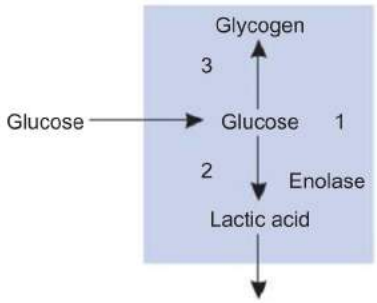


Figure 36.9 Role of bacterial enzymes in formation of acid.

amount of fluoride needed to inhibit the acid formation depends on pH of saliva, and more fluoride is needed to inhibit the acid formation at higher pH.

i. Fluoride acts on "enolase" enzyme and thus prevents the conversion of glucose to lactic acid.
ii. It prevents entry of glucose into bacterial cell.
iii. It prevents conversion of glucose into glycogen, which acts as storehouse when glucose is not available.

In general, plaque contains higher levels of fluoride than saliva. Although only a small amount of fluoride in the aqueous phase of plaque is in free ionic state (0.2 to 1 ppm), however, much more is released (1 to 5 ppm) when pH is lowered to levels found during caries activity. After the use of fluoride mouth rinses or fluoride dentifrice, it can reach 100 ppm for few minutes and it may remain elevated for several hours. The natural low concentration of fluoride in plaque at acid pH (1–5 ppm) has been found to reduce the amount of acid formation while higher concentration (70 ppm) achieved by using fluoridated dentifrices and mouth-rinses that serve to reduce the formation of polysaccharides. Whereas much higher concentrations (10,000 ppm) are lethal to bacteria especially for *Streptococcus mutans.*

Fluoride and enamel surface. Fluoride acts on enamel surface by two mechanisms:

i. Desorbs proteins and bacteria.
ii. Lowers free surface energy.

Desorbs proteins and bacteria: Higher concentration of fluoride in topical fluoride therapy could be effective in desorbing proteins and bacteria. Thus bacterial colonies and plaque formation are minimised. The use of fluoride containing preparation increases concentration of fluoride not only in the enamel but also in plaque. Not only the application of topical fluoride reduces the plaque accumulation but also results in lesser bacterial colonisation and lower caries score.
Lowers free surface energy: When tooth enamel is treated with metal fluoride solutions (stannous, amine), the free surface energy on the enamel surface is lowered. This action decreases the wettability of the enamel; in turn, it might contribute for lesser formation of plaque and thus prevents the initiation of dental caries.

Fluoride and morphology of teeth. The fluoride action on morphology of teeth is entirely through systemic route. Studies have shown that children living in fluoridated communities have shallow occlusal grooves, lower cuspal height and smaller size teeth. The teeth show more rounded appearance. Hence on the whole, lesser chances of plaque formation, lesser formation of acids and lesser caries activity.

CLASSIFICATION OF FLUORIDE THERAPY

Although the role of fluoride in caries prevention principally concerned fluoride, public water supply and other vehicles for fluoride administration have been recommended for long time since the first half of the century. Initially it was thought that, to be effective, the fluoride has to be ingested, absorbed into the body and laid down in forming tooth mineral. It occurs and undoubtedly has come to be known as the "systemic" or "pre-eruptive" method of fluoride administration. Later, it was found from many epidemiological studies that erupted teeth benefited substantially from exposure to fluoride. At the same time, it was shown that the amount of fluoride in tooth enamel could be increased by applying fluoride topically to tooth surfaces. This was the origin of the "topical" mode of action or topical method of applying fluoride.

There are various modes of administration of fluorides systemically and also various preparations of topical fluoride therapy available, each method having specific indications and advantages. The fluorides are mainly classified into systemic and topical fluorides.

1. **Systemic fluorides**
   a. Community water fluoridation
   b. Salt fluoridation
   c. School water fluoridation
   d. Milk fluoridation
   e. Fluoride supplements
2. **Topical fluorides**
   a. Professionally applied
      i. Sodium fluoride preparation
      ii. Stannous fluoride preparation
      iii. Acidulated phosphate fluoride (APF)
      iv. Fluoride varnish
      v. Fluoride impregnated floss and prophylactic paste
      vi. Fluoride containing dental materials and devices
   b. Self-applied
      i. Fluoridated dentifrice
      ii. Fluoride mouth rinse

Differences between systemic and topical fluorides are depicted in Table 36.2.

Systemic Fluorides

Community water fluoridation

Definition.
"Water fluoridation can be defined as the upward adjustment of the concentration of fluoride ion in public water supply in such a way that concentration of fluoride ion in the water may be consistently maintained at 1 parts per million (ppm) by weight."

Some communities where climate is hot, maintain the fluoride concentration slightly less than 1 ppm. This is to compensate for excess consumption of water during

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Table 36.2 Differences between systemic and topical fluorides

Systemic Fluorides	Topical Fluorides
• Applied through systemic route during development of dentition (maximum effect pre-eruptively) • Usually lower concentrations of fluorides are used • Effect of systemic fluorides are there throughout the life (used from birth to end of the life) • If excess amount of fluoride is ingested during developmental stage leads to dental fluorosis (more than optimal level of 1ppm) • Most of the time patient's co-operation and compliance are not required • Systemic fluorides are recommended in general for the whole population and mainly for prophylactic benefit against dental caries • Generally systemic fluorides are cost effective and cheaper • Generally patient can avail and utilize systemic fluoride on his/her own (self-application) • Effect lasts longer and throughout life (fluoride is incorporated in the tooth structure during developing stage)	• Applied topically after eruption of teeth (post-eruptively) Normally very high concentration of fluorides is used • Effects are seen only for shorter durations (used normally from younger age to 15 years) • Even if higher concentration of fluoride is applied topically it does not lead to fluorosis • Patient's co-operation and compliance are absolute necessary • Topical fluorides are recommended for special groups and high-risk children against dental caries • Generally topical fluorides are not cost effective and expensive • Normally topical fluoride therapy has to be applied professionally (sometime patients can use themselves at home, e.g. fluoride dentifrices, fluoride mouth rinses and fluoride gels) • Effect is for shorter duration and does not last for long (fluoride is lost from the tooth surface after the application). Hence requires repeated application

summer. In winter, the level of fluoride ion concentration is increased to compensate for lesser level of water consumption.

By 2008, nearly three-fourths of the U.S. population had access to fluoridated drinking water. An objective of the Healthy People 2010 was to increase coverage of water fluoridation that 75% of the world population would benefitted through this dental public health measure. The Healthy People 2010 objective was to increase coverage of water fluoridation so that 75% of the population would receive water with the optimum level of fluoride for prevention of tooth decay. Countries which have implemented water fluoridation are Australia, Brazil, Canada, Chile, Greece, Finland, Ireland, New Zealand, Spain, United Kingdom and the former USSR. About 350 million persons worldwide are estimated to regularly consume artificially fluoridated water.

Engineering Aspects

The three commonly used chemicals for fluoridation include:

1. **Sodium fluoride (powder)—Dry feeders**
2. **Sodium silicofluoride (powder)—Dry feeders**
3. **Hydroxyfluorosilicic acid—Solution feeders**

Sodium silico-fluoride is less expensive than sodium fluoride and hence has been used in large scale community water fluoridation, catering to 5000–50,000 people.

Today, most commonly used compound is hydrofluorosilicic acid in USA as it is less expensive and requires simpler technical handling. This can be used when serving more than 50,000 population. Sodium fluoride was the first compound used in controlled water fluoridation and still used widely in smaller community water system (fewer than 5000 people).

The methods by which fluorides are added to water supplies

1. A volumetric dry feeder system to deliver an estimated amount of fluoride (either sodium fluoride or sodium silicofluoride) in a given time interval.
2. In the solution feeder system, a small metering pump is used, to add hydrofluorosilicic acid to the water supply system. This is most commonly used and most popular method.
3. Saturator feed system (Specific to water fluoridation system).
4. Venturi fluoridation system for small rural communities.

Advantages

1. Beneficiaries receive continuous benefit without any conscious effort.
2. Does not require assembling of people at any one central location as is the case with other public health measures viz immunization programs.
3. It does not require the costly services and recurring costs involved as with that of dental clinic services.
4. The consumer is hassle free and need not worry about dosages.
5. It is available to all irrespective of social class or discriminations.

Limitations

1. Water fluoridation can be implemented only in areas which have central pipe water supply system.
2. It interferes with personal choice.
3. People may think of overprotection.
4. Initial cost for installing fluoridation plant is more.

Effects of Water Fluoridation

1. Reduction of dental caries: 50–70%. in permanent dentition and lesser in deciduous teeth if children are exposed to fluoridation programme from birth.
2. 75% reduction in first permanent molar loss.
3. It prevents malocclusion due to prevention of early loss of deciduous teeth.
4. It also prevents malocclusion due to prevention of loss of contact points due to caries.
5. The smooth surfaces get maximum benefit.
   (Expected caries reduction on different surfaces)
   On pit and fissures: 43%
   On proximal surfaces: 74%

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On gingival surfaces: 88%
Total: 58%.

6. When fluoride is present in tooth structure, if dental caries lesion develops, caries progression could be minimised or slowed down.
7. There is a reduction in the number of surfaces attacked by dental caries.
8. It prevents osteoporosis among elderly women, helps in prevention of pathological fracture in old age.
9. It prevents old-age hearing loss due to prevention of osteosclerotic changes.

Dilution Effect
Dilution effect results from increased availability of fluoride from multiple sources, diluting the impact of any one source of fluoride including water.

Diffusion or Halo Effect
Diffusion or halo effect is ingestion of various types of fluoride from sources other than water.

Salt fluoridation. As a dietary vehicle for fluoride, domestic salt is the second best to water. Fortification of salt with iodide illustrates the success tale of salt as an important delivery vehicle to prevent goiter on a mass scale. The same approach could be successful in fluoride delivery.

Salt is the good vehicle for systemic fluoride introduction. Salt fluoridation was introduced by Wespi in Switzerland in 1955. It is most popular in Colombia, Hungary and Spain.

The methods of addition of fluoride into salt include: (i) fluoride can be added to salt by spraying concentrated solution of NaF or KF on salt on a conveyor bed and (ii) it can also be prepared by mixing premixed granules added to the salt.

Recommended concentration is 250 mg of fluoride/kg salt.

Advantages
1. Quite economical
2. Practical/feasible
3. Caries reduction is about 40 to 50%

Disadvantages
1. Consumption of salts till 4–5 years after birth is negligible, hence no benefit for younger children.
2. Not useful in case of medically compromised patients (hypertension and renal failure).

Summary
Effectiveness of fluoridated salt in caries prevention can be compared to that of fluoridated water. Salt appears to be safe vehicle for fluoride administration.

School water fluoridation

Rationale
In communities with no central water supply or fluoride deficient water supply, at least, school water fluoridation can be recommended for school children.

School water fluoridation reduces dental caries by 40%. Its primary effects are systemic and also have topical effects. In a study teeth erupted after exposure to school water fluoridation, 57% less caries have been noticed. Those erupted before the introduction of school water fluoridation, showed 31% lesser caries. For maximum benefit, children should attend the school regularly and stay there till they complete the higher secondary school.

The concentration of fluoride recommended for school water fluoridation is 4.5 ppm, which is higher than the concentration of fluoride applied in community water fluoridation.

The reasons for recommending high concentration of fluoride in school water fluoridation are:

- Students receive only small part of the daily intake of water when they are in school.
- Students may not attend the school throughout the year.
- Frequency of drinking water in school by children is variable.
- Children attend the school only for a couple of hours.

On account of these reasons, the concentration of fluoride level has been increased.

Advantages
1. Target population—school children.
2. Caries experience is high during the developmental period (among children).
3. Quite economical.

Disadvantages
1. Cannot be implemented, if there is no safe water supply in the school.
2. There is a need for co-operation from school authorities.
3. All children may not attend the school all days.

Milk fluoridation. Milk fluoridation refers to the addition of a measured quantity of fluoride to bottled milk or milk packet. It is mainly recommended for growing children. The substantial caries preventive effects have been noticed, especially when milk consumption began before the eruption of the permanent teeth.

Milk fluoridation was strongly promoted by Ziegler, a paediatrician. In 1962, the first project with fluoridated milk began in the Swiss city Winterthur in 1965.

Globally, children are major consumers of milk. Nutritional programs in schools, aanganwadis as part of National Health Programs also include milk. Therefore, owing to the fact that milk distribution can cater to children from various sections of society, it seems a rational proposition to introduce milk as vehicle for delivery of fluoride in order to target children. People are also having the choice to opt for fluoridated and non-fluoridated milk, which upholds consumer's freedom of choice as well.

Various channels have been used for milk fluoridation, such as programmes distributing milk in kindergartens, and schools, and powdered milk and milk-cereal distributed as part of the National Complementary Feeding Programme in Chile. The objective of such programmes is to maintain the consumption of milk for at least 180 days per year.

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Concentration

- 2.2 mg of sodium fluoride (containing 1 mg of F) was added to 250 ml of milk.
- Later, milk bottles of 250 ml, containing 0.625 mg of fluoride are introduced in Switzerland and UK. Caries reduction is about 60%.

Limitations

1. Since children from lower socioeconomic groups tend to drink less amount of milk or no milk at all, hence they would be benefited least.
2. Any benefits cease, as an individual grows older and if he or she drinks less milk.
3. Costly.
4. Parent co-operation is important.

Fluoride supplements (fluoride tablets and drops)

Rationale

Community water fluoridation is the method of choice in providing systemic fluoride, but where community water fluoridation is not feasible or where there is political opposition preventing its implementation, fluoride supplements offer an alternate source of systemic fluoride.

Fluoride supplements can be given in the form of fluoride tablets, fluoride drops and lozenges. The cariostatic effect ranges from 30 to 70% depending on dosage and degree of compliance.

Fluoride supplements are taken on a daily basis from 6 months to 16 years of age. They have fluoride quantity of 1, 0.5 or 0.25 mg.

The American Academy of Pediatric Dentistry (according to 2014 revision) recommends fluoride supplement dose based on age and concentration of fluoride in drinking water as illustrated in the following.

Fluoride supplements were originally formulated as fluoride pill to be dissolved in a little of the infant's drinking water. Later, chewable tablets and lozenges are manufactured for older children. Lozenges are chewed or sucked for one or two minutes before swallowing. The intention is to get both systemic and topical effects. During chewing "F" is also pushed into deeper pits and fissures on the tooth surface.

Most tablets contain neutral NaF although APF tablets have been tested. There are also "F" vitamin drops for infants, often prescribed by paediatricians—just acts as motivational factor.

The factors to be considered for the correct dosage in prescribing fluoride supplements are dependent on: (i) age of child, (ii) the existing fluoride concentration in the water supply and (iii) climatic conditions.

Recommended dosage levels of supplemental fluoride, as established by the American Dental Association in 1994 (in mg F/day), are depicted in Table 36.3.

Sodium fluoride tablets are commercially available under the trade names of Fluoriday, Tymafluor, Luride (HOYT Ltd. London, UK).

Prenatal "fluoride" supplementation

The question of whether to prescribe "fluoride" supplements for expectant women to increase caries resistance in the offspring has been around for many years. "Fluoride" can cross the placental barrier and enter fetal circulation.

Table 36.3 Recommended dosage levels of supplemental fluoride

Age	<0.3 ppm F	0.3 to 0.6 ppm F	>0.6 ppm F
Birth to 6 months	0	0	0
6 mo to 3 years	0.25 mg	0	0
3 to 6 years	0.50 mg	0.25 mg	0
6 to at least 16 years	1.00 mg	0.50 mg	0

Research on fluorosis supports the view that the most critical time for fluoride uptake in enamel is the post-secretory and early mineralisation phase. As a result, prenatal fluoride will have little effect, especially as mineralisation even of primary teeth, is not far advanced at birth. However, fluoride prescription can be recommended from the point of motivating and educating the expectant mothers regarding preventive benefits of fluoride.

Review of expert working group of WHO (1994)

Current Position of Fluoride Supplements

- Fluoride supplements have limited application as possible health measure.
- Fluoride supplements should be administered with caution or only warranted in target population of only low-medium risk of caries. A dose of 0.5 mg F/day is recommended for high-risk children of age 3 years or older.
- Prescribed supplements should be used in childproof container. The fluoride tablets issued at one time all together should not exceed 120 mg of fluoride.

Daily administration of fluoride tablets at home requires a very high level of parental motivation and co-operation.

Topical Fluorides

Community water fluoridation and salt fluoridation have apparently achieved the decline of dental caries world-wide, being the most effective public health measures of caries prevention. Unfortunately, community water fluoridation and salt fluoridation have not been implemented in many parts of the world due to feasibility issues and complex problems in the supply and distribution. Therefore, additional methods of fluoride delivery have been explored.

The term, "topical fluoride therapy" refers to surface application of fluoride onto the teeth for caries prevention. Topical application of fluoride promotes the remineralization and reduces demineralization during the post-eruptive maturation phase, which is about 2 years duration from the time of eruption.

At the time of tooth eruption, the enamel is not yet completely calcified and undergoes a post-eruptive maturation period, approximately 2 years in length, during which enamel mineralisation and maturation continues.

Throughout this period, fluoride as well as other elements continue to accumulate in the superficial portion

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of enamel (source—saliva, fluoridated water and food). Most of the fluoride incorporated into the developing enamel occurs during pre-eruptive period of enamel formation and later post-eruptive period of enamel maturation. Highest concentration of fluoride is at the outermost layer of enamel, and the fluoride content decreases as one progress towards the dentin.

The fluoride ions substitute the hydroxyl ions in the hydroxyl-apatite crystal and stabilize the crystal structure of hydroxyl-apatite, substituted into hydroxyapatite crystal, fit more perfectly into the crystal than do hydroxyl ions. This makes the apatite crystals more stable and compact. These crystals are now more resistant to acid dissolution. As fluoride replaces the hydroxyl groups, a perfect fluorapatite is not formed; instead fluorhydroxyapatite is formed as not all hydroxyl ions are replaced and fluoride is continuously lost during the demineralization cycle of the dynamic oral environment and simultaneously gets re-precipitated as fluoridated hydroxylapatite. Furthermore, in an acidic environment, topical fluoride uptake is increased.

When fluoride reacts with hydroxyl apatite, calcium fluoride is produced (Muhler, 1952 and Fejerskov, 1978).

$$Ca_{10}(PO_4)_6(OH)_2 + 20F \leftarrow 10CaF_2 + 6HPO_4 + 2OH$$

As can be seen from the equation given earlier, there is a loss of phosphate ions from treated enamel. Newer fluoride systems incorporate a means of preventing such loss of phosphate ions.

The calcium fluoride (CaF_2), which is precipitated when the solubility product of CaF_2 is exceeded, could be a source of fluoride ions to the plaque fluid and into the porous underlying tooth substance during and after cariogenic attacks. Because it is more soluble than hydroxyapatite (HA) or fluorapatite (FA), and because of its high fluoride content, CaF_2 seems to be an ideal compound for the slow release of fluoride ions at the appropriate times (cariogenic challenge and during subsequent remineralization). The fluoride will be released at the tooth surface and available to inhibit demineralization and enhance remineralization.

Influencing factors

1. Concentration of fluoride
2. pH of the solution
3. Length of the exposure

High concentration of fluoride and acidic solutions of the fluoride reagent resulted in the formation of CaF_2 whereas lower concentration of fluoride (100 ppm or less) and neutral pH of the topical fluoride reagents resulted in the formation of fluorapatite.

Topical fluorides fall into two categories: (i) those applied by the dentist in clinics or dental offices, i.e. professionally applied, and (ii) those applied by the patients at home, i.e. self-applied. Normally the one applied by the dentist are of high fluoride concentrations and are applied generally at regular but frequent intervals, perhaps twice or once in a year. Those used by the patients are of low fluoride concentration and are applied at frequent intervals, often daily (Table 36.4).

Professionally applied

1. Sodium fluoride: NaF—2%

Milestone studies were conducted by Bibby in 1941 and Knutson (1942, 1947, 1948). The present preparation of sodium fluoride is developed by Knutson, which is referred to as Knutson's technique. 2% sodium fluoride is used with a pH of 7.

Method of preparation of 2% NaF: 2 g of NaF powder is dissolved in 100 ml of distilled water. It should be stored in plastic bottles because if stored in glass container, the 'F' ion of solution can react with silica of glass forming SiF_2, thus reducing the availability of free active fluoride for anticaries action.

Method of Application

- Oral prophylaxis is done only in first visit of the four applications.
- Isolation of each quadrant with cotton rolls.
- 2% NaF is then applied to the tooth surface with cotton applicators and kept wet for about 4 minutes.
- The procedure is repeated for the remaining quadrants.
- After the treatment, instruct the patient to avoid eating, drinking or rinsing for 30 minutes.
- This is to prolong the availability of "F" ion to react with tooth surface.
- 2nd, 3rd and 4th applications are carried out at weekly intervals.
- A full series of four treatments is recommended at the ages of 3, 7, 10 and 13 years, coinciding with the eruption of different groups of primary and permanent

Table 36.4 Summary of different modes of action of different fluoride preparations

	Mechanism			
	Increased Enamel Resistance	Remineralization	Antibacterial	Improved Morphology
Supplement	✧	✧	✧	✧
Dentifrice	✧	✧	●	
Rinse	✧	✧	●	
Topical application	✧	✧	✧	
Prophylaxis paste	●	✧		

✧ Significant effect possible.
● Effect possible on incipient lesion.

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teeth. Thus most of the teeth will be treated soon after their eruption for maximum protection.

Mechanism of Action

$$Ca_{10}(PO_4)_6(OH)_2 + 20F \leftarrow 10CaF_2 + 6HPO_4 + 2OH^-$$

As a result of this reaction, the principal compound formed is CaF_2, and this is due to the high concentration of "F" (9000 ppm) in 2% NaF. This results in the phenomenon called "choking off"—once a thick layer of CaF_2 forms, it interferes with further uptake of "F" ions. Later, CaF_2 dis-solves slowly in oral fluids and breaks down into Ca^+ and F^- ion. This fluoride is in free ionic form.

$$CaF \Rightarrow Ca^{++}\ F^-$$

This "F" is highly reactive and reacts with HA to form fluoridated hydroxyapatite.

Disadvantages

1. The patient has to visit the dentist four times within a relatively short time (weekly intervals for four weeks).
2. The expected caries reduction is not satisfactory (20-25%).

2. Stannous fluoride: SnF_2—8% or 10% (Fig. 36.11)

Stannous fluoride preparation is developed by Muhler (1947, 1950).

- Annual or biannual application.
- pH is 2.4-2.8.
- Available in gel and solution forms.

Method of Preparation

- It has to be freshly prepared before use each time as it has no shelf-life and also it is chemically highly unstable.
- 0.8 g or 1 g of Stannous fluoride powder (SnF_2) is dissolved in 10 ml of distilled water to get 8% or 10%.

Method of Application

- Perform oral prophylaxis.
- Isolation is done using cotton rolls.
- Treated quadrant wise.
- Quadrant to be treated should be free of saliva and if possible a saliva ejector should be used.
- The solution should be applied repeatedly so that the teeth are continuously moistened for 4 minutes.
- After the treatment, the patient should expectorate the residual fluoride.
- Instructed to abstain from eating, drinking or rinsing for 30 minutes (this may result in slightly longer fluoride contact and react with enamel).

Mechanism of Action

$$Ca_{10}(PO_4)_6(OH)_2 + 19SnF_2 \rightarrow \underset{\text{(Stannous trifluorophosphate)}}{10CaF_2 + 6Sn_3F_3PO_4} + \underset{\text{(Hydrated tin oxide)}}{SnO.H_2O}$$

Compared with that of NaF, the reaction of SnF2 with enamel is unique in that both the cations (stannous) and anions (fluoride) react chemically with enamel components. Formations of stannous fluorophosphates prevent at least temporarily the phosphate loss, which is typical of NaF applications. The CaF_2 so formed, further reacts with hydroxyapatite and forms fluoridated hydroxyapatite (FHA). The tin hydroxy phosphate gets dissolved in oral fluids and is responsible for metallic taste. The $Sn_3F_3PO_4$ makes the tooth structure more stable and less susceptible to acid dissolution.

Advantages

- It is applied half-yearly or annually.
- It is a very effective topical fluoride preparation.
- It is very useful for spot application among patients with ECC and rampant caries.
- Stable stannous fluoride gel is also available and it is the recommended and ideal preparation in case of radiation caries (cervical) among patients undergoing radiation therapy for head and neck cancers.
- Expected caries reduction is 25-35%.

Disadvantages

- It is chemically highly unstable (cannot be stored).
- Due to this, it requires instant preparation just prior to the application (takes more chair side time).
- Pigmentation of teeth after application of SnF_2 and brown staining can occur on enamel and anterior restorations. It has a metallic taste (astringent taste)—and not palatable to children.
- When it is brought in contact with gingiva during application, it causes blanching and burning sensation due to astringent property.
- It is not economical.

3. Acidulated phosphate fluoride (APF) 1.23%

Acidulated phosphate fluoride is available both in solution and gel forms.

A new topical fluoride preparation, acidulated phosphate fluoride (APF) was introduced by Brudevold and co-workers in 1960. Development of APF was based on the knowledge that slightly demineralised enamel will acquire more fluoride than unaffected enamel. It was hypothesised that addition of phosphate to acidified sodium fluoride would inhibit the enamel dissolution associated with the solution's low pH, but still allow an increased fluoride uptake. Thus, the APF solution was developed and it was acidulated with orthophosphoric acid and buffered to a pH of approximately 3. The general composition of APF is 1.23% of NaF, buffered to a pH 3–4 in a 0.1 M phosphoric acid.

- Developed in an effort to achieve greater amounts of fluoridated hydroxy apatite (FHA) and lesser amounts of calcium fluoride (CaF_2) formation.

Method of Preparation

Acidulated phosphate fluoride contains 1.23% "F" in 0.1 M phosphoric acid at pH of 3.

It is prepared by dissolving 2 g of NaF in 100 ml of 0.1 M phosphoric acid. To this 50% HF is added to adjust the pH at 3 and "F" concentration at 1.23%.

Acidulated phosphate fluoride gel contains methylcellulose or hydroxyethylcellulose as a base.

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Method of Application
- Perform oral prophylaxis.
- Isolation with cotton rolls.
- APF solution applied continuously and the teeth are kept moist for 4 minutes.
- Semiannual or annual application.
- In case of gel application, disposable trays of various sizes are used for both upper and lower jaw simultaneously.

Mechanism of Action

$$Ca_{10}(PO_4)_6 + NaF \rightarrow CaHPO4 \cdot 2H_2O$$

$$CaHPO_4 \cdot 2H_2O + F \rightarrow Ca_5(PO_4)_3F + HPO_4$$

Dicalcium phosphate dihydrate (DCPD)

APF applied on the teeth leads to loss of fluid and shrinkage in the volume of hydroxyapatite crystals and formation of dicalcium phosphate dihydrate (DCPD). This DCPD is highly reactive with "F" and leads to the formation of Fluorapatite "FA".

Advantages
- Semiannual or annual application.
- Chemically stable and can be stored for ready use.
- Does not produce staining of enamel.
- They are available in different flavouring tastes.
- Expected caries reduction is about 30 to 40% better than NaF and SnF_2.
- Can be recommended for home use by self-application.

Fluoride Containing Prophylactic Paste

Prophylactic paste with fluoride was developed to provide both the cleaning and the fluoride application in one step. With an easy single procedure, this can be accomplished and also save the time. This approach has proved to be an acceptable cariostatic method. It consists of 1.23% sodium fluoride, silicon or sodium metaphosphate.

Fluoride varnishes

Rationale

After topical fluoride application, there is substantial leaching of absorbed fluoride from surface enamel. To prevent this immediate loss, fluoride has been incorporated in varnishes that have ability to adhere to enamel for long period, and it is hypothesised that it will slowly release fluoride to the teeth. The retentive and possible slow release of fluoride from these products increase the exposure time of the fluoride by several days, without increasing chairside time, and presumably allow fluoride to be more permanently bound to the teeth.

Fluoride varnishes are applied as the standard regimen of topical fluoride therapy in Europe and Canada.

Types

1. Duraphat: 22.6 mg F/ml.
   5%NaF in Colophonium base—available in 10 ml tube.
   1% difluorisilane in polyurethane base (1 mg/ml).
2. Fluorprotector: pH lower than Duraphat and it is available in box with 20 vials—each vial contains 0.4 ml of solution.
3. Duraflour : 22.6 mg/ml.
   5% NaF in alcoholic suspension of natural resins.
   Addition of sweetening agent—xylitol.
4. Cavity shield: 5% NaF in resinous base.

Each pack contains 0.25 ml/0.4 ml and it is convenient to use depending on number of teeth to be treated. It is a cost-effective and safe method of fluoride application with least risk of over application and resulting fluoride toxicity.

Varnish Application and Technique
- Based on the caries risk of the individual, the dental professional decides the frequency of application.
- Semiannual application.

Technique

The technique involves the following steps:

1. Oral prophylaxis.
2. Isolation (Isolation is critical till the varnish sets/dries; once set, moisture control is not very critical; however, newer commercially available fluoride varnishes set in the presence of moisture.)
4. 0.5-1 ml of varnish is sufficient for the whole dentition; hence it is important to judiciously dispense the varnish.
5. Varnish application using a brush or cotton applicator. Contact of varnish with soft tissue should be avoided.
6. Varnish set is in a few seconds. The whole dentition varnish application takes 3-4 minutes. Most varnishes leave the tooth surface yellow. The parents and the patients should be informed that this yellowish discoloration is only temporary and that on brushing after one day, the discolouration will disappear. Patient should be instructed to abstain from brushing for the rest of the day and eating for the next 2 hours. It is desirable to advice the patient to consume soft diet for the rest of the day.

Fluoride Containing Dental Materials and Devices

Caries along the margins of the restorations is called secondary or recurrent caries. This is more common in case of silver amalgam restorations. Dental researchers have deliberately added fluoride to dental restorative materials, luting cements and cavity varnishes in order to impart a cariostatic property. They have demonstrated that these materials have the ability to impart fluoride to enamel or to reduce enamel solubility at the margins of restorations, in turn, might prevent development of secondary caries.

Fissure sealants are effective in preventing occlusal caries as long as they adhere to the tooth surface. The retention of sealants, however, is not definite all the time and if lost sealant is not replaced, caries can develop. This can be minimised if fluorides are incorporated in the fissure sealants.

There is also accepted concept of application of topical fluoride to the occlusal surfaces immediately after placing pit and fissure sealants, and in turn to provide

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better caries protection to the vulnerable pits and fissures of occlusal surfaces.

Fluoride Impregnated Dental Floss and Prophylaxis Cups

Both dental floss and dental prophylaxis cups have been impregnated with fluorides as additional methods of imparting fluoride to the teeth. Fluoride impregnated floss have the effect on the colonisation of *Streptococcus mutans* on interproximal surfaces.

The temperature of the enamel surface is raised during prophylaxis procedure because of the friction between prophylaxis cup and the tooth. Increased temperatures enhance fluoride uptake from prophylaxis paste. Therefore, if a fluoride impregnated prophylaxis cup is used during prophylaxis, fluoride would be released from the prophylaxis cup and be deposited in the outer layer of the enamel. However, when fluoride containing prophylaxis paste is used, there is no need for using fluoride impregnated prophylaxis cup.

Ingestion and Toxicity Concerns

Chances are more for ingestion of fluoride during application in almost all types of topical fluoride preparations, but they can be minimised by taking appropriate measures. As topical fluorides contain high concentration of fluoride and if they are swallowed during application, especially in very young children, it may lead to fluoride toxicity. It is recommended to use saliva ejector and thorough isolation with cotton rolls during the application procedure. And also ask the patients to spit out whatever the remnants of fluoride remaining in the mouth at the end of the application.

Self-applied fluoride preparations

Fluoride Dentifrice

In 1942, Trendly Dean reported that as little as 1 ppm fluoride in drinking water significantly reduced the prevalence of dental caries. This not only led to the introduction of fluoride in the drinking water but also the topical application of fluoride in the form of gels and solutions, fluoride mouth rinses and dentifrice.

In early clinical trials, fluoride toothpastes were unsuccessful, primarily because the polishing agents used in the toothpaste reacted with fluoride and thereby made it unavailable to the teeth. Since those early years, toothpaste formulations have undergone improvements, and the use of fluoridated dentifrices has been considered as the major reason of decline in caries in parts of the world where there is no water fluoridation program. There is no second view on the fact that the most widely used method of applying fluoride topically is by means of dentifrice.

History

During early years of research on fluoride, it was thought that mechanism of anticaries effect depended on fluoride being incorporated into enamel and that increasing the concentration of fluoride in enamel would reduce its solubility in acids.

Stannous fluoride toothpaste. Following the development of a relatively compatible abrasive system, a stannous fluoride toothpaste was formulated and clinically tested and marketed (Radiate et al. 1960). Disadvantages of stannous fluoride toothpaste include:

- Tendency for the formation of stain among some people, especially at the margins of the fillings or in demineralised areas.
- Short shelf-life because calcium pyrophosphate abrasive system slowly inactivates the fluoride.

APF tooth paste. Attempts to increase the fluoride deposition in enamel led to the development of APF. Based on its good results with this material when applied in the clinic, it was incorporated into toothpaste.

On comparison in a clinical trial with SnF_2, APF was not found to be superior (Brudevold et al.), eventually was removed from the market.

Sodium fluoride tooth paste. Sodium fluoride (NaF) thought to be less effective than other fluoride agents and because it was not compatible with early types of abrasive systems.

However, in recent years, it has been found that it is just as effective as other fluoride agents (Mellberg et al. 1990).

Amine fluoride tooth paste. Another approach to increase the effectiveness of fluoride toothpastes was based on the use of an agent that would attack the plaque and inhibit its ability to produce acids—the more effective fluoride is amine fluoride.

This toothpaste is currently sold in Europe (Muhlemann et al. 1967).

Sodium monofluorophosphate (MFP) tooth paste. In 1969, a toothpaste containing sodium monofluorophosphate and insoluble metaphosphate abrasive system was developed. Today, it is the world's most widely used fluoride. Because MFP ion is compatible with a wider variety of toothpaste abrasives compared to other fluorides and sodium monofluorophosphate does not require an acid pH. MFP dentifrices have a neutral or slightly alkaline pH and do not stain enamel surfaces or the margins of restorations.

Historically, fluoride toothpaste formulations have moved from products perceived to be ineffective in preventing dental caries to products that are now being credited for the worldwide decline in caries prevalence.

Current Status

Toothpastes properly formulated, with compatible components, with different fluoride agents are available and differ in clinical effectiveness.

Abrasive Systems

SnF_2 + Insoluble metaphosphate	Not stable.
NaF + Silica combinations	Quite stable.
MFP + Insoluble metaphosphate	Most commonly used.
MFP + $CaCO_3$	
SnF_2 + Ca Pyrophosphate	Not stable.
NaF + $CaCO_3$	

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Fluoride Concentrations in Toothpastes

Earlier clinical studies showed that 1500 ppm F toothpaste better than the 1000 ppm of fluoride toothpaste. Higher F concentration means increased anticaries activity.

Now available at 900 or 1000 ppm (0.76% of sodium MNF) concentrations for adults whereas in case of children they are available at about 500 ppm fluoride concentration.

Ingestion of Fluoride Dentifrice

During routine toothbrushing, some dentifrice containing fluoride is ingested accidentally. The amount is greater among young children, who do not have good control over their swallowing reflexes. The average amount ingested varies from about 35%, in children aged 2–4 years to only 3% in adults. As a precaution, parents should monitor the toothbrushing of very young children to prevent excessive dentifrice use and ingestion of fluoride.

Conclusion

Toothpastes are an ideal aid of maintenance of good oral hygiene status, and role of fluoridated toothpaste is the benchmark in providing necessary amount of fluoride to the tooth surface. Hence, they serve as constant source of supply of fluoride in the oral environment. Thus, it is the most important factor in accelerating remineralisation process in the enamel (helps in arresting or reversing the caries process).

Fluoride mouth rinses

Rationale

The cariostatic effect of frequent application of low concentration fluoride is greater than that of less frequent application of high concentration topical fluoride application. Fluoride mouthrinses are important means of caries prevention, especially in regions where it is not possible to implement water fluoridation. This method is most ideal for school children. The daily, weekly or fortnightly use of fluoride mouth rinse is a valuable anticaries measure in high-risk patients and also among children.

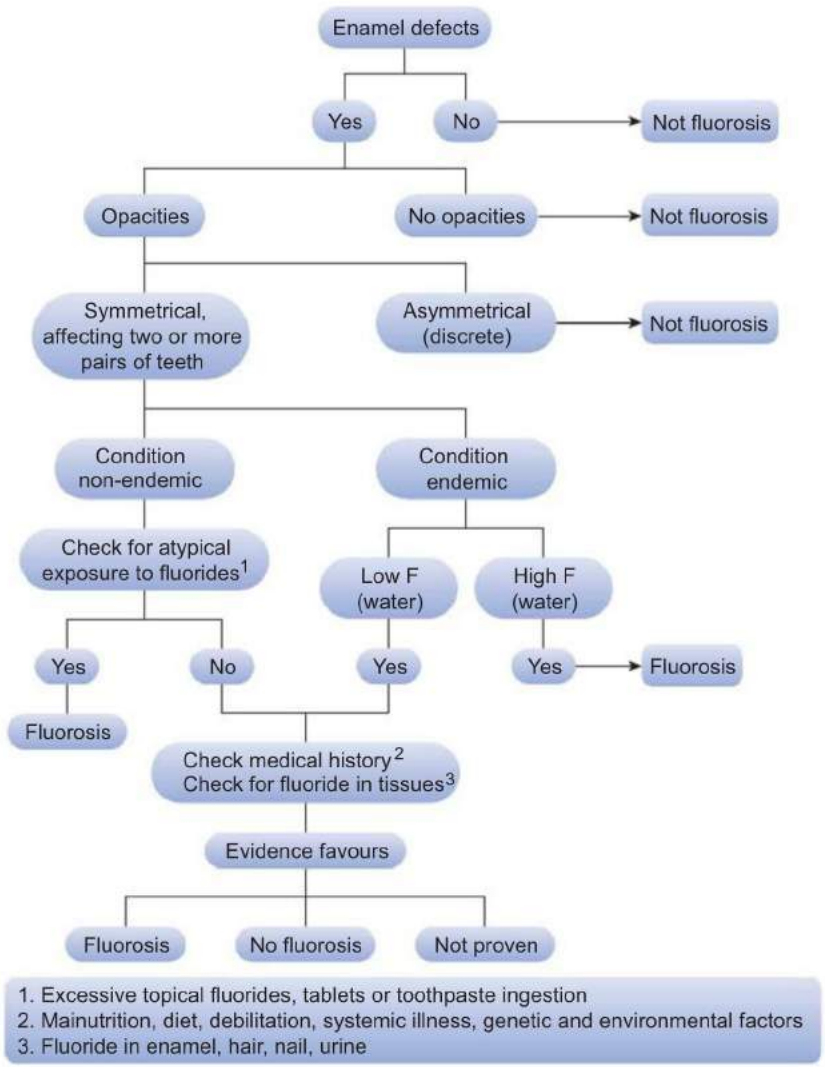


Figure 36.10 Mechanism of fluoride exposure for dental fluorosis.

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Dosage

1. Once daily
   (Low concentration and high frequency) *0.02% of NaF*
   0.05% NaF
2. Once weekly/fortnightly
   (High concentration and low frequency)
   0.2% NaF
   0.5% NaF

Indications

1. Caries susceptible children over the age of 6 years provided that they can rinse and spit everyday.
2. Patients wearing orthodontic appliances.
3. Patients with tooth wear and root caries.
4. Patients having dentinal hypersensitivity.

Contraindication

Fluoride mouth rinses are contra-indication in children under 6 years of age who are not capable of rinsing appropriately (who do not have reflex control of swallowing).

Preparation

Fluoride rinses can be prepared accordingly either for daily mouth rinse or fortnightly in schools.

2 g powder of NaF is dissolved in 1 litre of water. The children should be made to rinse for 1–2 minutes using 5–10 ml of NaF solution under supervision.

Home Preparation

Sodium fluoride (200 mg) tablet is dissolved in approximately 100 ml of fresh clean water, which is sufficient for daily mouth rinse of a family of about 4 members.

Special note

1. Dietary fluoride supplements should be considered for patients at high risk of caries and it is contraindicated when the water supply is optimally fluoridated or contains more than 0.3 ppm of fluoride.
2. Topical fluoride preparations should be applied carefully to prevent potential toxic effects. Fluoride varnish is the choice of topical agent especially for high-risk patients whose compliance with home regimes of fluoride preparations may be a problem.
3. Parents should always supervise young children's use of toothpaste.
4. Dental products for home use, including tooth-paste, should be kept out of the reach of young children.
5. The use of fluorides in preventive dental practice should always be combined with dietary advice and oral hygiene instructions and should be tailored to the needs of the individual patients.

Conclusions: Topical fluoride therapy

1. Children with high caries activity from non-fluoridated community and also from fluoridated community should receive professional topical fluoride application regularly.
2. Effects of topical fluorides in fluoride deficient communities generally are positive and greater.
3. Caries reduction for primary teeth is not as more as observed in permanent dentition.
4. The potential benefit of topical fluoride application is more in younger age group than in the adults.
5. The incorporation of fluoride into a viscous gel allows a convenient and time saving tray application.
6. They are useful in the management of root caries and root surface hypersensitivity in adult patients with exposed root surfaces.
7. Young patients undergoing orthodontic treatment and unable to maintain plaque control can benefit considerably from varnish treatment as an effective measure to prevent caries.
8. Although calcium fluoride will dissolve in aqueous solutions, it is reported to be relatively stable in the oral environment. This is presumably as a result of the interaction of the outer surface of the calcium fluoride globules with phosphate and or proteins.
9. Fluoride compounds have been added to various dental materials in order to prevent secondary or recurrent caries.
10. Various topical fluoride formulations have shown to rises fluoride levels in oral fluids, which can positively regulate the demineralization-remineralization equilibrium.

DENTAL FLUOROSIS

The range of fluoride concentration in drinking water normally recommended is 0.8–1.2 ppm. The fluoride concentration more than 1 ppm may result in some forms of toxicity like fluorosis. The chronic ingestion of excess fluoride during developmental stage only over a long period of time causes fluorosis.

The endemic fluorosis though it is prevalent in India, but affecting only 4-6% of the Indian population. In India, the more commonly affected states are Rajasthan, Gujarat and Andhra Pradesh, and lesser affected states are Tamil Nadu, Bihar and Karnataka.

Definition

Dental fluorosis is a hypoplasia or hypomineralisation of tooth enamel or dentine, produced by chronic ingestion of excessive amounts of fluoride during the period when teeth are developing.

Fluorosis is the hypomineralisation of enamel induced by fluoride in the proximity of the developing tooth during the secretory and/or maturation phases of amelogenesis. The severity and distribution of fluorosis depends on the fluoride concentration, duration of exposure to fluoride, age of the subject i.e. the stage of ameloblast activity and individual variation in susceptibility.

Dental fluorosis is clinically manifested as dull, opaque, white areas in the enamel, which may become mottled, discoloured or pitted. The mottled areas may be yellow or brown in colour. Clinical criteria for differential diagnosis of enamel fluorosis are given in Table 36.5.

Dental fluorosis results from ingestion of water, containing high levels of fluoride, during the development stage of teeth in infants and children [during the first

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Table 36.5 Clinical criteria for differential diagnosis of enamel fluorosis*

Characteristics	Milder Form of Enamel Fluorosis	Non-fluoride Enamel Opacities
Areas affected	Usually seen on or near tips of cusps or incisal edges	Usually centred in smooth surface; may affect the entire crown
Shape of the lesion	Resembles line shading in pencil and demarcation sketch; line follow incremental lines in enamel, from irregular caps on cusps	Often round or oval
Demarcation	Resembles line shading in pencil sketch lines	Often round or oval
Colour	Slightly more opaque than normal enamel: 'paper white'. Incisal edges, tips of cusps may have frosted appearance. Does not show stain at time of eruption (in milder degrees, rarely at any time)	Usually pigmented at time of eruption. Often creamy to reddish-orange
Teeth affected	Most frequent on teeth that calcify slowly (cuspids, bicuspids, second and third molars). Rare on lower incisors. Usually seen on six or eight homologous teeth. Extremely rare in deciduous teeth	Any tooth may be affected. Frequent on labial surfaces, lower incisors. May occur singly. Usually one to three teeth affected. Common in deciduous teeth
Gross hyperplasia	None. Pitting of enamel does not occur in the milder forms. Enamel surface has glazed appearance, is smooth to point of explorer	Enamel surface may seem etched and rough to explorer detection
Detection	Often invisible under strong light; most easily detected by line of sight tangential to tooth crown surface	Seen most easily under strong light on line of sight perpendicular to tooth

*Adapted from Russell.

5 years of life (0–5 years is the window period for fluorosis)]. Permanent teeth are more severely and more often affected than permanent teeth. This may be due to the fact that much of the mineralization of primary teeth occurs before birth and placenta serves as a barrier to the transfer of high concentrations of plasma (window period—0 to 5 years) fluoride from a pregnant mother to her developing fetus, thus controlling to a certain extent the delivery of fluoride to the developing primary dentition. Other reasons may be that period of enamel formation for primary teeth is shorter than for permanent teeth and that the enamel of primary teeth is thinner than that of permanent teeth.

Fluorosis in primary dentition could be a possible predictor of fluorosis in permanent dentition according to the recent studies. Use of fluoridated tooth paste before two years of age and concentration of drinking water fluoride content has been associated with primary tooth caries. The primary second molar is the most affected tooth among the deciduous.

Recommended optimum level of fluoride for drinking water is 0.7–1.2 ppm (WHO, 1963), and average daily intake of fluoride from all sources recommended for adults is 2–2.2 mg and in case of children (5-14 years) it is 1.2 mg.

Acute Fluoride Toxicity

Acute fluoride toxicity can result when dose of fluoride intake starts from certain level of fluoride that is 32-64 mg/kg body weight (certain lethal dose), i.e. approximately 2.5–5 g of fluoride in case of children and 5–10 g, one single retained dose, in case of adults. The safety tolerated dose is 8–16 mg of fluoride per kg body weight.

Management of acute fluoride toxicity

History

- Determine the exact nature and time of exposure or ingestion. Find out from the patient, relatives or eyewitnesses regarding details of exposure or ingestion of fluoride.

Physical Signs

- Gastrological signs: Hypersalivation, nausea, vomiting, diarrhoea, abdominal pain, dysphagia, mucosal injury.
- Neurologic effects: Headache, tremors, muscular spasm, tetanic contractions, hyperactive reflexes, seizures, muscle weakness.
- Electrolyte abnormalities: Hypocalcaemia, hypomagnesaemia, hyperkalemia, hypoglycaemia.

Causes

1. Excessive ingestion of substances with high levels of fluorides is the most common cause of acute fluoride toxicity. Try to obtain the exact name of the product and how much was ingested is extremely important.
2. Accidental ingestion of very high amounts of fluoride preparations like fluoride supplement at one time.

Emergency Care

- Cardiac monitoring.
- Hypocalcaemia may be detected.
- Perform gastric aspiration and lavage. Gastric lavage with 1–5% calcium chloride or milk or calcium/Magnesium hydroxide.
- Lavage and aspiration should be instituted within 1 hour for best outcome.

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- Administer milk, calcium carbonate and aluminium- and magnesium-based antacids (e.g. hydroxides) to bind fluoride.
- Correct calcium deficiencies with IV calcium chloride.

Conclusion

1. Timing, duration and dose of exposure to fluoride determine the severity of fluorosis.
2. Excessive ingestion of fluoride leads to increased porosity of enamel.
3. Risk for enamel fluorosis with fluoride exposure is lowest during the secretory stage.
4. Risk for enamel fluorosis with fluoride exposure is highest during maturation stages.
5. With an increase in dose of fluoride, risk of fluorosis increases.
6. The effects of fluoride are cumulative and increase with increased duration of exposure.

Treatment and Prevention of Fluorosis

Treatment. For very mild form of dental fluorosis, grinding and polishing of fluorosed teeth can be done:

1. Etching with hydrofluoric acid followed by bleaching with hydrogen peroxide (30%) can be done.
2. Acid etch technique is followed by resin labial veneer restorations.
3. In case of severe form of fluorosis, crown placement can be done.

Prevention of fluorosis

1. Avoid ingestion of water containing excess amount of fluoride between the age from birth and 5 years.
2. In population with malnutrition, prevalence and severity of dental fluorosis probably can be minimised by improving their nutritional status. The nutritional status for all the people is to be improved along with general health.
3. Identification of alternative water supplies with optimal or suboptimal levels of fluoride.
4. If possible, recommending switching over to alternative supply of water or mixing of water with different concentration of fluoride, so that ultimately there is reduced level of fluoride in drinking water.
5. If the aforementioned technique is not feasible, for all people, at least for the population of growing children (0-5 years), it should be implemented.
6. Recommendation for defluoridation, either at domestic level or at community levels.

Fluoride Analysis Methods (Fig. 36.22)

Fluoride analysis methods are: (i) ion chromatography, (ii) spectrophotometric method, (iii) fluoride ion-electrode method, (iv) gas chromatography, (v) aluminium monofluoride molecular absorption spectrometry, (vi) photon-induced X-ray emission, (vii) electron probe microanalysis and (viii) X-ray-induced photo-electron spectroscopy.

Ion chromatography. Analysis of aqueous samples in parts per million (ppm), quantities of common anions such as fluoride, chloride, nitrate and sulphates are done by a technique called ion chromatography. It uses ion exchange resins to separate atomic or molecular ions based on their interaction with the resin.

Spectrophotometric method. Used to analyse all forms of inorganic fluoride (Ionic and non-ionic)

- Inexpensive
- Faster and convenient at all circumstances

Fluoride ion-electrode method. This is used to measure fluoride ion activity (free fluoride ions). This method is expensive and slow.

Current Status of Fluorosis in India

Fluorosis is an endemic disease prevalent in 17 states of India (Fig. 36.11).

1. 70–100% districts are affected in Andhra Pradesh, Gujarat and Rajasthan.
2. 40–70% districts are affected in Bihar, national capital territory of Delhi, Haryana, Jharkhand, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Tamil Nadu and Uttar Pradesh.
3. 10–40% districts are affected in Assam, Jammu and Kashmir, Kerala, Chhattisgarh and West Bengal while endemicity for the rest of the states is not known.

DEFLUORIDATION

Definition

The downward adjustment of the level of fluoride in drinking water to optimal level of 1 ppm.

Methods of Defluoridation

Defluoridation can be done by two methods: (i) Ion exchange process or adsorption and (ii) Addition of chemicals to water during treatment.

Based upon ion exchange process or adsorption. In this method, the materials used in contact beds include processed bone, natural or synthetic tricalcium phosphate, hydroxyapatite, magnesia, activated alumina, activated carbon and ion exchangers.

Ion exchange resins

Anion Exchange Resins

Anion exchange resins are polysterine anion exchange resins. They are strongly basic quaternary ammonium type resins, especially Tulsion A-27, Deacodite FF (IP) and Lawatit MIH-59.

Cation Exchange Resins

1. Defluoron 1-sulphonated saw dust impregnated with 2% alum solution
2. Carbon
3. Magnesia

Based on addition of chemicals to water during treatment. Chemical treatment methods include use of lime either alone or with magnesium salts, aluminium salts either alone or in combination with a coagulant air.

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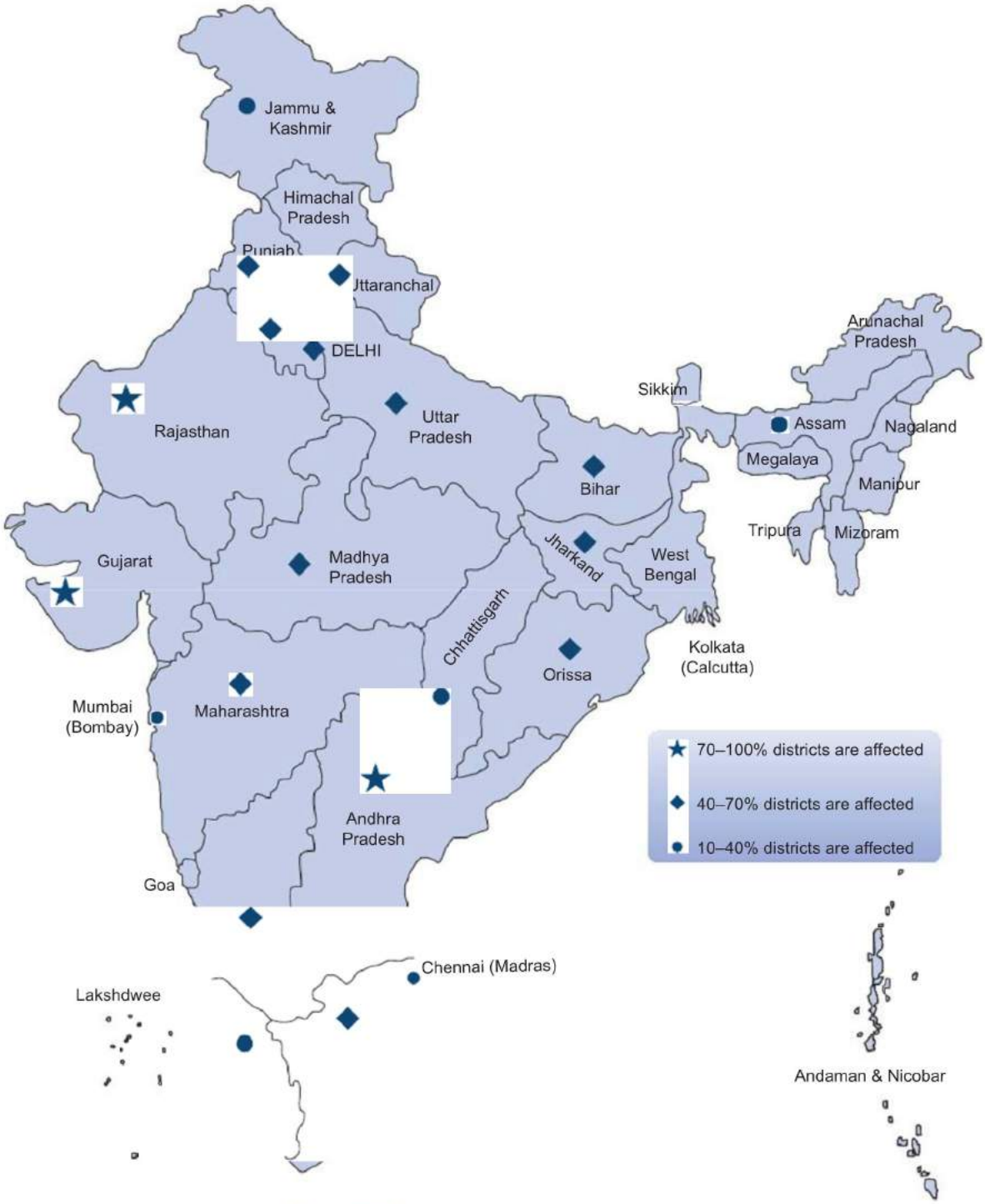


Figure 36.11 Endemicity of fluorosis in India.

Nalgonda Technique

(NEERI–National Environmental Engineering Research Institute–Nagpur)

Nalgonda technique of defluoridation: By this technique, safe drinking water with fluoride content within acceptable concentration of 1.5 mg/L for domestic and community drinking water (Fig. 36.12).

Salient features of process/technology. Water containing high concentrations of fluoride can be purified by the addition of aluminium salt, lime and bleaching powder to the raw water followed by flocculation, sedimentation and filtration. The domestic level treatment is performed in a bucket or any plastic container. For community level, fill-and-draw type plants are used.

Equipment and machinery. Equipment and machinery required are FC/RCC setting tank, flash mix and pump, flocculator, rapid gravity sand filter and disinfection unit.

Raw materials. Raw materials required are high fluoride raw water, alum, lime and bleaching powder.

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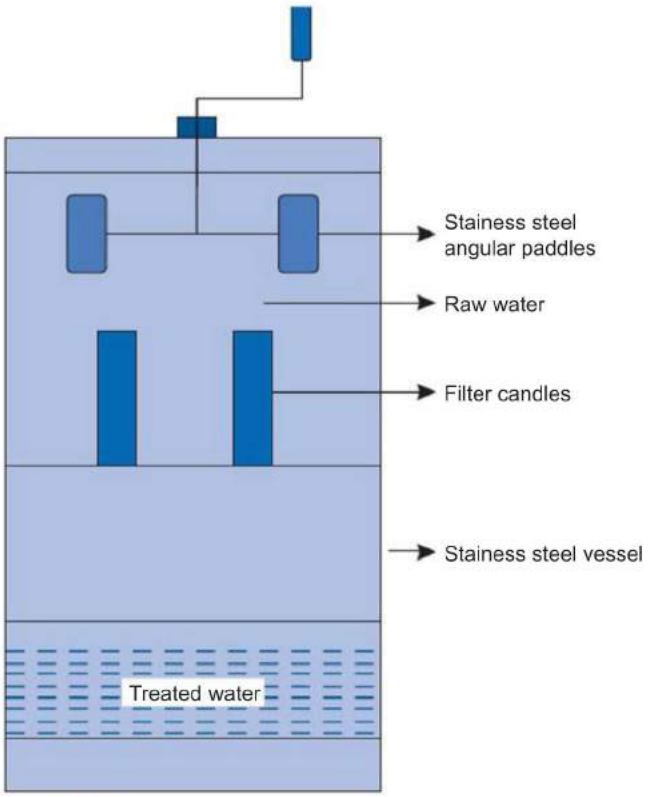


Figure 36.12 Stainless steel candle filter— Nalgonda technique.

Procedure. A container of 20–50 litres capacity is suitable for this purpose. Adequate amount of lime water (30 mg/litre of water) and bleaching powder are added to the water first and mixed well with it. Alum solution (500 mg/litre of water) is then poured and the water is stirred for 10 minutes.

Later, the contents are stirred for one hour and will be followed by flocculation, sedimentation and filtration. The water is allowed to settle down for 1 hour. The clear water is drawn through filtration without disturbing the sediment.

REPORTS FROM WHO ON APPROPRIATE USE OF FLUORIDES FOR HUMAN HEALTH

A conference in 1982 on the appropriate use of fluorides for human health under the auspices of Federation Dentaire International (FDI), the Kellogg Foundation and WHO reached the following conclusions and recommendations:

1. The conference, while welcoming the reports of decline in caries experience in many developed countries, it was greatly concerned about the sharp increase in dental caries in some developing countries. It proposed that as there is no possibility of treating so many decayed teeth with the dental resources at present available in the developing countries, the only hope is to contain the caries problem by preventive measures.
2. A well developed, centralized public water supply for community water fluoridation is an ideal measure for prevention of dental caries. Community water fluoridation is an effective, safe and inexpensive preventive measure, which requires no active compliance on part of the person benefited.
3. Unfortunately, community water fluoridation is not feasible in most part of the world as centralized public water supplies are not available. Hence, alternative strategies like fluoridated salt may be recommended.
4. There is no justification for using more than one systemic fluoride measure at any one time.
5. Use of various topical fluoride methods may be beneficial in communities along with systemic fluoride therapy.
6. Wherever possible, while using combination of fluoride therapy it is best to choose those that are self-administered or group administered as they are less expensive.
7. For high-risk individuals, professionally applied topical fluorides are ideal.
8. In areas with high concentration of fluoride in public water supply, there is an urgent need to develop an effective, simple and economical defluoridation method. It is recommended that in order to prevent excessive ingestion, brushing with fluoride toothpaste in children under the age of 6 years should be supervised. It is also recommended not to use fluoride mouth rinsing for children under 5 years.
9. It is recommended that each country should review its own dental needs, so as to take appropriate action to adopt various methods of using fluorides that is best suitable according to the needs in different regions. Thus, to promote dental health without any further delay, it is recommended that fluorides should be used wherever it is feasible.

CONCLUSION

Fluoride is the foundation of non-invasive dental caries management. It has been demonstrated most clearly that fluoride has to be ingested and to be incorporated into the tooth mineral during its development or it can be applied on to the tooth surfaces after the eruption of teeth into oral cavity, to have acceptable mechanism of action against dental caries. The various mechanisms underlying the protective effects of fluoride on erupted teeth of children and adults require frequent exposure to fluoride throughout life in order to achieve and maintain concentration of the fluoride ion in dental plaque and enamel. A constant exposure of fluoride in low concentration throughout life is important to prevent caries and maintain the demineralization-remineralization equilibrium. The earlier the children are exposed to the fluoridated water or dietary fluoride supplements, the greater the reduction in dental caries in both the primary and permanent dentition. Salt fluoridation is a widely practiced alternative

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CONCLUSION—cont'd

that has the advantage of allowing consumer choice. However, topical fluoride treatments also play a major role in remineralisation of the carious lesions and also to extend resistance of the tooth to dental caries is increased. The chemical product, calcium fluoride formed by the interaction of fluoride with tooth mineral is the major determining factor for the effectiveness of topical fluoride therapy. Water fluoridation will continue to retain its important role in caries prevention as mass strategy. Water fluoride concentration close to 1.0 mg/L is associated with high degree of caries inhibitory effect and least risk of fluorosis. Handicapping skeletal fluorosis fortunately is extremely rare throughout the world.

There is a wide acceptance of fluoride as anti caries agent world-wide and it is an evidence-based method for preventing and managing dental caries. Unfortunately, public and dental care providers do not have the knowledge about the value of fluoride.

REVIEW QUESTIONS

1. Write in detail the history of water fluoridation.
2. Discuss water fluoridation studies.
3. Write in brief about Deans 21 cities study.
4. Define water fluoridation. Discuss its feasibility for India.
5. Define fluoridation. Add a note on mechanism of action, advantage, disadvantages of community water fluoridation.
6. Discuss about fluoride homeostasis.
7. Describe the mechanism of action of fluorides in preventing dental caries. Mention the various professionally applied topical fluorides.
8. Discuss anticaries effect of fluorides.
9. Classify fluoride therapies.
10. Discuss in detail about systemic fluoridation.
11. What are topical fluorides. Discuss in detail about fluoride varnishes?
12. Write notes on:
    a. differences between systemic and topical fluorides
    b. rationale of school water fluoridation
    c. APF gel
    d. choking off phenomenon
    e. acute fluoride toxicity
    f. dental fluorosis
    g. Dean's fluorosis index
    h. prevention of dental fluorosis
    i. Nalgonda technique of defluoridation

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37 A Global Perspective on Application of Fluoride Technology

Amit Chattopadhyay, Jayanth V Kumar and Astha Singhal

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INTRODUCTION

It is now well established with ample evidence that fluoride prevents dental caries and fluoridation of public (or private) drinking water supply reduces dental caries incidence and prevalence in those communities that do not have fluoride exposure in a cost-effective manner. Removal of fluoridation from public water supply leads to increase in incidence and prevalence of dental caries in these communities. As a disease, manifestation of dental caries is different globally because in advanced nations, gross dental destruction due to caries is mostly a thing of the past (even though pockets of such manifestations exist). At the same time, in poorly developed or the developing world, such destructive presentations are still common. Different countries follow different paradigms of using fluoride to prevent dental caries.

GLOBAL VARIATION IN FLUORIDE DELIVERY

Fluoride exposure from drinking water may occur through adjusted or naturally occurring fluoridated municipal water supplies. Other sources of fluoride include non-fluoridated municipal water (the latter has minute concentration of fluoride), well water, bottled water from municipal source, spring water, bottled 'infant" or "nursery" water, bottled water with added fluoride and distilled or purified water. In some countries, particularly parts of India, Africa and China, drinking water can contain high concentrations of naturally occurring fluoride well in excess of the WHO recommended Guideline Value of 1.5 mg/L.

Fluoride is also available through foods and beverages. For example, tea is rich in fluoride. Heavy drinkers of beer, wine and other alcoholic or non-alcoholic beverages may also be exposed to substantial quantities of fluoride. Workers in certain industries such as Aluminum processing plants are also exposed to fluoride.

The use of fluoride for the prevention of dental caries ranges from the emphasis on water fluoridation in the US and Australia, with laws in Ireland and certain states of the US, through the French and Swiss using salt fluoridation to the major use of professionally applied fluorides on an individual basis in Scandinavia. The use of fluoride technology is diverse throughout Europe. Within Europe there also is a wide variation in the importance given to a population approach to the prevention of disease.

BALANCING BENEFITS AND RISKS OF FLUORIDE

In developing fluoride policies to control dental caries, different countries and communities have to consider various factors including the level of naturally occurring fluoride in water and other sources of fluoride. Appropriate level of fluoride exposure is maintained in a way that benefit is maximized and potential harm is minimized. Adjustment of fluoride to an optimum level in community water supplies or

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water fluoridation is promoted as a population-based strategy whereas the alternatives are more individual dependent. Adoption of a particular fluoride technology or a combination of different fluoride measures varies globally according to environmental, cultural, economic and political circumstances of the country or community. Although exposure to fluoride could occur through air, food and drinking water, the most common methods of fluoride delivery for prevention of dental caries are water fluoridation and fluoride toothpastes. In communities where fluoride in drinking water exceeds an acceptable level, it is removed to prevent enamel fluorosis and skeletal fluorosis.

Fluoridation-related policy development has been a major focus of public health dentistry since water fluoridation started in Grand Rapids, USA. The National Center for Fluoridation maintains a website at the following address http://www.fluoridationcenter.org/ to keep all fluoridation-related scientific information linked and easily accessible. However, there is no central and comprehensive global fluoride data repository. Some self-reported data can be found at http://www.fdiworlddental.org, which is the website of The FDI World Dental Federation that maintains self-reported data (http://www.fdiworlddental.org). Several organizations that are opposed to water fluoridation also maintain web sites and publish reports to disseminate information suitable to their perspective. Currently, especially with the advent of the Internet as an information mining resource, it is easy to obtain articles related to any topic of study. What is not easily available, however, is a guide to evaluation of reports and judicious inference making. Well-conducted studies published in respected peer-reviewed journals and from authoritative sources usually are better compared to opinions and unpublished articles of poor quality. The moral premise of relying on well-conducted and documented studies comes from the assurance of scientific methods, logical deduction and tempered conclusions. A quick reference guide to evaluating a scientific article can be found at: http://www.angelfire.com/nj/inquisitivemind/CritSciReadGuide.pdf.

WATER FLUORIDATION GLOBALLY

The first community program for water fluoridation was instituted in Grand Rapids, the United States of America (USA) in 1945. Other major evaluation programs followed: in the USA in Newburgh, New York (1945), and Evanston, Illinois (1946); in Brantford, Canada (1945); in the Netherlands (1953); in New Zealand (1954); in the United Kingdom (1955); and in the German Democratic Republic (1959). As a result of successful demonstration, many community water fluoridation programs were introduced in large cities of the USA, including Indianapolis (1951), San Francisco (1952), Philadelphia (1954), Chicago (1956), New York (1965), Dallas (1966) and Detroit (1967). At the present time, the public water supply in 43 out of the 50 largest cities in the USA is fluoridated. Worldwide, extensive fluoridation programs have also been introduced in Australia, Brazil, Chile, Colombia, Canada, Hong Kong Special Administrative Region of China, Ireland, Israel, Malaysia, New Zealand, Singapore, the United Kingdom and elsewhere. More recently new programs have been introduced in large conurbations in the southern and western regions of the USA including Los Angeles (in 1999), Las Vegas (in 2000), Sacramento (in 2000) and San Antonio (in 2002). Water fluoridation ended in the erstwhile Soviet Union and Eastern Europe with the break-up of the Soviet Union. European countries such as Austria, Belgium, Denmark, France, Germany, Italy, Norway and Sweden have no water fluoridation. On the contrary, Ho Chi Minh City in Vietnam introduced water fluoridation in 1990 after the prevalence of dental caries continued to increase despite the introduction of a school-based dental health program in 1979. Five years of water fluoridation helped to reduce the prevalence of dental caries in 12-year-olds from 84% in 1989 to 78% in 1995, with a mean DMFT of 3.4 in 1990 and 2.7 in 1995.

The only countries with 100% water fluoridation are Ireland and Singapore. Tables 37.1 to 37.3 show fluoridated water coverage from the 27 countries that have water fluoridation schemes with fluoridated water reaching a substantial number of people for which data are available with the WHO. These are the most reliable published reports for the penetration of fluoridated water till date. Countries where more than 50% of the population receives fluoridated water include: Australia, Ireland, Malaysia, New Zealand, Singapore and the United States.

The Asian and African Situation

Of the 50 countries in Asia, 20 outside the Middle-east, have some kind of fluoride administration available (fluoride toothpaste available in all). These include: Bhutan, Brunei; Cambodia; China; Hong Kong; India; Indonesia; Japan; Korea; Laos; Malaysia; Mongolia; Myanmar; Nepal; Pakistan; Philippines; Singapore; Sri Lanka; Thailand; and Vietnam. Eight of these have some kind of a community fluoridation program. Of these, six have water fluoridation programs (Brunei, Hong Kong, Korea, Malaysia, Singapore and Vietnam); Laos and Vietnam have salt fluoridation, whereas Thailand has milk fluoridation program.

WHO states that "the natural level can be as high as 95mg/L in some waters, such as in Tanzania, where the rocks are rich in fluoride-containing minerals." For a clear scientific assessment, adequate data are not available from most Asian and African countries not mentioned in Table 37.1. There has been a concern that natural water fluoride exposure in at least some communities may be high, which evokes circumspection in adopting water fluoridation in some of these countries. For example, few investigations on skeletal fluorosis or the risk of fractures include quantitative estimates of the dose–response relationship. Studies in China and India report the occurrence of skeletal fluorosis above the fluoride level of 1.4 mg/L in drinking-water.

Problems with such studies have been that although fluorosis was clearly observed, it could not be completely attributed to any threshold levels of fluoride in the drinking water as the total intake from all sources of fluoride was not measured. Furthermore, these studies also relied

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Table 37.1 Estimated coverage of fluoridation in countries serving 1 million or more population*

Country	Population** (Millions)	Water fluoridation schemes covering populations of 1 million or more		Drinking water supplies with a natural fluoride concentration of around 1 mg/L covering populations of 1 million or more	
		Population Covered†	% Population Covered	Population Covered†	% Population Covered
Argentina	43.0	3.9	9	5.4	12.5
Australia	23.5	14.2	60.6	—	—
Brazil	206.1	78.3	38	—	—
Canada	35.5	15.2	42.9	—	—
Chile	17.8	6.2	35.1	—	—
Colombia	47.8	32.8	68.7	—	—
France	66.2	—	—	2.0	3
Gabon	1.7	—	—	1.7	100
Guatemala	16.0	2.5	15.4	—	—
Hong Kong	7.2	7.2	100	—	—
Ireland	4.6	2.8	60.5	—	—
Israel	8.2	5.5	67.2	—	—
Korea	50.4	5.9	11.7	—	—
Libya	6.3	—	—	1.2	18.5
Malaysia	29.9	20.9	69.9	0.0	
Mexico	125.4	—	—	3.8	3
New Zealand	125.4	75.9	60.5	—	—
Philippines	99.1	6.4	6.5	—	—
Senegal	14.7	—	—	1.5	10.3
Singapore	5.5	5.5	100	—	—
Spain	46.4	4.6	10	—	—
Sri Lanka	20.6	—	—	3.0	14.7
Tanzania	51.8	—	—	18.1	34.9
UK	64.5	5.9	9.1	—	—
USA	318.9	193.9	60.8	11.5	3.6
Vietnam	90.7	5.0	5.5	0.0	
Zimbabwe	15.2	—	—	3.0	20

* Adapted from: Lennon MA, Whelton H, O'Mullane D, Ekstrand J.
† Actual population (numbers) covered will vary from the study[6] because estimates have been updated using new population estimates keeping proportion covered same.
** World population estimates have been updated from the study using World Bank data (2011–2015).

Table 37.2 Estimated average cost per person per year of various fluoride-delivery options*

Fluoride Alternative	Cost (USD)†
Fluoridated Water	$ 0.71
Sealants (per Tooth)	$ 7.03–$ 52.00
Fluoride Toothpaste	$ 14.05–$ 102.59
Fluoride Treatment by Dentist	$ 21.08–$ 35.13
Fluoride Drops	$ 102.59
Fluoride Tablets	$ 119.7
Vitamin with Fluoride	$ 119.7
Fluoride Mouth Rinse	$ 153.9
Fluoride Gel	$ 205.19

* Adapted from: Kimminau, K.S., Shepherd, M.D., and Starrett, B.E.
† Costs updated to 2016 US dollars using standard inflation factors [$1.00 (2000) = $ 1.405 (2016)]

on self-reported symptoms of skeletal fluorosis and did not report a clear diagnostic criteria or clinical examination protocol. In some states of India, fluoride concentration in natural water is excessive and defluoridation of this natural water needs to be done to prevent skeletal fluorosis.

The highest prevalence of drinking-water-related fluorosis in China has been reported to be in the North-Eastern region of the country. Endemic fluorosis is prevalent in China occurring in 29 of its provinces, municipalities and autonomous regions. WHO attributes skeletal fluorosis in China to consumption of drinking-water containing high fluoride levels, pollution caused by burning fluoride-rich coal and high levels of consumption of brick tea. Quoting some studies from the 1990s, WHO states that over one million cases of skeletal fluorosis in China are attributable to drinking-water with another million cases (Total 2 million) occurring due to coal smoke pollution. Furthermore, study estimated

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Table 37.3 Relative ranking of fluoride alternatives by different criteria*

Fluoride Alternative	Cost	Safety vs. Risk	Effectiveness	Acceptability as a Public Health Alternative
Public Fluoridated Water	Low	Low	High	High
Toothpaste	Low	Moderate	High	Moderate
Rinses (School Administered)	Low	Moderate	Moderate	High
Supplements	Moderate	High	Moderate	Moderate
Sealants	Moderate	Low	Moderate	Low
Chewing Gum (Xylitol)	Moderate	Moderate	Moderate	Moderate
Gels	High	High	Low	Low
Floss	Low	Low	Unknown	Moderate
Toothpicks	Low	Low	Unknown	Moderate
Fluoridated Bottled Water	Moderate	Low	Unknown	Moderate
Varnishes	Unknown	Low	Moderate	Low
Salt	Unknown	Not Applicable (N/A)	Moderate	Low
Milk	Unknown	N/A	Moderate	Low
Sugar	N/A	N/A	N/A	Low

* Adapted from: Kimminau, K.S., Shepherd, M.D., and Starrett, B.E.

suggest that "over 26 million people in China suffer from dental fluorosis due to elevated fluoride in their drinking-water, with a further 16.5 million cases of dental fluorosis resulting from coal smoke pollution" according to the report.

Fluoride in Waters of the Indian Subcontinent

Quoting a UNI/ Times of India report from 2nd June 2000, WHO states on its fluoride webpage that "Nearly 100,000 villagers in the remote Karbi Anglong district in the north-eastern state of Assam were reported to be affected by excessive fluoride levels in groundwater in June 2000. Many people have been crippled for life. The victims suffer from severe anaemia, stiff joints, painful and restricted movement, mottled teeth and kidney failure. The first fluorosis cases were discovered in the middle of 1999 in the Tekelangiun area of Karbi Anglong. Fluoride levels in the area vary from 5-23 mg/L, while the permissible limit in India is 1.2 mg/L. Local authorities launched a scheme for the supply of fluoride-free water and painted polluted tube-wells red: they also put up notice boards warning people not to drink the water from these wells." This is an example of sound policy making by indentifying a cluster of high fluoride exposure through natural water and replacing it with neutral water.

A review published in 2013 , Bashir et al. reported that while data from Nepal was sketchy and unreliable, ground water fluoride levels in Bangladesh were below the WHO maximum threshold value of 1.5 mg/L. In India, high natural water fluoride levels have been reported from several districts in Kerala and Gujarat; districts such as Jaipur, Ladhak, Yavatmal (Maharashtra), Tabtoly (Bihar), Nalgonda (Telengana), Tattapani (Chattisgarh), Bakreshwar (West Bengal), Khurda (Odisha), Erode (Tamil Nadu) and Kanpur (Uttar Pradesh). Similarly, high fluoride in natural waters have been reported in several districts in Pakistan such as Attock, Faisalabad, Karachi, Bhawalnagar, Gujaranwala, Lahore, Rahim Yar Khan, Sargodha, Shaikhopura, Kasur and Quetta. The Sri Lankan dry zone (a tropical dry broadleaf forest ecoregion) has been reported to have high natural water fluoride at 8.00 mg/L.

Regulating Fluoride Level in Water

Historically, the United States has led the efforts in promoting water fluoridation. In the USA, under the Safe Drinking Water Act, the U.S. Environmental Protection Agency (EPA) is required to establish exposure standards for contaminants in the public drinking water systems that might cause any adverse effects on human health. These standards include the maximum contaminant level goal (MCLG), the maximum contaminant level (MCL) and the secondary maximum contaminant level (SMCL). The MCLG is a health goal set at a concentration at which no adverse effects are expected to occur and the margins of safety are judged adequate. The MCL is the enforceable standard that is set as close to the MCLG as possible, taking into consideration other factors, such as treatment technology and costs. For some contaminants, EPA also establishes an SMCL, which is a guideline for managing drinking water for aesthetic, cosmetic or technical effects. These levels are reviewed periodically in the wake of new scientific evidence.

Currently, EPA has established the MCLG at 4mg/L and the SMCL at 2 mg/L. The most recent report, "Fluoride in drinking water: A scientific Review of EPA's Standards" by the Committee on Fluoride Drinking Water, Board on Environmental Studies and Toxicology of the Division on Earth and Life Studies, National Research Council of the National Academies was published in

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March, 2006. This report suggested that the current MCLG should be lowered to prevent severe enamel fluorosis. Further, lowering the fluoride concentration to below 2 mg/L will reduce the lifetime accumulation of fluoride into bone that might put individuals at a risk of bone fracture and possibly skeletal fluorosis. The report stated that prevalence of severe enamel fluorosis is very low (near zero) at fluoride concentrations below 2 mg/L. It also stated that EPA established the SMCL to reduce the prevalence of moderate enamel fluorosis to less than 15% of the exposed population.

Petersen and Lennon suggest that for countries with high consumption levels, it is recommended that national health authorities and decision-makers formulate country-specific and community-specific goals for fluorides. However, WHO also notes that many countries currently undergoing nutrition transition do not have adequate fluoride exposure. It is the responsibility of national health authorities to ensure the implementation of feasible fluoride programs for their country.

SALT FLUORIDATION IN THE WORLD

Use of fluoridated salt has become popular in several parts of the world as an alternative to water fluoridation. One of the objections to water fluoridation is that it limits consumers' choice. If the public water supply is fluoridated, a consumer has few practical alternatives other than to purchase bottled drinking-water that does not contain fluoride. One of the attractions of fluoridated salt is that it can be sold alongside a non-fluoridated alternative just as iodized and non-iodized salts. When most sources of salt for human consumption are fluoridated, the effectiveness of salt fluoridation approximates that of water fluoridation.

Success in using salt fluoridation has been reported in Colombia, Costa Rica, Jamaica, and the Canton of Vaud in Switzerland, and some parts of France and Germany. Jamaica is the only country where virtually all salt destined for human consumption on the island has been fluoridated since 1987.

Fluoride concentrations in salt used around the world range from 90 mg/kg to 350 mg/kg although more recent studies have suggested an optimal concentration of around 250 mg/kg. Concerns have been raised in some parts of the UK about people consuming more salt contrary to the recommendation of salt-restricted diet for hypertension control. Such misgivings, which can be addressed by clarifying that fluoridated salt, need not be consumed in any greater quantity than non-fluoridated salt to derive beneficial effects. Therefore, fluoridated salt has to be consumed in lieu of the regular salt. The year 2005 was the 50th anniversary of the fluoridation of salt in Switzerland. Upon the evident success of this measure, the fluoridation of salt became a general product available within the supermarkets. In 2003, fluoridated salt held 86% market share of all domestic salt sold in Switzerland.

Fluoridated salt has the ability to reach a wide population irrespective of geographic location and economy; the process does not require experienced and trained operators at the community level or at the salt factory. The cost of implementation is absorbed through the normal salt marketing process and the cost of fluoride compounds (kilos per person per year versus tons per person per year in the case of water fluoridation) is substantially less (estimated 98–80% less, dependent upon local system) than the cost of water fluoridation. For example, in Nepal a detailed situational analysis revealed that salt fluoridation would be a good strategy for delivering fluoride to the oral environment. Due to poor general infrastructure and a large rural population, water fluoridation was considered not to be a suitable option for Nepal. Although fluoridated toothpastes are now more available since 2000, there are many disadvantaged communities in Nepal where the use of toothpaste is not a social norm or not affordable.

MILK FLUORIDATION IN THE WORLD

As an alternative to water fluoridation, several other vehicles have been tried to deliver fluorides to the oral environment. All fluoridated milk programs reported till now have been for children. It is conceivable that elderly people in assisted care centers and old age homes can be a good target for milk fluoridation schemes for control of root caries. Among the requirements for such vehicles are that these programs should have wide reach, should be inexpensive and should not require people to make any significant change in their behavior to access these options. Just like salt, which is consumed regularly, milk is another vehicle that is universally consumed globally. Use of milk as a vehicle for delivering fluoride was first reported from Switzerland by Ziegler in 1962 and was followed in Scotland and Hungary. Bulgaria is a world leader in milk fluoridation and has demonstrated substantial caries-reducing effects of milk fluoridation. Although Pakhomov et al. attribute the caries reduction to milk fluoridation, the authors suggested that mere introduction of the milk fluoridation project might have led to other changes affecting dental caries, such as improved oral hygiene and better dietary habits. Fluoridated milk has been distributed in kindergartens and schools. Powdered milk and milk-cereal have been distributed as part of the National Complementary Feeding Program in Chile. A program of distributing fluoridated milk to school has been successful in China. Because milk is an important nutrient for children, its acceptability can be easily explained to parents. Milk fluoridation schemes have generally tended to suggest the importance of starting the program in early childhood to ensure an optimal effect on the deciduous teeth, and to maintain the consumption of milk for at least 180 days per year.

GLOBAL FLUORIDE TOOTHPASTE USAGE

Use of fluoride toothpastes is probably the most universal oral habit practices in the developed and developing countries. A 1987 estimate suggested that more than 500 million people worldwide use fluoridated toothpaste out of an estimated population of 5-billion people. Fluoride toothpastes were introduced in the 1960s and 1970s as a

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way to control caries by delivering fluoride directly to the oral environment. Use of fluoride toothpastes is regarded as a major factor for the reduction of dental caries seen in several countries.

Being a marketed dental product, access to toothpaste may be limited by monetary resources available. The estimated 1999 annual cost of toothpaste in the USA varied between US$ 6 and US$ 12 per person per year. Although limitations to buying toothpastes are difficult to understand for any reasonably earning family, it becomes an important barrier among lower income class. This raises the possibility of social inequity and equitable access to health care. Fluoride toothpaste use has been reported to be less likely among underprivileged groups. Decline in dental caries attributable to toothpastes has been noticed around the world although such results were substantially greater among higher socio-economic classes in the UK and other countries.

Many countries in Asia have not been able to implement national health programs, which include a role of fluoride. The reasons for non-implementation of prevention programs (including fluoride)vary, ranging from the lack of national policy for oral health to low awareness of oral disease. Most Asian countries have fluoridated toothpaste available in the market. In China, availability of fluoridated tooth paste is uncommon and restricted to the urban areas. Most toothpastes with fluoride are locally produced and are reported to have insufficient levels of fluoride in them.

The WHO Oral Health Program emphasizes that everyone should be encouraged to brush daily with fluoride toothpaste. Due to the potential for inequality in uniform access to toothpaste, the WHO Oral Health Program has promoted the development and use of "affordable" fluoride toothpaste. This program has been effectively demonstrated in a school-based program in Indonesia. WHO defines "affordable" toothpaste as one that is available at a price that allows low-income individuals to purchase it. The Indonesian school-based program confirmed that companies can manufacture low-cost toothpastes. However, studies assessing the effectiveness of marketing such toothpastes to low-income groups are not yet available.

INEQUALITY IN ORAL HEALTH AND FLUORIDE POLICY

As has been discussed earlier, social inequalities and oral health inequity are important considerations of policy development as well as for adopting certain healthcare measures. Inequalities in health status as well as access to oral health care delivery system for minority ethnic groups, between sexes and across age groups, have been documented in several countries. Reducing these inequalities has been a major policy focus in most countries. Role of fluoride in health promotion and disease prevention activities has often been closely identified with the need to use vehicles that can have universal reach to maximize benefits. This has often prompted a debate as to the role that governments should play in deciding to what extent the people themselves should determine health care choices. Whereas pro-active people belonging to higher socio-economic class can afford to make choices about their healthcare attributes, most people living in poorer circumstances cannot afford to make such choices as they cannot reach marketable products. In such situations, universally available preventive methods are required. Water fluoridation has been seen as a preventive measure that does not lead to any social inequality as anyone who uses fluoridated water derives the benefits. Similarly, although relatively less effective compared to water fluoridation, salt and milk fluoridation also help in addressing the social inequality problem.

Health promotion policy must take into consideration the uneven distribution of health and disease, the uneven distribution of health hazards in the physical social environment, personal behavioral risk factors, opportunities to adopt healthier lifestyles and the uneven distribution and quality of health care. In addition, the Jakarta Declaration advocated health promotion strategies that could develop and change lifestyles and social, economic and environmental conditions that determine health.

In the UK and Australia, fluoridation of public water supplies is a proven public health measure that has been demonstrated to reduce caries experience, especially amongst socially deprived communities. In Australia water fluoridation reduced oral health inequalities amongst children and provided benefits for all social classes but the effects were more pronounced in lower social class children.

Since the Water (Fluoridation) Act 1985, no new fluoridation schemes have been introduced in the UK. Over 60 health authorities have completed the consultation required by the Act, but implementation of their fluoridation policies is being frustrated by the water undertakers. It has been suggested that there is an urgent need for amendment of the 1985 Water Fluoridation Act to facilitate the extension of this proven public health measure in the UK.

Policy issues related to fluorides can be understood from the current struggle by the UK dental interest groups to get the value added tax on toothpastes removed. Fluoride toothpaste has been claimed to be the single most important reason for the dramatic decline in caries in the past 20 years in the UK. Several dental interest groups contend that a reduction in cost would facilitate the increased use of fluoride toothpaste amongst socially deprived members of society, many of whom have high levels of caries.

Inequality is not just a phenomenon of the western world, but occurs in all societies. Inequalities in oral health have been documented among different school districts, across ages, between sexes, across religious groups and across education status of population in Uganda. Use of water fluoridation may have a more generalized effect in such societies and may help in reducing these inequalities.

For developing countries, cost is a major consideration with fluoridation. Water fluoridation requires large plants that have to be financed by governments at the local/state/national levels. Therefore, there is always a political struggle to maintain fluoridation status in tight budgetary situations. The average cost of water

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fluoridation in the USA has been estimated at US$ 0.72 per person per year (1999 prices). A number of studies have been carried out to examine the cost effectiveness and cost savings of various fluoride systems. For water fluoridation, the cost ranges from 12 US cents per person per year to 5 US dollars with an average of 51 US cents per person per year. Studies have shown benefits of 49 per cent in savings in treatment costs as a result of the use of water fluoridation. It has been estimated that for every $1 invested in water fluoridation, $38 can be saved in treatment costs. Rinsing weekly or bi-weekly with a fluoride solution has been estimated to cost 1 US dollar per child per year. Fluoride gels and varnishes are expensive to use because of the high labor costs involved. In comparison, fluoride toothpaste is a very cost-effective method for delivering fluoride. An estimate developed by the Kansas Health Institute examined the comparative cost and public health attributes of different alternative fluoridation strategies (Tables 2 & 3). The authors suggested that a variety of factors could affect the cost of the alternatives presented in this section of the report. For example, purchasing fluoride mouth rinse for home use as compared to the costs of purchasing the rinse for an entire school district would be substantially higher.

Fluoride is a key component of oral health promotion and is the cornerstone in the prevention of dental caries, both in children and adults. Its safety and effectiveness has been accepted by international health agencies. A co-ordinated approach to the delivery of fluoride on a community and individual basis is necessary to ensure the efficient use of resources and produce a maximum reduction in dental caries. This approach will also ensure that the prevalence of dental fluorosis will remain at an acceptable level. The use of fluoride as a public health measure, such as through water or salt fluoridation, combined with the use of fluoride toothpastes, needs to be maintained and indeed expanded into new regions. Using other fluoride delivery products has an important role in reducing caries in high-risk groups. Continued support from government and the corporate sector is required so that ongoing research can be carried out on fluoride to ensure its vital role in oral health promotion.

DEVELOPING POLICY ON FLUORIDE

Fluoridation of drinking water has become a victim of political machinations and rhetoric which ignores the fact that sources of exposure to fluoride vary from place to place leading to difficulties in making sound policy regarding fluoridation of community drinking water for health benefits. Two clear health outcomes exist related to fluoride, the world over. First, fluoride prevents dental caries, which is a major health problem worldwide. Second, excess exposure to fluoride over long period leads to skeletal fluorosis, which is a serious health issue in several pockets around the world. An important point to keep in mind is that those exposed to high fluoride from natural waters are probably not municipal community water drinkers. Also, it is likely that there exists clusters of high fluoride exposure through natural water consumption. An optimal way forward to develop rational fluoridation policy would be to map these clusters and assess exposures of different people exposed to high fluoride waters and multiple sources of water. Based on the outcomes of such studies, an optimal fluoridation of community drinking water can be recommended. The 2015 USPHS study-led policy recommendation, referred to below, shows the way how strong scientific evidence from well-conducted studies can inform good policy making without giving in to unscientific rhetoric.

Fluoride-related policy issues usually revolve around the mode of delivering fluoride to all community residents, usually drinking water fluoridation and related cost issues. Political and other considerations can alter water fluoridation policy as in the case of the Netherlands in 1976, Kuopio, Finland in 1992 and Basel, Switzerland in 2003. Following the success of water fluoridation worldwide, salt fluoridation in Latin American countries has been claimed as a major public health success. The advantage of both these forms is that social equity is accomplished in that in both forms, mere use of water/salt allows for fluoride delivery to every user. At the same time, democratic rights perspective argues that by fluoridating the water, political authorities take away the right of choice from consumers because the consumers who do not want to use fluoride do not have the choice of doing so. In a more authoritative political set-up, such an argument may not hold credence, but a democratic set-up champions the right of individuals to choose. Although, in a democracy, policies are developed in the best interest of the society, considerable efforts are needed to convince the public and policy makers to mandate fluoridation. Chlorination of water, compulsory vaccination, ban on cigarette smoking and use of seat belts are some examples where elected governments have enacted laws to protect the society at the expense of an individual's choice.

Fluoridation is a safe, cost-effective, socially equitable public health strategy for ensuring healthy smiles, which does not require the populace to adopt healthy behaviors or depend on professional care. The initiation and implementation of salt fluoridation requires a health promotion approach, which includes advocacy and facilitation, in addition to a long-term commitment by stakeholders to ensure that the whole population will benefit from this technology.

Global Fluoride Policy Development Recommendations

The WHO Oral Health Program continues to emphasize that everyone should be encouraged to brush daily with fluoride toothpaste. In addition, where the incidence and prevalence of dental caries in the community is high to moderate, or where there are firm indications that the incidence of caries is increasing, an additional source of fluoride (water, salt or milk) should be considered. Where the country (or area of the country) has a moderate level of economic and technological development, a municipal water supply reaching a large population, trained water engineers and favorable public opinion, water fluoridation using fluoride at a concentration of 0.5-1 mg/L is the method of choice, as per WHO.

In 1962, the U.S. Public Health Service (USPHS) provided recommendations for optimal fluoride concentrations in

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community drinking water for the United States. Their recommendation ranged from 0.7–1.2 mg/L and was based on ambient outdoor air temperature. This recommendation was followed the world over and continued to be a major source of reference. In a recent update released in 2015, the USPHS revised this recommendation. The USPHS assessed "scientific evidence related to the effectiveness of water fluoridation in caries prevention and control across all age groups". It considered that multiple exposures to fluoride is now common. Earlier, fluoride in drinking water was "one of several available fluoride sources; trends in the prevalence and severity of dental fluorosis; and current evidence on fluid intake of children across various outdoor air temperatures." In trying to balance the benefits of community drinking water fluoridation and minimize any potential harmful effects of it, the USPHS now recommends an optimal fluoride concentration of 0.7 milligrams/liter (mg/L) in community drinking water". This exercise is a fine example of policy making and revisiting earlier recommendations to make changes as needed based on contemporary conditions. In 1963, drinking water was the only source of fluoride for most communities, which has now changed due to consumption of fluoridated water, beverages and foods and widespread use of fluoridated toothpastes and infant formula prepared with fluoridated water. WHO states "multiple exposure must be taken into account when assessing the effects of trace elements in water. The main toxicity from drinking water is from long-term exposure *and occasional consumption of water above the guideline value is generally of no public health importance.*"

The resolutions of WHO and Pan American Health Organization (PAHO) and other international health agencies recommend the introduction of salt fluoridation where water fluoridation cannot be implemented or where water fluoridation cannot be further pursued for philosophical or political reasons. In the developing world, lack of implementation of fluoridation is largely related to the existence of public water treatment systems, cost, the availability of trained personnel and the availability of compounds at a price that such economies could afford. Likewise developing countries often have large rural populations with little access to treated water supplies or the necessary infrastructure to implement alternative manpower intensive measures for the prevention of dental caries. Residents of many communities cannot afford fluoridated toothpaste let alone a toothbrush.

It has been suggested that countries with excessive levels of fluoride ingestion, particularly where there is a risk of severe dental fluorosis or of skeletal fluorosis, should maintain a maximum fluoride level of 1.5 mg/L as recommended by WHO Water Quality Guidelines (with a target of between 0.8–1.2mg/l to maximize benefits and minimize harmful effects), although this objective is admittedly not always technically easy to achieve.

Furthermore, where sugar consumption is high or increasing, the caries preventive effects of fluorides need to be enhanced. WHO recommends that every effort must be made to develop affordable fluoride toothpastes for use in developing countries. As a public health measure, it would be in the interest of countries to exempt these toothpastes from the duties and taxation imposed on cosmetics. Water fluoridation, where technically feasible and culturally acceptable, has substantial advantages particularly for subgroups at high risk of caries. Alternatively, fluoridated salt, which retains consumer choice, can also be recommended. WHO is currently in the process of developing guidelines for milk fluoridation programs based on experiences from community trials carried out in both developed and developing countries.

It is essential to maintain and foster research, most importantly to:

- Update our information on the cost-effectiveness of water, salt and milk fluoridation against a background of the now wide-spread use of fluoride toothpastes;
- Continue to develop and update our knowledge of the health effects of ingested fluoride;
- Further develop affordable techniques for adjusting water supplies with excessive natural fluoride to the levels recommended by the WHO Water Quality Guidelines;
- Better understand the public perception of dental fluorosis;
- Evaluate the effects of the introduction of affordable fluoride toothpastes on public purchasing and utilization.

PAHO Recommendations

PAHO made ten recommendations, which included items related to the type of fluoridation programs to be maintained in each participating country, those that need to be phased out and the instruments for data collection to monitor program implementation for surveillance of salt fluoridation programs:

1. Only one systemic source of fluoride is recommended in each country. This should be either salt or water, but not both.
2. Dental caries should be monitored to evaluate the effectiveness of the preventive program. The recommended survey uses a tooth-based index (DMFT) and the diagnostic criteria and coding recommended by WHO. A surface-based index (DMFS) is not essential but could be utilized by the countries.
3. Dental fluorosis monitors past exposure to fluoride and should be monitored to assess unacceptable cosmetic effects of systemic fluoride overuse during the permanent teeth formative years.
4. Urinary fluoride excretion should be monitored to evaluate the current exposure to fluoride.
5. The baseline study of fluoride concentration in the water supplies for human consumption is essential. In all participating countries fluoride occurs naturally and its concentration may experience variations by season of the year and other geological activities. As a consequence, all water sources with concentrations higher than 0.5 parts per million of F should be monitored on a permanent basis to avoid overexposure if the fluoride content of the water increases after the introduction of salt fluoridation.
6. A nutritional survey to determine the consumption and ingestion of salt is non-essential. Data from previous nutritional studies could be used and/or extrapolated.

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7. Regarding other sources of fluoride:
   - Systemic fluoride, i.e. dietary fluoride supplements (drops, tablets and in multi-vitamin combinations) should be eliminated.
   - In a country with a national systemic fluoride program, fluoride mouthrinse programs provide additional topical preventive effect and should not be used if the DMFT at age 12 falls below 3. In countries without national fluoridation program, these programs should be continued if the DMFT index is greater than 3. If the index is less than three, these programs could continue if shown to be cost-effective. When used, fluoride mouth rinses should only be provided to children older than 6 years.
   - The use of fluoridated toothpaste is highly recommended. In younger children, less than 6 years, only a "pea" size of toothpaste should be delivered by the parent/guardian. It is recommended that children under 6 years should use toothpaste with a fluoride concentration between 400 and 550 ppm. Children over 6 years or age should use the standard formulated fluoride toothpaste (between 1000 and 1500 ppm).
   - Oral health promotion and tooth brushing training should continue after the implementation of national programs using systemic fluoride.
8. The recommended range of fluoride concentration in the salt for human consumption is 200-250 mg per kilo (equivalent to 250 ppm Fluoride).
9. Countries should assess the existing and regulatory framework that supports or hampers the introduction and sustainability of fluoridation programs. This requires the review of existing laws, regulations and the promotion of new or supplementary ones. Also, a regulatory mechanism for quality control should be part of the regulations concerning dosage.
10. Continuing education to the public and to health professionals is essential.

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38 Oral Hygiene Aids

Hiremath SS and Sushi Kadanakuppe

CHAPTER OUTLINE

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INTRODUCTION

Oral health is an inherent part of general health. Poor oral health can have adverse effects on a person's general health. Hence, a good oral health is very essential, which in turn is achieved by good oral hygiene. It is only in the beginning of the 19th century that the concept of good oral hygiene gained more importance even though the concept of good oral hygiene evolved some 5000 years ago. Plaque is an infectious agent responsible for many common dental diseases. The earlier concept of maintaining oral hygiene by just clearing the food debris has been taken over by removal of plaque in the 20th century. Studies have shown correlation with poor oral health and many systemic diseases even though it has not been substantially proven. Various types of oral hygiene aids were introduced in the 20th century to maintain a good oral hygiene. The aim of oral hygiene aids is to modify the oral micro flora to promote healthy oral tissues. The current oral hygienic measures appropriately used in conjunction with professional care are capable of maintaining oral health by virtually preventing caries and most periodontal diseases. Toothbrushing and flossing are most commonly used oral hygiene aids. Interdental brushes and wooden sticks can offer advantage in periodontally involved dentition. Mechanical measures using dentifrices, mouth rinses, gels and chewing gums can be supplemented with chemotherapeutic methods as delivery vehicles, which can improve oral hygiene. Oral hygiene promotion needs to be implemented for the population at large to make effective use of these oral hygienic measures. To maximise opportunities for oral health for all and to reduce inequalities by removing financial and other barriers, community oral hygiene promotion must be seriously attempted.

MANUAL TOOTH BRUSH

History

Hirboschfield, in his 1939 landmark textbook on the toothbrush and oral care, has described an in-depth review of history of toothbrushing. The exact origin of mechanical devices for cleaning teeth is not known. Twigs from plants with high aromatic properties were chewed by ancient people to clean their teeth. The mechanism of cleaning with chewing these twigs freshened the breath and spread out fibres at the tips of the twig for cleaning the tooth and gum surfaces. A piece of the root of the arak tree was used by the Arabs before Islam, because its fibres stood out like bristles; they called this device a *siwak*. The bristle fibres became soft after several uses. Therefore, the end will be stripped off to make new bristle fibres and this created a new "brush". Mohammed made rules for oral hygiene in the 7th century, and so it became a religious obligation. To this day the siwak is still used, composed from aromatic types of wood. Because they contain antibacterial oils and tannins chewing sticks not only to help physically clean teeth but also may help to prevent or remove plaque. Chinese, during the Tang dynasty (618–907 AD), are credited for inventing the toothbrush comprising a handle with bristles used hog bristles similar to those in some contemporary models. 'The first modern toothbrush' was manufactured in 1780, in England, by William Addis. This instrument had a bone handle with holes for placement of the natural hog bristles that were held in place by wire.

A changeover to Celluloid began to replace the bone handle in the early 1900s, which was hastened by World War I as bone and hog bristles were in short supply.

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Because of the blockade of high-quality natural hog bristles from China and Russia during World War II, nylon bristles were used instead. Originally, nylon bristles were copies of natural bristles in length and thickness but they were stiffer than natural bristles of similar diameter. Nylon bristles, compared to natural bristles, have the additional advantages that they can be prepared in various uniform diameter and shapes and can be end rounded to be gentler on gingival tissues during the brushing procedure. An American dentist in 1924 reported on 37 different manual toothbrushes with regard to handle shape, head design, bristle length and width. In the United States, the primary toothbrush shapes marketed in the 1940s through 1980s had flat, multi-tufted toothbrush. Newman toothbrushes have been introduced since the 1990s with different shapes, sizes, colours and claimed advances. The length and the angle of filaments in the brush head are varied so that brushing with these newly designed products has been documented to improve plaque removal since the bristle filaments can be directed into the sulcus and interproximal areas. Improved plaque removal has been shown with new unconventional toothbrushes with two or more heads or segments of filaments in angular relationship. For example, one new brush with three heads can be used simultaneously to clean the buccal, occlusal and lingual surfaces.

Manual Toothbrush Designs

More than any other category of dental products, manual toothbrushes vary in size, shape, texture and design. A manual toothbrush consists of a handle and a head with bristles. Tufts in a toothbrush head are composed of the bristles, which are bunched together. The head is divided into the toe, which is at the extreme end of the head, and the heel, which is closest to the handle. A constriction, termed the shank, usually occurs between the handle and the head. Many toothbrushes are manufactured in different sizes such as large, medium and small so that they adapt better to the oral anatomy of different individuals. Toothbrushes also differ in their defined hardness or texture classified as hard, medium, soft or extra soft. Much of the early data comparing the efficacy of various toothbrush designs is contradictory because of

- The lack of quantitative methods used to measure plaque removal
- The many sizes and shapes of toothbrushes used
- The lack of standardised toothbrushing procedures used in the studies

More recently, in attempts to better reach interproximal area toothbrush heads have been altered to vary bristle lengths and placement. To accommodate multiple dexterity levels handles have also been ergonomically designed.

Profiles

Toothbrushes have three basic lateral profiles when viewed from the side: concave, convex and multileveled (rippled or scalloped). For improved cleaning of facial surfaces the concave shape can be useful, whereas convex shapes appear more useful for improved cleaning of lingual surfaces. Toothbrushes with multilevel profiles are found to be consistently more effective than flat toothbrushes, especially when interproximal efficacy is monitored.

Bristle Shapes

Recently toothbrush products utilizing the bristles of new shapes and textures in multiple diameters, textures and bristle trims have been developed. Compared to toothbrushes with standard round bristles, laboratory studies have documented improved efficacy of toothbrushes with tapered, feathered and diamond-shaped bristles.

End-rounding. Originally, individual toothbrush bristles were cut bluntly, which often had sharp end configurations. In 1948, it was reported by Bass that these bristle tips could damage the soft tissues and that rounded, tapered or smooth bristle tips were less abrasive. When toothbrush is examined under low magnification, most bristles labeled as "rounded", in fact, are smooth or end rounded. Bristle wear has been shown to be related directly with the toothbrushing load and amount of dentifrice and inversely with bristle diameter.

Handle Designs

In the Unites States, many of the new toothbrushes have a styled handle design. Many modifications, such as triangular extrusions or indentations along the sides for a better grasp, a "thumb position" on the back of the handle for more comfort, and various angle bends to permit better access into and around the mouth have been introduced. Based on the handle designs four types of toothbrushes are available in the market (Fig. 38.1): (i) straight, (ii) angled, (iii) offset and (iv) angled offset.

Handle design and length may provide comfort and compliance during toothbrush use, and these factors have recently been documented to improve the quality of toothbrushing. This is particularly important for children whose dexterity may not be highly developed.

Texture

Bristle resistance to pressure is defined as texture, which is also referred to as firmness, stiffness and hardness. The firmness or texture of a bristle is related to

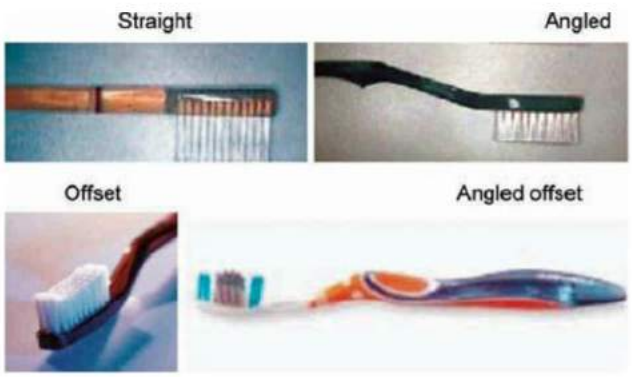


Figure 38.1 Different types of toothbrushes.

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its: (i) composition, (ii) diameter, (iii) length and (iv) the number of individual bristle per tuft.

Diameter of the bristle becomes critical determinant of texture, because majority of toothbrushes contain bristles 10 to 12 mm long. The usual range of diameters for adult toothbrush bristles ranges from 0.007 to 0.015 inches. Factors which affect texture are temperature, uptake of water (hydration) and frequency of toothbrush-use.

There is no standardized texture labeling. According to individual manufacturers' testing criteria, the brushes are labeled. Hence, one manufacturer's 'soft' grade may be stiffer than another manufacturer's 'medium' grade. Testing procedures have been formulated by International Organisation for Standardisation (ISO) that permit manufacturers to label their brushes in a consistent manner.

Nylon versus natural bristles. Nylon bristle is superior to the natural (hog) bristle in several prospects. The flexibility of Nylon bristles is as many as 10 times more often than natural bristles before breaking; they are easy to clean and do not split or abrade. The configurations and hardness of nylon bristles can be standardized within specified and reproducible tolerances. Natural bristles are tapered in diameter and therefore vary greatly in each filament. The resulting texture of the marketed toothbrush can lead to wide variations. Relatively few natural bristle toothbrushes are marketed, as a result the advantages of nylon, as well as its ease and economy of production. Bristle actions caused by different brushing motions and individual's brushing techniques do not vary and are inadequate.

POWERED TOOTHBRUSHES

Harper's Weekly in February 1886 first advertised powered toothbrushes. With the commercial success of this product, battery-powered products were a commercial success, which had the advantage of being portable and available at a lower cost. Unfortunately, problems with these battery-powered products included short 'working times' and mechanical breakdowns. The enthusiasm for the powered toothbrush declined. They are recommended mainly for the handicapped.

Head designs used now are basically of two primary types: (i) rotating, (ii) oscillating type with small, round molar-crown-size brushes head and (iii) oscillating brushes with either vibrational or rotational sonic movements. Plaque removal by these brushes appears equally effective (Fig. 38.2).

Bristle Designs

The heads of most powered or mechanical toothbrushes are usually removable to allow for replacements and are smaller than manual toothbrushes. The head follows three basic patterns when the motor is started:

1. Reciprocating, a back-and-forth movement
2. Arcuate, an up-and-down movement
3. Elliptical, a combination of the reciprocating and arcuate motions



Figure 38.2 Powered toothbrush.

In case of handicapped patients, powered toothbrushes are consistently superior to manual toothbrushes in plaque removal and gingivitis efficacy. However, under ideal conditions they are not superior to natural toothbrushing.

Toothbrushing Methods

Toothbrushing has the following objectives: (i) to clean teeth surfaces from food, debris and stain, (ii) to remove plaque and disturb reformation, (iii) to stimulate the gingival tissues and (iv) application of dentifrice with specific therapeutic agents to address caries, periodontal disease or sensitivity problem.

Many toothbrushing methods have been introduced during the past 50 years, and most are identified by an individual's name, such as **Bass method, Stillman method, Charters method and Fones method** (specially for children) or by a term indicating a primary action to be followed, such as roll or scrub (Table 38.1). No one method shows consistently better results in removing plaque.

Brushing Techniques

There are many brushing techniques among which some are very complicated. But here is the easiest and most practical one referring to what the patient should and should not do. A person can brush without damaging the gums or the teeth whatever the way he/she pleases as

Table 38.1 Brush motions used in toothbrushing methods

I. Horizontal reciprocating scrub
II. Vibratory • Bass (sulcular technique) Stillman • Charters
III. Vertical sweeping • Rolling stroke (press roll)—modified Stillman • Modified charters • Modified bass • Leonard • Smith-Bell (physiologic technique)
IV. Rotary (Fones)

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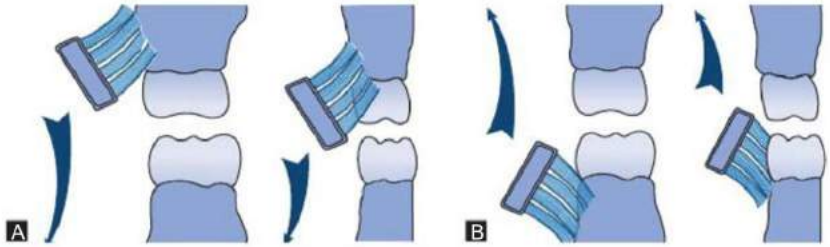


Figure 38.3 Vertical brushing technique: upward to downward and downward to upward.

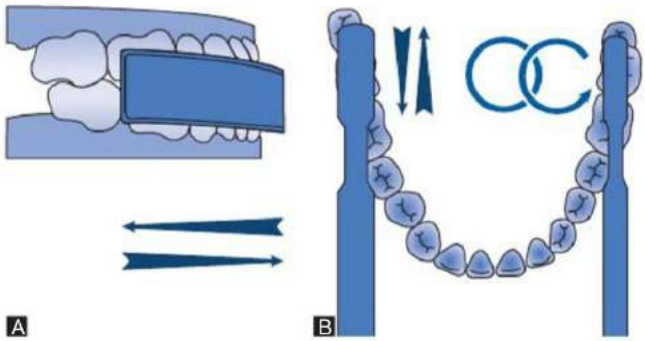


Figure 38.4 Horizontal brushing technique.

long as the dental plaque and/or other deposits are removed. As a dentist this should be respected since it is very hard to change a person's brushing habits, even harder is to teach someone who has never brushed.

It is recommended to tell the patient to use vertical movements, which is always from the gums to the edge of the tooth. In other words, in the upper jaw, from upward to downward and on the lower jaw from downward to upward.

It is always better to start by leaning the toothbrush against the gum and then move to the face of the tooth, giving the gum a little massage stimulating blood circulation and emptying the gingival sulcus.

Vertical brushing technique. There are many patients, who use vertical brushing method like the one shown in Fig. 38.3, but in directing the toothbrush from the edge of the tooth to the gum, the surface is cleaned but plaque is introduced to the gingival groove.

Horizontal brushing technique. Horizontal brushing technique is acceptable in children and on occlusal surfaces of the teeth (Figs. 38.4A, B).

Stillman's technique. Stillman's technique is basically the same but adding to the movement from gum to the tooth, a vertical movement, and making the toothbrush rotate forward. Stillman's method was originally developed to provide gingival stimulation. Brush is positioned with the bristles at a 45 degree angle to the apex of the tooth, with part of the brush resting on the gingiva. Other part of the toothbrush is placed on the tooth with rotatory motion and is also used to stimulate the gingiva slightly (Figs. 38.5A, B).

Bass method. Bass technique of toothbrushing uses the toothbrush to position on the gingival sulcus at a 45-degree angle to the tooth apex (Figs. 38.6A, B). The bristles are gently pressed to enter the gingival sulcus. A vibratory motion with a back and forth horizontal jiggle causes a pulsing of the bristles to clean the gingival sulcus.

Toothbrush in Adequate Position for Bass Method: In children and in adolescents, use of horizontal technique is acceptable. Though this method is easier, use of excessive force can produce injuries to the gum and tooth (cervical notch among canine teeth). The horizontal technique is acceptable when cleaning the occlusal surface (chewing sides of the molars and premolars).

Natural methods of brushing. The most natural brushing methods used by patients are reciprocating horizontal scrub technique, a rotary motion (Fones technique), or a simple up and down motion over the maxillary and mandibular teeth (Leonard's technique). Patients managing effective toothbrushing with these methods without causing traumatic injuries to the soft and hard tissues and should be allowed to continue.

Charters proposed a pressure technique to clean interproximal surfaces area. He advocated that toothbrush should be placed at an angle to the long axis of the teeth

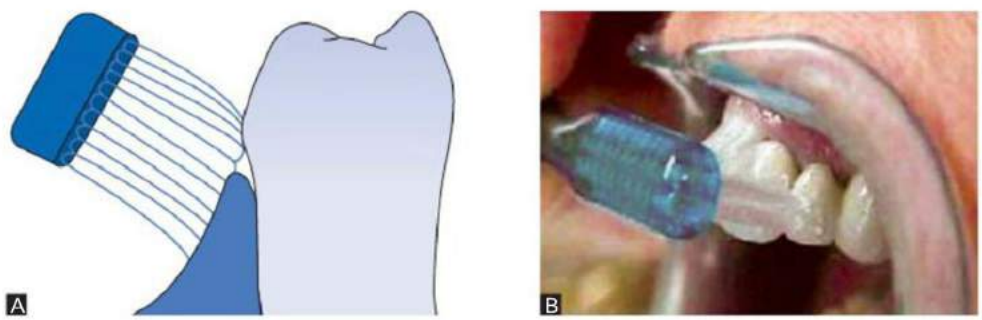


Figure 38.5 Demonstrating Stillman's method of brushing technique.

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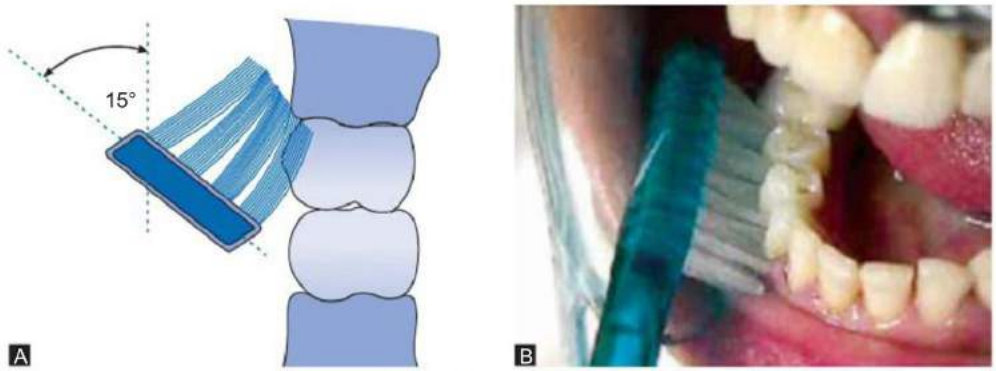


Figure 38.6 Bass method.

and bristles are gently forced between the teeth but do not rest on the gums. The brush is moved in several small rotary motions so that the bristles are in contact with the gum margin. After two or three such motions, the brush is removed and replaced in the same area and motions are repeated.

Modified brushing methods. Following considerations are considered important when teaching patients a particular toothbrushing technique: (i) the patient's oral health status including number of teeth, their alignment, patient's mouth size, presence of removable prostheses, orthodontic appliances, periodontal pockets and gingival condition; (ii) the patient's systemic health status including muscular and joint diseases, and mental retardation; (iii) the patient's age; (iv) the patient's interest and motivation; (v) the patient's manual dexterity; and (vi) the ease and effectiveness with which the professional can explain and demonstrate proper toothbrushing procedures.

Toothbrushing Time and Frequency

For many years dental professional advised patients to brush their teeth after every meal. Daily brushing is still extremely important to maximise sulcular cleaning as a periodontal disease control measure, because few individuals completely remove plaque. Daily brushing is also important to afford an opportunity to use fluoride dentifrices more often in caries control. However, it is recommended to use 8 to 10 strokes in each brushing area of the tooth surface. Brushing after every meal would be ideal, but keeping the practical problems in view, twice daily brushing is recommended, i.e. once in the morning after breakfast and once in the night immediately after the dinner. As the debris is not easily removed due to reduced salivary flow during sleeping, night time brushing is more important. Benefits of proper oral care must be explained and demonstrated to patients to ensure continued commitment to a personal oral hygiene program. It is proposed **not to insist about the duration of brushing**, e.g. for 3 to 5 minutes, but advice to brush all the teeth surfaces thoroughly as far as possible.

"One brushing area". The area covered by normal length of the toothbrush is one area covering about 3–4 teeth (Fig. 38.7).



Figure 38.7 One brushing area.

There is no universally accepted oral hygiene device. The appropriate oral hygiene regimen is determined according to the dictates of the oral condition, personal preferences, dexterity and lifestyle. Adequate instruction in the use of any recommended device must be provided. It is advisable to remove interproximal plaque at least once every 24 hours for caries prevention.

DENTAL FLOSS

For plaque and debris removal from embrasures, where the papilla fills the interproximal space and the teeth are in contact, dental floss is best indicated. Effective use of dental floss accomplishes the following objectives (Fig. 38.8):

1. Removes plaque and debris that adheres to the teeth, restorations, orthodontic appliances, fixed prostheses and pontics in the interproximal embrasures and around implants
2. Aids the clinician in identifying the presence of interproximal calculus deposits, overhanging restorations, or interproximal carious lesions
3. Reduces gingival bleeding
4. May be used as a vehicle for the application of polishing or chemotherapeutic agents (fluorides) to interproximal and subgingival areas

Not all interproximal contact areas, natural or restored, have the same configuration. Hence, several

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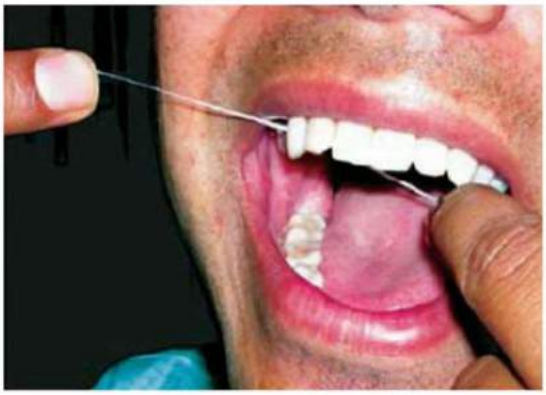


Figure 38.8 Use of dental floss.

types of floss are available to accommodate these differences. These vary from thin unwaxed varieties to thicker waxed types and include variable thickness floss. No significant differences in the cleaning ability between waxed and unwaxed floss are shown by clinical trials. Wax residue has not been found on tooth surfaces cleaned with waxed floss. Unwaxed floss is frequently recommended because it is thin and slips easily through tight contact areas. However, unwaxed floss can fray and tear when contacting rotated teeth, heavy calculus deposits or defective and overhanging restorations. For such conditions, waxed, lightly waxed resistant floss are recommended. Waxed dental tape, unlike round dental floss, is broad and flat, and may be effective in an interproximal space without tight contact points.

Dental floss and tape are available as coloured and flavoured brands. In addition to increased appeal, colour provides a visual contrast to plaque and oral debris. This enables one to see what is being removed, possibly increasing the motivation to floss. Flosses impregnated with a variety of agents have been introduced. Examples of these include floss treated with baking soda, fluoride, herbal extracts, antimicrobial agents or abrasives for whitening. Fluoride impregnated floss are also available in market.

A limitation of flossing is the inability to conform to a concave interproximal surface such as the mesial surface of maxillary premolars. Hence, other interproximal devices, which clean those surfaces more effectively, should be used.

Flossing Methods

Two commonly used flossing methods are the spool method and the circle or loop method. Both methods facilitate control of the floss and ease of handling. The spool method is particularly suited for teenagers and adults who have acquired the necessary neuromuscular coordination required to use floss. For children as well as adults with less nimble hands or physical limitations caused by conditions such as poor muscular co-ordination or arthritis, the loop method is suited. When using the spool method, a piece of floss approximately 18 inches long is used.

The thumb and index finger of each hand are used in various combinations to guide the floss between the teeth. It is gently eased between the teeth with a seesaw motion at the contact point when inserting floss. The gentle seesaw motion flattens the floss, making it possible to ease through the contact point and prevent snapping it through. This avoids trauma to the sulcular gingiva. The floss is adapted to each interproximal surface by creating a C shape once past the contact point. The floss is then directed apically into the sulcus and back to the contact area, up and down against the side of the tooth, several times or until the tooth surface is clean. The procedure is repeated on the adjacent tooth in the proximal area. While re-adapting to the adjacent tooth, care should be taken to prevent damage to the papilla. A clean, unused portion should be used for each interproximal area.

In certain circumstances, the use of a floss holder, floss threaded, variable, thickness floss or precut floss strands with a stiff end may be more effective.



Figure 38.9 Dental floss holder.

Dental Floss Holder

The floss holder is a device that eliminates the need for placing fingers in the mouth (Fig. 38.9). It is recommended for individuals with: (i) poor manual dexterity, (ii) physical disabilities, (iii) limited mouth opening, (iv) large hands, (v) a strong gag reflex and (vi) low motivation for traditional flossing.

When one person is assisting another with flossing, the floss holder may also be helpful.

INTERPROXIMAL AND UNITUFTED BRUSHES

Small interproximal brushes come in a variety of designs, which are attached to a handle. Some of the designs have a non-replicable brush. The entire device is discarded when the brush is worn (Fig. 38.10). Interproximal brushes can be used to clean spaces between teeth and around furcations, orthodontic bands and fixed prosthetic appliances with spaces that are large enough to easily receive the device. They may also be utilized to apply chemotherapeutic agents into interproximal areas as well as furcations. An ideal mechanism for delivery of medicaments inter-proximally or at furcations is by using foam tips initially developed for use with implants. For cleaning between teeth where the papilla does not fill the embrasure space or where root concavities are present, interproximal brushes are preferable to the use of dental floss (Fig. 38.11). The brushes are available in a variety of sizes and are tapered or cylindrical in shape. The core of the brush that holds the bristles is made of plastic, wire or nylon-coated wire.

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Figure 38.10 Interproximal bursh attached to handle.



Figure 38.11 Interproximal brush in position between premolars.

WOODEN OR PLASTIC TRIANGULAR STICKS

Interproximal cleaning can be enhanced using sticks made of wood or plastic (Fig. 38.12). Balsam and birchwood are most commonly used since they are pliable. Utilizing wooden or plastic sticks to reduce plaque accumulations has demonstrated a reduction in inflammation and bleeding sites. To slide easily between teeth and to reduce potential tissue trauma, these sticks are triangular in cross-section.

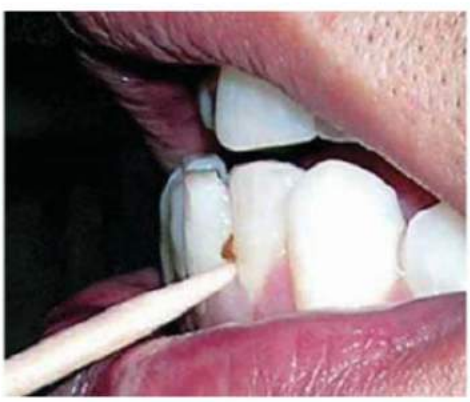


Figure 38.12 Toothpicks



Figure 38.13 Tongue cleaner.

TONGUE CLEANERS

Tongue cleaning has been practiced since antiquity. To further reduce bacterial plaque beyond toothbrushing and interproximal cleaning, studies on tongue debridement have renewed interest in this supplemental measure (Fig. 38.13). The large papillary surface area of the tongue dorsum favours accumulation of oral microorganisms and oral debris. Anatomically, tongue has shorter fungiform papillae and the longer filiform papillae, which create elevations and depressions that may entrap debris and harbour microorganisms, making the tongue an ideal location for bacterial growth. It is found that oral debris from these sites may contribute to plaque formation in other areas of the mouth. Reduction of this debris by mechanical tongue debridement is essential to affect plaque accumulation and oral malodour.

Oral Malodour

Oral malodour, also called bad breath or halitosis, can have a systemic origin or originate in the oral cavity. A thorough physical examination can rule out a systemic disorder. When food-containing proteins and peptides are hydrolyzed by gram-negative bacteria in an alkaline environment, usually odors in the oral cavity occur. Odiferous sulphur-containing products created by this process include hydrogen sulphide, methylmercaptans and dimethyl sulphide. Odour production is associated with a shift from a predominantly gram-positive to a gram-negative and anaerobic bacterial population.

Local factors such as reduced salivary flow or a rise in oral pH may affect this shift. Inconsistent or ineffective interproximal plaque removal can provide an ecological niche for gram-negative bacteria to degrade sulphur-containing amino acids resulting in malodour. The presence of periodontal disease may also be a contributing factor as the inflammatory process creates substrate that stimulates bacterial growth.

RINSING

Vigorous rinsing of mouth helps in the removal of food debris and loosely adherent plaque. Although water rinsing

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does not remove attached plaque, it may help in returning the mouth to a neutral pH following the acid production that result from ingesting fermentable carbohydrates. For individuals with orthodontic appliances, rinsing or use of an irrigator is also helpful.

IRRIGATION DEVICES

Whereas rinsing is a means of flushing the entire mouth, irrigation devices are a means of irrigating specific areas of the mouth. Although the pulsating stream is preferable, a home irrigation device that is used for self-care provides a steady or pulsating stream of fluid (Fig. 38.14). Irrigation can result in disruption of the loosely attached or unattached supra and sub-gingival plaque. The action is twofold in that loosely attached micro floras are disrupted when pulsating fluid makes initial contact and there is a secondary flushing action as the irrigant is deflected from the tooth surface. Hence, the micro flora is disrupted both qualitatively and quantitatively.

Denture Maintenance

Instructions should be provided for proper care and cleaning of both the dentures and the underlying tissues. Only 40% of dentures worn by the elderly are adequately cleaned according to one survey. Dentures rest on soft tissues. Hence, care of the soft tissues includes: removing the denture overnight or for a substantial time each day, cleaning and massaging the tissues under the denture daily, and performing regular oral self-examinations to observe and report any irritating chronic changes in appearance of the tissues. Failure to remove the denture may result in oral malodour, excessive alveolar ridge resorption, diseased or irritated oral tissues or the development of epulis fissuratum.

Cleaning and massaging of the soft tissues should be performed either by brushing with a soft-bristled toothbrush or by massaging with the thumb or forefinger wrapped in a facecloth.

For *Candida* infection, denture should be soaked in an antifungal suspension while simultaneously also treating the oral tissues with same medication. Dentures harbour the bacteria involved in the creation of the volatile sulphur compounds that contribute to oral malodour. Hence, daily thorough cleansing of the denture is recommended.



Figure 38.14 Oral irrigation device.

Commonly practiced cleaning methods include immersion, brushing or a combination of both.

While with brushing some areas of the denture may be missed, immersing the denture in a cleaning solution has the advantage of reaching all parts of a denture. Hypochlorite solutions diluted 1:10 with tap water act as antifungal and antibacterial agents. Commercial alkaline peroxide powders and tablets are also available, which typically contain an alkali for oxidising, perforate or carbonate for effervescing and a chelating agent (ethylenediamine tetra acetic acid—EDTA).

DENTIFRICES AND MOUTH RINSES

Dentifrices and mouth rinses are the major products for routinely administering effective *cosmetic* and *therapeutic* agents in the mouth. These products are most widely used by consumers, generating the largest sales of all dental products.

Dentifrices and mouth rinses differ considerably. Dentifrices are complex and difficult to formulate. Enormous innovations have occurred in the past 20 years in the appearance and packaging of dentifrices. Presently, a contemporary consumer is faced with many alternatives in *appearance* (pastes, clear gels, stripes) and *packaging* (conventional tubes, stand-up tubes, pumps), as well as products marketed specifically for children. In addition, numerous claims are made for dentifrices. They are said to *prevent* calculus and caries to whiten teeth, to eliminate hypersensitivity and to reduce plaque and gingivitis.

Mouth rinses are available in liquid form, which is a traditional method for stabilising and delivering many pharmaceutically active agents. Mouth rinses are considered by consumers to have primarily cosmetic benefits such as breath fresheners. Therefore, mouth rinses are used as frequently and routinely as dentifrices in the daily oral hygiene regimen. Two categories of mouth rinses have been recognized by the American Dental Association (ADA) as effective against *plaque* and *gingivitis:*

- One category contains the ***essential oils*** as the active ingredients. Products in this category include Listerine and its generic equivalents containing the original *essential oils.*
- Other category of products contains ***chlorhexidine*** as the active agent. Currently marketed products are *Orahex, Chlohex and CMW.*

Chewing gums have the potential to be used by the consumer for periods of 5 to 20 minutes several times a day, which is usually until the flavour of the product dissipates. This can be used as an advantage to deliver a cosmetic or therapeutic agent for a *longer time* than dentifrices or mouth rinses. Supplementing the benefit of prolonged delivery of an agent, chewing gums *stimulate salivary flow,* which can provide a buffer effect and also ensure removal of debris from occlusal and interproximal sites.

Dentifrices

- According to standard dictionary, the term dentifrice is derived from dens (tooth) and fricare (to rub).

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A simple, contemporary definition of a dentifrice is a mixture used on the tooth in conjunction with a toothbrush.

- Dentifrices are marketed as toothpowders, tooth-pastes and gels. All are sold as either cosmetic or therapeutic products.
- If the purpose of a dentifrice is therapeutic, it should act as an adjuvant to reduce some disease-related processes in the mouth. Usually, actual or alleged therapeutic effect is to reduce caries incidence, gingivitis and tooth sensitivity. The sales appeal of a product is strongly linked to its flavor and foaming action.

Packaging. Commercial dentifrices marketing was stimulated by the development of the toothbrush in 1857. Toothpowders were popular because boxes and cans from which they could be dispensed were already in existence. The formulae consisted of little more than water, soap and flavour. Toothpastes began to appear on the market following the development of lead tubes for packaging, which was changed to plastic packaging during World War II.

Advantages of plastic packaging

- Eliminated the possibility of the user ingesting lead
- Reduced the possibility of incompatibility of the tube and paste components
- Squeezing aided the expelling of the paste
- Permitted an easier and more economic production of tubes
- Provided a good surface for the printing of decorative designs and information

A drawback with initial use of plastic tubes was the permeability and subsequent loss of flavours through packaging. This has been resolved with the use of new plastic materials and the use of laminated or layered packaging materials.

Dentifrice Ingredients

"Dentifrices were originally formulated to provide a cosmetic effect and deliver a pleasant taste". They are effective in removing *extrinsic* stains, which occur on the surface of the tooth. Extrinsic stains are often the end products of bacterial metabolism, range in colour from green to yellow to black. Foods, coffee, tea, cola-containing drinks, red wines, tonics and medicines may also result in stains.

Dentifrices do not remove intrinsic stains for the following reasons:

- Intrinsic stain is a result of altered amelogenesis, as seen in *fluorosis*
- Staining due to *tetracycline*
- Non-vital tooth due to trauma or chronic pulpitis
- Physiologic aging

Composition of Dentifrices

- Abrasive: 20–50%
- Humectants: 20–40% Preservatives: 0.05–0.5%
- Binding agent: 1–3%
- Foaming agent (detergent): 1–3%
- Flavouring agent: 1–2%
- Sweetening agent: 1-2%
- Therapeutic agent: 0.4–1%
- Colouring or preservative: <1%

Abrasives. The inherent *hardness* of the abrasive size of the abrasive particle and the *shape* of the particle decide the degree of dentifrice abrasiveness. Many other variables can affect the abrasive potential of the dentifrice: brushing technique, pressure on the brush, hardness of the bristles, direction of the strokes and number of strokes.

Calcium carbonate and *calcium phosphates* were previously the *most commonly used abrasives.* These agents often reacted adversely with fluorides. Chalk (calcium carbonate) and baking soda (sodium bicarbonate) are also commonly used dentifrice abrasives. New silica, silicon oxides and aluminium oxides are being introduced into dentifrice formulae, which have additional efficacy claims. Abrasives usually do not damage enamel, but they may dull the tooth luster and hence to compensate for this, polishing *agents* are added to the dentifrice formulation. These polishing agents are usually small-sized particles of aluminium, calcium, tin, magnesium or zirconium compound.

Humectants. Toothpaste consisting only of a tooth-powder and water results in a product with several undesirable properties. For example, over time, solids in the paste tend to settle out of solution and the water evaporates. This may result in caking of the remaining dentifrice.

Preservatives. The humectants are nontoxic, but mould or bacterial growth can occur in their presence. Therefore, *preservatives* such as *sodium benzoate* are added.

Binding agent. Humectants help to maintain the consistency of toothpaste. But despite their presence, the solids tend to settle out of the paste. Hence, to *counteract* this, *thickening* or *binding agents* are added to the formula. Gums, such as gum tragacanth, were first used. These are followed by colloids derived from seaweed, such as carrageenan. Synthetic celluloses, in turn, have replaced these.

Foaming agent (detergents). Soap was the logical cleansing agent because toothpastes were originally manufactured to keep the teeth clean. The foaming action of the soap aids in the removal of the loosened material as the toothbrush bristles dislodge food debris and plaque. Nevertheless, soaps have several disadvantages: they can be irritating to the mucous membrane, their flavour is difficult to mask, and often causes nausea, and many times soaps are incompatible with other ingredients, such as calcium. When detergents appeared on the market, soaps largely disappeared from dentifrices. Today, *sodium lauryl sulphate (SLS) is most widely used detergent.* It is *stable,* possesses some *antibacterial* properties and has a *low* surface *tension,* which facilitates the flow of the dentifrice over the teeth. SLS has a flavour that is easy to mask, is active at a neutral pH and is compatible with current dentifrice ingredients. The patients who suffer from various oral mucosal diseases should avoid the use of dentifrices containing SLS. Low SLS dentifrices have

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been in markets that claim to be associated with a lower incidence of oral ulcers.

Flavouring agents. *Public acceptance of a dentifrice* is dependent on flavour, along with aroma, *colour* and consistency of product characteristics. Dentifrices should possess these characteristics for better acceptance. Usually synthetic flavours are blended to provide the desired taste for dentifrices. Spearmint, peppermint, wintergreen, cinnamon and other flavours give toothpaste a pleasant taste, aroma and refreshing aftertaste. Some manufacturers use essential oils such as thymol, menthol, etc. that may provide a medicinal taste to the product. In addition, these oils may impart antibacterial effects to the dentifrices.

Sweetening agents. Sugar, honey and other sweeteners were used in early toothpaste formulations. These materials may increase caries because these can be broken down in mouth to produce acids and lower plaque pH. They have been replaced with primary *non-cariogenic* sweetening agents namely saccharin, cyclamate, sorbitol and mannitol. Sorbitol and mannitol serve a *dual role* as sweetening agents and humectants. Glycerine, which also serves as a humectant, adds to the sweet taste. Xylitol is the new sweetener in some dentifrices.

Baking soda dentifrices. Baking soda (sodium bicarbonate) has had a long history of use as an oral hygiene aid. It contains hydrated silica that is compatible with fluoride. Baking soda was not the sole active ingredient in dentifrices. It was only after fluoride was added to the formulations, several baking soda-fluoride dentifrices were accepted as effective in caries control. In addition to the standard fluoride compatible abrasives, these baking soda dentifrices actually contain only a small amount of baking soda.

Therapeutic dentifrices. The most commonly used therapeutic agent added to dentifrices is *fluoride* that aids in control of caries. Original level of fluoride in dentifrices and gels over the counter (OTC) was restricted to 1,000 to 1,100 ppm of fluoride. It was also limited to a total of not more than 120 mg of fluoride in the tube, with a requirement that the package includes a safety closure. Therapeutic toothpastes dispensed on prescription could contain up to 260 mg of fluoride in a tube.

The following fluorides are generally recognised as effective and safe for OTC sales:

- 0.22% sodium fluoride (NaF) at a level of 1,100 ppm
- 0.76% sodium monofluorophosphate (MFP) at a level of 1,000 ppm
- 0.4% stannous fluoride (SnF2) at a level of 1,000 ppm

However, long-term studies with this SnF_2 dentifrice has demonstrated an increase in extrinsic stain attributed to the stannous ion.

Triclosan. Triclosan is a broad spectrum antibacterial agent, which is effective against a wide variety of bacteria and is widely used as an antibacterial agent in OTC consumer products. Triclosan can be considered safe for use in mouth rinse and dentifrice products.

Anticalculus Dentifrices

Calculus control dentifrice formulations are designed basically to *interrupt the process of mineralisation of plaque* to *calculus.* Due to the *supersaturation* of saliva with calcium and phosphate ions, the bacterial matrix of plaque mineralizes. To provide a reduction in calculus formation, crystal growth inhibitors may be added to dentifrices. Combination of s*odium phosphate and disodium dihydrogen pyrophosphate* are crystal growth inhibitors, which retard the formation of calculus.

Antihypersensitivity Products

When exposed areas of the root, especially at the cementoenamel junction, are subjected to heat or cold, many people experience pain. Several dentifrices have been accepted with the active agents such as *potassium nitrate, strontium chloride, and sodium citrate* with a combination of active ingredients, demonstrating both antihypersensitivity and caries preventive benefits. This combination results in a therapeutic dentifrice directed simultaneously at solving two problems, caries and hypersensitivity, with the same brushing operation.

Whiteners

There is considerable controversy surrounding the use of stain removers and tooth whiteners. These products are being marketed for professional use or for use by the patient at home. Dentifrices marketed with tooth whitener claims are available as a toothpaste or gel, or are used in a two-or three-step treatment process. Bleaching or whitening ingredient in these products usually are *hydrogen peroxide* or *carbamide peroxide.* Carbamide peroxide breaks down to form urea and hydrogen peroxide. Hydrogen peroxide, in turn, forms a free radical containing oxygen, which is the active bleaching molecule. To thicken the solution and prolong contact with the tooth surface, glycerine or propylene glycol is commonly added. In the two-or three-step products, agents can be delivered to teeth via a custom-made tray or by toothbrushing.

Mouth Rinses

The traditional purpose of mouth rinses has been breath freshening. The claimed active ingredients of mouth rinses include *quaternary ammonium compounds,* boric and benzoic acids, and phenolic compounds. Commercial sales of cosmetic rinses have been related to taste, colour, smell and the pleasant sensation that follows. The pleasant sensation is often improved by addition of astringents. Commonly used astringents are alum, zinc stearate, zinc citrate and acetic or citric acids. Zinc sulphate is usually added to mouth rinses as a claimed antiplaque ingredient. Alcohol in mouth rinses is used as a *solvent, a taste enhancer* and an agent providing an *aftertaste.*

Cosmetic Mouth Rinses

For halitosis. Oral malodour has been a neglected research area in dentistry. Bad breath is a cause of embarrassment,

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and frustration on the part of the general public. Identifying cause of halitosis and developing an appropriate treatment plan can be a difficult task. Many mouth rinses claim breath freshening, but the effect is caused by flavours and has no effect after 3 to 5 hours. Clinician should consider psychological as well as physical factors while diagnosing and treating complaints of bad breath.

Mouth rinses for xerostomia. Many people experience dry mouth *(xerostomia)* traceable to certain possible causes, such as damage to the salivary glands following radiation therapy for head and neck cancer, Sjogren's syndrome and use of tranquilizing drugs, especially the tricyclic antidepressants. In such cases, mucous membrane is found in a continually dry and uncomfortable state. Artificial saliva has been developed to ameliorate the dryness, which is used by the patient to moisten the mucous membrane. Because xerostomia is correlated with an *increased caries incidence,* the rinses usually contain *fluoride* as well as chemical compounds in concentrations that closely parallel those of saliva. The rinses that contain fluoride may, in reality, be *remineralising solutions.*

Chlorhexidine. Prescription of plaque control rinses containing 0.2% chlorhexidine has been approved by FDA. Chlorhexidine has proved to be one of the most effective antiplaque agents to date. Chlorhexidine is a cationic compound that binds to the hydroxyapatite of tooth enamel, to the pellicle, to plaque bacteria, to the extracellular polysaccharide of the plaque, and especially to the mucous membrane. Chlorhexidine adsorbed to the hydroxyapatite is believed to inhibit bacterial colonisation. After binding, the agent is *slowly released in* active form over 12 to 24 hours. This ability of the oral tissues to adsorb an active agent and to permit its slow release in active form over a prolonged period is known as substantivity. As the substantivity of an antiplaque agent decreases, the frequency of use needs to be increased. Chlorhexidine has not proved beneficial as the *sole* method of treating periodontitis with deep pockets. Following root planning, prophylaxis or periodontal surgery, chlorhexidine irrigation may be effective in helping to control inflammation and subgingival plaque.

Disadvantages

- Altered taste sensation
- Superficial desquamation of tissue
- Hypersensitivity
- Chlorhexidine is inactivated *by* most dentifrice surfactants and, therefore, it is not included in dentifrices. Also, because of this inactivation, it is *critical* for dental professionals to alert patients not to use chlorhexidine mouth rinses within 30 minutes before or after regular toothbrushing.

Essential oils. The first anti-plaque and antigingivitis mouth rinse to be approved is Listerine antiseptic. In addition to their usual oral hygiene regimen, the patients are advised to rinse twice daily with 20 ml of Listerine for 30 seconds. Listerine has been used as a mouth rinse for more than 110 years. The active ingredients are thymol, menthol, eucalyptol and methyl salicylate, termed *essential oils.* The original formula contains 26.9% *alcohol.*

Chewing gum. Because gum chewing is pleasurable, people normally chew for longer periods of time than they spend brushing their teeth. Likewise toothbrushing is complemented by chewing gum by reaching many of the tooth surfaces commonly missed during brushing. It is found that the average person fails to contact approximately 40% of tooth surfaces during toothbrushing, especially posterior teeth and lingual surfaces. It is also shown that regular toothbrushing removes only about 55 to 60% of dental plaque present on tooth surfaces. In addition, chewing gum is especially advantageous during the course of the day when toothbrushing is not possible or convenient. *Beneficial effects* of chewing gum include:

- Increased saliva production resulting in the physical removal of dental plaque and debris
- Reducing plaque accumulation

The area of focus of chewing gum research to date has been on "sugar free" products, which contain polyol sweeteners such as *sorbitol* or *xylitol.* The advantage of these sweeteners is that they are not broken down by plaque or oral microorganisms to produce acid. Studies on plaque pH xylitol have documented reduction of plaque acidity and maintenance of plaque neutrality for periods of 2 to 3 weeks following gum chewing.

CONCLUSION

Good oral hygiene is an essential component of a good oral health. Simple oral hygiene activities on day-to-day basis can prevent the most common dental diseases without any additional cost. Today, a variety of oral hygiene aids, both mechanical and chemical, are available to maintain good oral hygiene at a cost now affordable unlike before. A combination of these based on the individual's needs can be used for effective maintaining of the oral hygiene. It is the duty of dental professionals to inform and motivate the people to use these oral hygiene aids in the right way to promote oral health and prevent damage to the oral tissues.

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REVIEW QUESTIONS

1. Classify oral hygiene aids. Write about mechanical aids.
2. Discuss ADA specification of toothbrush.
3. Write an essay on oral hygiene aids with a note for handicapped individuals.
4. Write notes on:
   a. Powered toothbrushes
   b. Role of dental floss in oral hygiene maintainance
   c. Composition of dentifrices
   d. Antiplaque agents
   e. Interdental brush

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39 Pit and Fissure Sealants

Hiremath SS

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INTRODUCTION

Tooth surfaces with pits and fissures are particularly vulnerable to caries development. It was observed that although the occlusal surfaces represented only 12.5% of the total surfaces of the permanent dentition, and it accounted for almost 50% of the caries in school children. This can be explained by morphological complexity of these surfaces, which favours plaque accumulation to the extent that they are difficult to clean (inaccessible areas) and the enamel does not receive the same level of caries protection from fluoride as does smooth surface enamel. The plaque accumulation and caries susceptibility are greatest during the eruption of the molars. Caries susceptible individuals are therefore vulnerable to early initiation and fast progression of caries in these sites. Many studies have showed that in fluoridated communities, over 90% of dental caries is exclusively pit and fissure caries. Buonocore and his co-worker published their first paper on the successful application of sealants to pits and fissures in 1967. In the middle of the 1970s, the glass ionomer cement (GIC) was introduced as an alternative to the resin-based sealants. Retention to the tooth surface is based on the adhesive properties of the cement, and the application of GIC is not as sensitive to moisture as the resin-based sealants. Another advantage with GIC is its release of fluoride. The cement is relatively brittle, however, and a considerable disadvantage with GIC as a fissure sealant is its insufficient retention. In more recent years, resin-modified GICs have been introduced onto the market.

Fluorides are highly effective in reducing the number of carious lesions occurring on the *smooth surfaces* of enamel and cementum. Unfortunately, fluorides are not equally effective in protecting the occlusal pits and fissures where 90-95% of all carious lesions occur. Considering the fact that the occlusal surfaces constitute only 12% of the total number of tooth surfaces, it means that *the pits and fissures are approximately eight times as vulnerable as the smooth surfaces.*

Historically, several agents have been tried to deal with the deep pits and fissures on occlusal surfaces:

- In 1895, Wilson reported the placement of *dental cement* in pits and fissures to prevent caries.
- In 1923, Hyatt advocated early insertion of small restorations in deep pits and fissures before carious lesions had the opportunity to develop. He termed this procedure 'prophylactic odontotomy'. Disadvantage is that it requires the cutting of tooth structure.
- In 1926, Bodecker suggested that deep fissures could be broadened with a large round bur to make the occlusal areas more self-cleansing, a procedure that is called *enameloplasty.* The major disadvantage in modifying a deep fissure by this method is it is often necessary to remove more sound tooth structure than would be required to insert a small restoration.
- Use of copper amalgam packed into the fissures.
- Attempts have been made to use topically zinc chloride, potassium ferrocyanide and also ammoniacal silver nitrate. But they are unsuccessful.
- Following the use of fluorides, there is a large reduction of incidence in smooth surface caries but a smaller reduction in occlusal pit and fissure caries. This results in an *increased proportion* in the ratio of occlusal to interproximal lesions even though the total number may be less.

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- A final course of action to deal with pit and fissure caries is one that is often used, 'Do nothing—wait and watch'. This option avoids the need to cut the cavity until definite carious lesion is identified. It also may result in many teeth being lost when individuals do not turn up to periodic check-ups. Traditionally, occlusal surfaces have been regarded as susceptible to dental caries as a result of their incomplete post-eruptive maturation, i.e. their reduced mineral content in the enamel and due to the presence of narrow and deep fissures on the occlusal surfaces, which harbour bacteria that initiate the caries process.

With this option, a liquid plastic is flowed over the occlusal surface of the tooth where it penetrates the deep fissures to fill areas that cannot be cleaned with the toothbrush. The hardened sealant presents a barrier between the tooth and the hostile oral environment.

DEFINITION

A fissure sealant is a material applied to occlusal surfaces of the teeth in order to obliterate the occlusal fissures and remove the sheltered environment in which caries may thrive (Gordon 1962).

TYPES OF FISSURE SYSTEM

The occlusal surface has many developmental or morphological defects resulting in the formation of pits and fissures, which are in various shapes and sizes. They are also referred as structural defects. They are most difficult or inaccessible areas for cleaning (Figs. 39.1 and 39.2).

TYPES OF PIT AND FISSURE SEALANTS

Fissure sealants are marketed in a variety of formats: they can be filled, unfilled, tinted, clear or opaque. They may be polymerised in a variety of ways. The first generation of fissure sealants are ultraviolet light cure, the second generation are chemically cured (autopolymerised) and the third generation are visible light cure. The fourth generation fissure sealants are those containing fluorides.

A. **Types of fissure sealant**
   I. Three different kinds of plastics have been used as occlusal sealants:
      1. Polyurethanes
      2. Cyanoacrylates
      3. Bisphenol a glycidyl methacrylate (Bis-GMA)
   II. Resin-based sealants
   III. Glass ionomer sealants
   IV. Fluoride containing sealants

B. **Other Types of fissure sealant**
   I. Filled and unfilled
   II. Light cured and chemically (self) cured
   III. Clear and tinted

A. Types of Fissure Sealant

Polyurethanes. The polyurethanes were among the first to be commercially marketed. They proved to be too soft and totally disintegrated in the mouth after 2 or 3 months. Despite this drawback, their use was continued for some time—not as a sealant but as vehicle with which to apply fluoride to the teeth. However, it has been superseded by the use of *fluoride varnishes*, which are easier to apply.

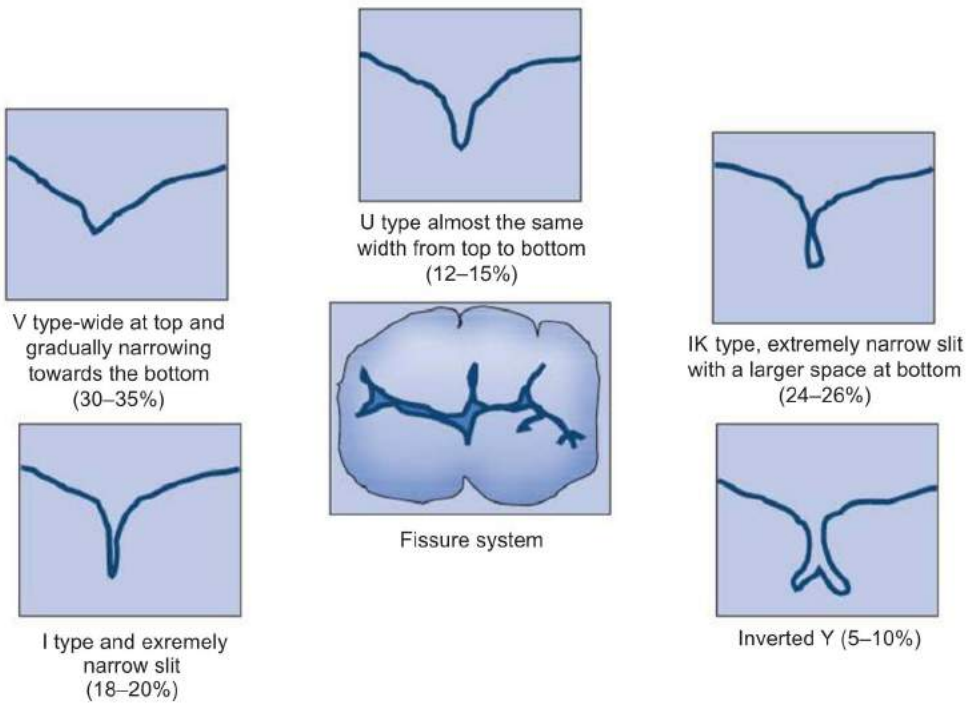


Figure 39.1 Types of fissure system.

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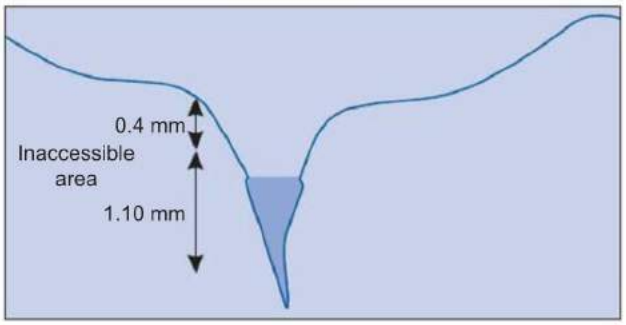


Figure 39.2 Cross-section of fissure system.

Cyanoacrylates. The cyanoacrylates have also been tried as sealants, but they too disintegrated after a slightly longer time. Hence, their use has been discontinued on account of low shelf-life and high unstability.

Bisphenol a glycidyl methylacrylate (Bis-GMA). Bisphenol A-glycidyl methylacrylate (Bis-GMA) is now the sealant of choice. It is a mixture of Bis-GMA and methyl methacrylate. Its successful use was first reported by Buonocore in the late 1960s.

In 1972, Nuva-Seal was the first successful commercial sealant to be placed on the market. Since then more effective second and third-generation sealants have become available.

Resin-based sealants

Resins. Resin sealants are bonded to underlying enamel by use of acid-etch technique. Their caries preventive property is based on the establishment of a tight seal, which prevents leakage of nutrients to the micro flora in deeper parts of the fissure. The resin sealants may be either pure resin, composites or compomers, and their polymerisation may be initiated chemically or by light (Fig. 39.3).

Several studies reported the effectiveness of second-generation chemical-initiated sealants. Ripa (1993) reviewed numerous studies that have been carried out comparing the retention rates between third and first and/or second-generation sealants. The results indicate that the performance level for chemical-initiated sealants and visible light/photo-initiated sealants are similar within an observation period of up to 5 years. However, in three comparative studies of longer duration, greater longevity was reported for the chemically cured pit and fissure sealants. Pit and fissure sealants are available as clear, opaque or tinted. No product has demonstrated a superior retention rate, but the tinted and opaque sealants have the advantage of more accurate evaluation by the dentist at recall.

Glass ionomer sealants

One of the main clinical advantages of glass ionomer cement (GIC) is their ability to bond chemically to dentin and enamel without the use of the acid-etch technique, which makes them less vulnerable to moisture. This, in conjunction with active fluoride release into the surrounding enamel has led to the development and evaluation of GIC as an alternative fissure sealant system, particularly in cases where moisture control is difficult to achieve. Clinical trials using glass ionomers sealants have showed poor retention, over periods, as short as 6 to 12 months (Fig. 39.4).

Studies of the use of GIC and resin modified glass ionomers as fissure sealants indicate significantly lower retention rates than resin-based pit and fissure sealants. However, several studies have found that GIC's exert a cariostatic effect even after they had disappeared macroscopically. This effect might be based on remnants of the cement in the fissure as well as increased levels of fluorides on the enamel surface.

Fluoride containing sealants

Addition of fluoride to sealants was considered about 20 years ago and it was probably attempted based on the concept that the incidence and severity of secondary caries are reduced or minimised around fluoride-releasing materials. Because fluoride uptake increases enamel resistance to caries, use of a fluoridated resin-based sealant may provide an additional anticariogenic effect if the fluoride released from its matrix is incorporated into the adjacent enamel. Fluoride-releasing sealants have shown antibacterial properties as well as a greater artificial caries resistance compared to a non-fluoridated sealant.

B. Other Types of Fissure Sealant

Filled and unfilled

Addition of filler particles to the sealant likewise appears to have little effect on clinical results. Filled and unfilled sealants penetrate the fissures equally well and have similar retention rates. The fillers make the sealant more *resistant to abrasion.*



Figure 39.3 Resin-based sealants.



Figure 39.4 Glass ionomer sealants.

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Light cured and chemically (self) cured

Two methods have been employed to catalyse polymerisation:

1. **Light curing** by use of a visible blue light *(synonyms:* photocure, photoactivation, light activation)
2. **Self-curing** in which a monomer and a catalyst are mixed together *(synonyms:* cold cure, autopolymerisation, and chemical activation).

Earlier Nuva-Seal and Nuva-Cote were the sealants requiring ultraviolet light for activation. Both have been replaced by other light-cured sealants that require visible blue light. Later, when the monomer is exposed to the visible blue light, polymerisation is initiated.

With the autopolymerising sealants, the catalyst is incorporated with the monomer. In addition, another bottle contains an initiator–usually ***benzoyl peroxide.*** When the monomer and the initiator are mixed, polymerisation begins.

The main advantage of the light-cured sealant is that the operator can initiate polymerisation ***at any suitable time***. Polymerisation time is shorter with the light-cured products than with the self-curing sealants. The light-cured process does require the purchase of a light source, which adds to the expense of the procedure. This light, however, is the same one that is used for polymerisation of composite restorations, making it available in all dental offices.

Precautions. When using a light-cured sealant in the office, it is advisable to store the product away from bright office lighting, which can sometimes initiate polymerisation.

Conversely, self-curing resins do not require an expensive light source. However, they have the great disadvantage that once mixing has started, if some minor problem is experienced during application procedure, the operator must either continue mixing or stop and make a new mix resulting in wastage. Once the polymerisation begins, *it occurs very rapidly, and any manipulation of the material during this critical time jeopardizes retention.*

Light-cured sealants have a higher compressive strength and a smoother surface compared to self-cured sealants. There are chances of incorporating air bubble when mixing self-cure resin sealant.

Clear and tinted (clear versus coloured sealants)

Both clear and coloured sealants are available. They vary from translucent to white, yellow and pink. Both clear and coloured sealants in either the light curing or autopolymerising forms are available. Selection of a coloured versus a clear sealant is a matter of individual preference. The coloured products permit a *more precise placement* of the sealant.

Retention can be more accurately monitored by both the patient and the operator placing the color sealant. On the other hand, a clear sealant may be considered more *aesthetically* acceptable.

REQUISITES FOR SEALANTS RETENTION

The surface of the tooth must have following conditions for good sealant retention: (i) have a maximum surface area, (ii) have deep, irregular pits and fissures, (iii) be clean, and (iv) be *absolutely dry* at the time of sealant placement and uncontaminated with saliva. These are the four commandments for successful sealant placement, and they cannot be violated.

1. **Increasing the surface area:** Sealants do not bond directly to the teeth. Hence, they are made to retain by adhesive forces. This can be done by using tooth conditioners or etchants normally, which are composed of 30–50% concentration of phosphoric acid.
   The etchant may be either in *liquid* or *gel* form. The former is easier to apply and easier to remove. Both are equal in abetting retention. If any etched area on the tooth surface is not covered by the sealant later normal appearance of the enamel returns within 24 hour *due to remineralisation* from constituents in the saliva.
2. **Pit and fissure depth:** Deep, irregular pits and fissures offer a much more favourable surface contour for sealant retention compared with broad, shallow. The deeper fissures protect the plastic sealant from the shear forces occurring as a result of masticatory movements.
3. **Surface cleanliness:** Thorough prophylaxis is advocated prior to sealant placement. Polishing prophylactic paste should be preferably non-fluoride and oil-free mixture to avoid contamination from the tooth surface, and also to get better etching in the enamel surface.
4. **Dryness:** The teeth *must* be dry at the time of sealant placement because present sealants are hydrophobic. Presence of saliva on the tooth is even more detrimental than water because its organic components interpose a barrier between the tooth and the sealant. Whenever the teeth are dried with an air syringe, the air stream should be *checked* to ensure that it is not moisture-laden. Otherwise, sufficient moisture can be sprayed on the tooth to prevent adhesion of the sealant to the enamel. Ideally, it is advised to check for moisture, and it can be accomplished by directing the air stream onto a cool mouth mirror; any fogging indicates presence of moisture.

PATIENT AND TOOTH SELECTION

Indications

1. Presence of deep occlusal pit and fissures of newly erupted teeth (molars and premolars) with high caries risk.
2. Presence of lingual pits or palatal pits in relation to upper lateral incisors and molars.
3. Presence of incipient lesion in the pit and fissure system.
4. Children and young people with medical, physical or intellectual impairment with high caries risk.
5. Children and young people with signs of higher caries activity and coming from non-fluoride area.

Contraindications

1. Presence of shallow pit and fissures of molars and premolars.
2. An open occlusal caries lesion with extension into dentin.
3. Presence of large occlusal restoration.
4. Presence of proximal caries extending on to occlusal surface.

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5. Partially erupted tooth where in isolation is a problem.
6. Unco-operative children (getting adequate dry field is a problem).

TECHNIQUE FOR SEALANT APPLICATION

Armamentarium

The following set of instruments are used during the procedure of sealant application (Fig. 35.5).

Time to Seal

There is good evidence for success rate of the prevention of occlusal caries with use of pit and fissure sealants if they are used early soon after the eruption of teeth. However, application of fissure sealant should be delayed until teeth are fully erupted.

Surface Cleaning

The tooth surface to be etched and sealed must be thoroughly cleaned. A pointed bristle brush, in a slow-speed contra angle hand piece, is excellent for gross plaque removal. It can be used with pumice, and it should be oil and fluoride free, otherwise it may interfere with etching (Fig. 39.6).

After cleaning the occlusal pits and fissures with a pointed brush, it is frequently beneficial to pull an explorer tine through all the grooves. This will remove some of the deeper plaque where the brush cannot reach. The tooth should then be washed with water and dried carefully prior to acid application.



Figure 39.5 Armamentarium.



Figure 39.6 Checking for a clean fissure system.

Isolation

Adequate isolation is the most critical aspect of sealant application. If enamel porosity created by the etching procedure is filled by any kind of liquid, including saliva, formation of resin tags in the enamel is blocked or reduced, and thereby the resin is poorly retained. Salivary contamination during and after acid etching also allows precipitation of glycoproteins onto the enamel surface, greatly decreasing bond strength to the sealant. If this occurs, re-etching is needed. Use of rubber dam is obviously the safest way of securing optimal moisture control, but, however, it is not practicable or feasible in case of public health programmes (field programmes). Keeping dry field must therefore usually be achieved by the use of cotton rolls and isolation shields in combination with a thoughtful use of the water spray and evacuation tip. Isolation procedure may frequently be extremely challenging, particularly in the partially erupted teeth or in those children with poor co-operation (Fig. 39.7).

Etchants

After isolation, the teeth are thoroughly dried to remove any remaining saliva that may hinder acid coverage of the enamel.

Phosphoric acid in the range of 30 to 50% is the best etching solution. It is best applied using a small mini-sponge, but a cotton pellet or a brush may also be used. It is important to etch approximately 2 mm on either side of an exposed groove (such as the buccal groove on mandibular molars or the lingual groove on maxillary molars) so that there is a sufficient area of etched enamel for sealant application. Tooth surface area is to be etched with acid for 20–60 seconds (in accordance with manufacturer's instructions) (Fig. 39.8).

Etched Enamel and Resin Penetration

Care must be taken as the etching progresses to treat the enamel surface very carefully and not to rub the cotton pellet or sponge on the surface during acid application, because this may damage the fragile enamel latticework



Figure 39.7 Isolation.

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Figure 39.8 Etching the isolated enamel surface.

being formed. In case of primary teeth and fluorosed teeth, another 15 to 60 seconds of acid etching is advocated, this is to compensate for the greater acid resistance of the enamel (Fig. 39.7).

The goal of etching is to produce an uncontaminated, dry and good etched surface, which appears as frosted surface (Fig. 39.8). Small variations in the concentration of phosphoric acid do not appear to affect the quality of the etched surface and showed no significant difference in retention of pit and fissure sealants after one year follow-up on second primary and first permanent molars when 15, 30, 45 or 60 seconds etching times were used (Fig. 39.9).

Washing and Drying (Fig. 39.10)

The tooth is usually irrigated vigorously with water for about 20 seconds and then dried with uncontaminated compressed air for 20 seconds. Following this procedure dried tooth surface should have a white, dull and frosty appearance. This is due to etching, which must have removed 5–10 microns of the original surface, although at times inter-rod penetration of up to 100 micron may occur. The etching does not always involve the inter-rod areas: sometimes the central portion of the rod is etched and the periphery is unaffected. Hence, this type of etching greatly increases the surface area (Fig. 39.10).

Mixing the Resin

Special care should be taken to avoid mixing of the air-bubbles during mixing of the resins (chemical resins). Bubbles if present at the margin of tooth, resin can lead to marginal leakage at a later period of time.

Sealant Application (Fig. 39.11)

A brush is the preferred method of applying sealant to an etched surface. It is possible to pick up sealant with certain small metal instruments, but touching the fragile *V*-etched surface may result in damage to the etched enamel prisms. In the ultraviolet curing systems, a brush can be used many times over since the unpolymerised resin can be easily cleaned from the brush. However, in case of autopolymerizing systems, disposable brushes should be used as it is not possible to completely remove all the resin from the bristles prior to polymerisation, and after one or two applications, the brush becomes clogged with resin and is unusable.

With either the light-cured or autopolymerised sealants, the material should first be placed in the fissures where there is the maximum depth. At times penetration

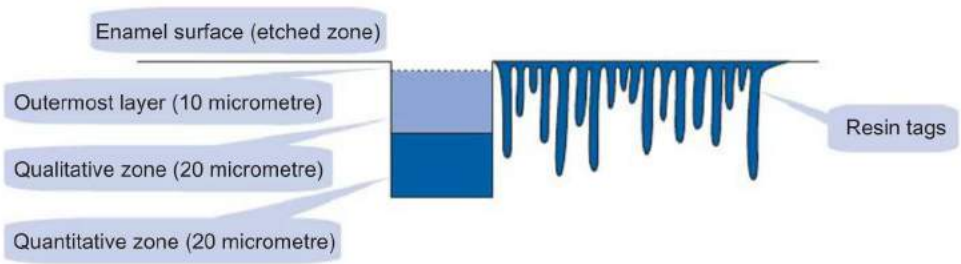


Figure 39.9 Schematic presentation of etched enamel surface.



Figure 39.10 Thorough rinsing and drying of the etched surface.



Figure 39.11 Sealant application and curing.

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of the fissure is negated by the presence of debris, air entrapment, narrow orifices, and excessive viscosity of the sealant. The sealant should not only fill the fissures but also should have some *bulk over the fissure*. After the fissures are adequately covered, the material is then brought to knife-edge approximately *halfway* up to the inclined plane. Following polymerisation, sealants should be examined carefully *before* discontinuing the dry field. If any voids are evident, additional sealant can be added *without* the need for any additional etching.

Evaluating Sealant Quality

Check for the following with a time of the explorer after curing the sealant (Fig. 39.12):

- Marginal integrity Pits or voids in sealant Overhangs
- Heavy occlusion

Retention of sealants. The finished sealant should be checked for retention 'without using' undue force. In the event that the sealant does not adhere, the placement procedures should be repeated, with only about 15 seconds of etching needed to remove the residual saliva before again flushing, drying, and applying the sealant. Plastic sealants are retained better on recently erupted teeth than in teeth with more mature surface; they are retained better on first molars than on second molars. They are better retained on mandibular than on maxillary teeth. This latter finding is possibly due to the fact that the lower teeth are more accessible, direct sight is possible, isolation of the teeth is easier, and gravity aids the flow of the sealant into the fissures.

Teeth that have been sealed and then have lost the sealant have had fewer lesions than control teeth. This is possibly due to the tags that are retained in the enamel after the bulk of the sealant has been sheared from the tooth surface.

FOLLOW-UP AND REVIEW

All sealed surfaces should be regularly monitored clinically and radiographically. The exact intervals between radiographic review depend not only on the risk factors, which may change with time, but also on the monitoring of other susceptible sites, for example approximal surfaces.

Defective sealants and/or preventive resin or glass ionomer restorations should be investigated and the sealant is reapplied in order to maintain the marginal integrity, provided the surface is caries free.

MINIMALLY INVASIVE PREVENTIVE RESTORATIONS PREVENTIVE RESIN RESTORATION (*PRR*)

The management of suspected pit and fissure caries can be done with occlusal restorations, which replace discrete area of carious tooth structure. This is termed as 'sealant restoration', which employs minimally invasive resin composite or resin-modified glass ionomer cement (Simonsen, 1980). The technique involves making a very small, local cavity preparation in the immediate area of the fissure system at which the presence of caries is suspected. No attempt is made to extend the cavity beyond the immediate area affected by caries. The defect in the occlusal surface is restored with sealant, a resin composite, or a type II resin-modified glass ionomer restorative material, depending on the size of the defect. Following this, the etched occlusal surface of the tooth may be sealed with sealant over the top of the restoration of resin composite or resin-modified glass ionomer material (Fig. 39. 13).

The advantage of this approach is that very minimum of tooth substance is removed. Walls et al (1988) reported that the occlusal amalgam restorations in their study occupied, on average, 25% of the occlusal surface of the tooth while the minimal resin composite restorations occupied 5%. In addition, the procedure avoids unfortunate consequences of an error in diagnosis. If a healthy tooth is investigated, little harm is done, for it quickly becomes evident that no caries is present and the resulting cavity is very small. If the caries is more extensive than was originally supposed, this will become apparent during the procedure, and appropriate action can be taken.

SEALING OF CARIOUS FISSURES

Placement of Sealants Over Carious Areas

Sealing over a carious lesion is important because of the professional concern about the possibility of caries

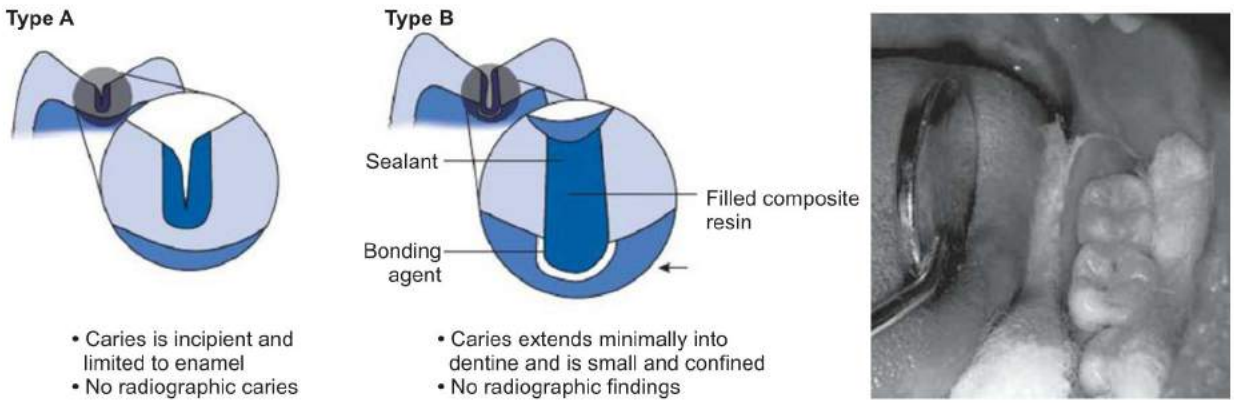


Figure 39.12 Evaluating sealant quality.

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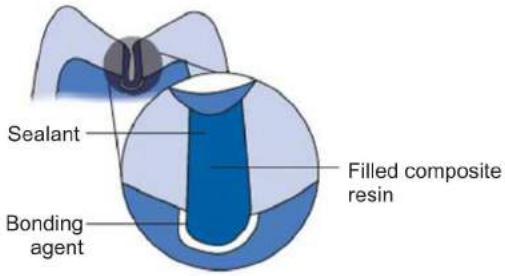


Figure 39.13 Preventive resin restoration.

progression under the sealant sites. Generally, the incipient or overt caries often occur within many fissures, which cannot be detected with the explorer. In some studies sealants have been purposely placed over small, overt lesions. When compared with control teeth, many of the sealed carious teeth have been diagnosed as sound after 3 and 5 years. In sealed lesions, number of bacteria recovered from the sealed area decreased rapidly.

Sealants have been placed over more extensive lesions in which carious dentin are involved. Even with these larger lesions, there is a decrease in the bacterial population and arrest of the carious process as a function of time. Studies indicate that there is an apparent reduction in microorganisms in infected dentin covered with sealant. Hence, there is no hazard in sealing carious lesions.

SEALANTS VERSUS AMALGAMS

Comparing sealants and amalgams is not an equitable comparison because sealants are used to prevent occlusal lesions, and amalgam is used to treat occlusal lesions that could have been prevented. There has been the belief that amalgams and not sealants should be placed routinely in anatomically defective fissures; this belief stems from misinformation that amalgams can be placed in less time, and that once placed they are a permanent restorations.

Several studies have been addressed these suppositions. For example, sealants require approximately 6 to 9 minutes to place initially, whereas amalgams take 13 to 15 minutes. Many studies on *amalgam* restorations have indicated longevity from only a few years to an average life span of 8 to 10 years.

In recent years, using later generation sealants, along with good care in technique used for their insertion, much longer retention periods have been reported, the longest retentive period for any tooth was 10 years. They found that after 8 years, about 80 percent of the sealed fissures showed total sealant retention and no caries.

After 10 years only 6 percent of the sealed occlusal surfaces showed caries or restorations. Up to 20 years after sealant had been applied, a surprisingly high 65 percent showed complete retention, 22 percent partial retention without caries and 13 percent caries or restoration in the occlusal fissures or buccal pits.

Hence, average life span of sealants can be comparable with that of the amalgam.

The most common cause for sealant replacement is ***loss of material,*** which mainly occurs during the first 6 months; the most common cause for amalgam replacement is ***marginal decay,*** with 4 to 8 years being the average life span. To replace the sealant, only re-sealing is necessary. No damage occurs to the tooth. Hence, it is totally-***non-invasive.*** Whereas amalgam replacement usually requires cutting more tooth structure with each replacement and it is totally ***invasive procedure,*** this repeated replacement of restoration is called as "**Repeated Restoration Cycle**" (RRC). Hence, placement of amalgam and replacement of amalgam restorations certainly weakens the tooth structure and may ultimately leads to loss of tooth. Even if longevity merits are equal, sealant has the advantage of being painless to apply and aesthetic, as well as emphasizing the highest objectives of the dental profession—prevention and sound teeth.

COST EFFECTIVENESS OF FISSURE SEALANTS

There are a number of factors to take into account when considering the cost effectiveness of a procedure. It depends on the value in terms of money that is placed on intangible benefits such as the prevention of pain and suffering, the adoption of reversible, non-traumatic procedures for the treatment of sticky fissures, and a change in the attitude on the part of both public and dental profession. Application of sealant, from a maximally cost-effective view, is best applied to high-risk patients and sealants are extremely under used as a preventive treatment.

Manpower and Economics

The *cost* of sealant placement *increases* directly with the level of professional education of the operator. Dental hygienists, assistants and even lesser trained auxiliaries can place sealants. In view of the cost effectiveness, dental auxiliaries should be considered as the logical individuals to place sealants. This is especially to be considered in developing countries wherein professional manpower is a problem.

Bear in mind that not every tooth receiving a sealant would necessarily become carious; hence the cost of preventing a single carious lesion is greater than the cost of single application. Sealants would be most cost-effective

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if they could be placed over only those teeth that are at risk to become carious, such an option as type of preventive dentistry restoration. Unfortunately, we do not have a caries predictor test of such exactitude. Instead, it is necessary to rely on professional judgment based on the severity of the caries activity indicators: number of 'sticky' fissures, level of oral hygiene status, number of incipient and overt lesions and microbiologic test indications. In an ideal clinical setting, it is estimated that it costs 4-6 times more to treat a tooth than to seal. However, the benefit-cost ratio for caries inactive subjects amounted to only 0.3, while for the caries active group, it was 1.0. Hence, sealing of the fissures for the caries prone is beneficial and offers good preventive measures.

It has therefore been suggested that fissure sealants should not be routinely used in all children and all teeth, but based on an individual risk evaluation. Dental auxiliary staff may be trained to apply fissure sealant and can achieve retention rates similar to those obtained by dentist, thereby the choice of staff employed to apply fissure sealants will have an impact on the cost effectiveness of the procedure.

SEALANT AS PART OF A TOTAL PREVENTIVE PACKAGE

The sealant is used to protect the occlusal surface. A major effort should be made to incorporate the use of sealants along with other primary preventive dentistry procedures, such as plaque control, fluoride therapy and sugar discipline. Whenever a sealant is placed, a topical application of fluoride should follow it. In this manner, whole tooth can be protected. In many public health programmes, however, it is not possible to institute full-scale prevention programmes, either because of apathy or lack of time and money. In such cases, there is some consolation in knowing that at least *the most vulnerable* of all tooth surfaces (the occlusal) is being protected.

PRESENT STATUS OF PIT AND FISSURE SEALANTS

By the mid-1980s most of the answers were available as to the need and *effectiveness* of Bis-GMA sealants to reduce the incidence of occlusal caries, and *techniques* of placement of pit and fissure sealants were known.

The *safety* of their placement had been demonstrated that when placed over incipient and minimally overt caries sites, there was no progression of caries *as long as the sealant remained intact.* Finally, the sealants could be *applied by properly trained auxiliaries,* thus providing an *economical* source of *manpower,* both for private clinical practice and government programmes as well as for large school and public health programmes.

It has been observed that there had been an increase in *knowledge,* but little change in *attitude* concerning sealant use. And also it was found that paediatric dentists, who are continually involved in treating children, placed more sealants than did general dentists again, probably on account of negative attitude and lack of willingness among general practitioners.

The concepts and actions of prevention are not being fully implemented in dental schools. Dental school faculties need to be educated about the effectiveness and methods of applying sealants. The biggest concerns to a general dental practioner regarding pit and fissure sealants are: (i) sealants do not last long in the mouth, and (ii) decay can be initiated or progresses under sealants. Based on the available scientific literature, it would appear that concern of clinicians regarding poor longevity of sealant and problems associated *with* inadvertent sealing of undetected carious lesions *is* not justified.

There is a general agreement in the published literature that a positive relationship exist between sealant retention and occlusal caries protection. It is, therefore, most unfortunate that such a large number of practitioners do not use pit and fissure sealants.

CONCLUSION

Approximately 90–95% of all carious lesions that occur in the mouth occur on the occlusal surfaces. Which teeth will become carious cannot be predicted: however, if the surface is sealed with a pit and fissure sealant, no caries will develop as long as the sealant remains in place. Recent studies indicate an approximate 90% retention rate of sealants 1 year after placement. Even when sealants are eventually lost, most studies indicate that the caries incidence for teeth that have lost sealants is less than that of control surfaces that has never been sealed. Research data also indicate that many incipient and small overt lesions are arrested when sealed.

Sealants are easy to apply but the application of sealants is an extremely technique-sensitive procedure.

Sealants are competitive with amalgam restorations for better survival and longevity and do not require the cutting of tooth structure. Sealants are cost effective as compared to amalgams. Despite their advantages, use of sealants has not been embraced by the dental profession.

It is of paramount importance for the dental schools to teach and train the students, hygienist and dental auxillary personnel's to use dental sealants more routinely and judiciously. The accurate documentation of clinical trial and education of general practitioners and general public must be undertaken regarding dental health benefits, especially of school going children who are at higher risk of development of fissure caries, while using pit and fissure sealants.

REVIEW QUESTIONS

1. What are the different types of fissure system that you can encounter?
2. Classify fissure sealants.
3. Write in detail the technique of fissure sealing.
4. Write notes on:
   a. Bis-GMA
   b. Preventive resin restoration
   c. Add a note on fluoride containing sealants

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40 Atraumatic Restorative Treatment

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INTRODUCTION

Atraumatic restorative treatment (ART) is a procedure where carious cavities of teeth are excavated using hand instruments only and restored with tooth friendly and adhesive cement such as glass ionomer (type 9). This method of treatment initially developed with the idea of providing basic dental treatment to underprivileged people in less industrialized countries and neglected groups like refugees and disadvantaged communities. They usually do not approach dental health care for decay until teeth require its removal or pain is intolerable. These people are deprived of advanced oral health care as in the developed world. The main reasons for underlying circumstances are dearth of electricity and traditional restorative dental care requiring electrically driven equipments. On the other side, ART technique enables restoration of carious teeth of people in areas where scarcity of electricity and /or where the community cannot afford costly dental equipments.

"Teeth for life" concept is supported by ART technique by proving specially designed tool to health worker. With this technique tooth structure is conserved to a great extent by removing carious tooth part with hand instruments alone and restoring the cavity with tooth adhesive material such as glass ionomer cement. As glass ionomer cement has fluoride releasing property, it prevents further tooth decay.

ART concept has established a position in modern surgery in developed country. This technique could be performed in a patient with multiple carious lesions and caries progression is stabilized before more definitive treatment is provided. This technique also gained its importance in treating anxious patient who are scared of drilling. This is mainly because of accomplishing restorative procedure by using hand instruments only. As the ART procedure could be carried out in home or hospital, for this reason it gained popularity in treating patients with medical or physical disability and it has became easy. This also helped in introducing children to dental clinic by overcoming fears of traditional dental equipment.

In recognition of the huge potential that the ART approach offers to the management of dental caries, WHO presented ART on World Health Day, on 7 April 1994, an occasion that marked the beginning of the year of oral health, 1994-1995. Later, WHO has launched an initiative for the global promotion of ART. Currently Art is used in more than 25 countries and training for practicing ART technique among health care providers in several countries.

PRINCIPLES

1. Removing carious tooth tissue using hand instruments only
2. Restoring the cavity with adhesive cements (glass ionomer)

Reasons for Using Hand Instruments

- With this technique, restorative care is made available to all population groups.
- This technique is said to be tooth friendly as this conserves sound tooth tissues and causes less trauma to the teeth by requiring minimal cavity preparation.
- Cost effective technique as this uses hand instruments in place of costly electrically driven dental equipment
- Use of local anesthesia for pain management is minimal there by reducing the psychological trauma to patients.
- Hand instruments are easy clean and sterilize after every use, thus making infection control simplified.

Reasons for Using Glass Ionomers

- Glass ionomer cement has inherent property of chemically bond to both enamel and dentine, thereby need

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for the cutting of sound tooth structure for cavity preparation is reduced
- Leaching of fluoride from glass ionomer cement restoration also prevent and arrest the caries progression.
- Glass ionomer cement is considered to be biocompatible cement as this restoration does not cause any irritation to pulp and gingiva, and has a co-efficient of thermal expansion similar to tooth structure.

For these reasons, ART provides both preventive and curative treatment in one procedure.

In general, ART can be applied when there is a cavity involving the dentin and that cavity is accessible to hand instruments.

CONTRAINDICATIONS

- Presence of swelling (periapical abscess) or fistula (opening from periapical abscess region to the oral cavity) near the decayed tooth.
- Pulp exposure
- Chronic inflammation of the pulp with pain in the tooth.
  - Frank carious cavity with inaccessible opening to hand instruments. Tooth with definite signs of a caries, for example, in a proximal surface, but the cavity cannot be entered from the proximal or the occlusal side.

Atraumatic restorative treatment can be used for one surface or multiple surface cavities.

"Atraumatic" component of the ART approach

Since its start, the originators of the ART approach noticed that the technique had a potential to cause less discomfort to the patient and to be less invasive to the dental tissues than the conventional approach. The patient's acceptance of ART was satisfactory and they described it as **patient friendly** technique

SURVIVAL OF ART RESTORATIONS

Atraumatic restorative treatment can certainly be used with confidence in one-surface cavities, particularly in permanent teeth. The most recent meta-analyses on the performances of ART restorations, including data uptil February 2010, showed cumulative

ART restorations' survival rate for single and multiple-surfaces in deciduous teeth for period of 2 years is 93% and 62% respectively. Likewise cumulative survival rates for permanent teeth's single-surface ART restorations for a period of 3 and 5 years were 85% and 80%respectively.

- Survival rates of single surface ART restorations in posterior permanent teeth using high viscosity of glass ionomers do not differ that much significantly compared to conventional amalgam restorations.
- Survival rates of either single or multiple surface conventional restorations in primary posterior teeth done by compomer and composite when compared with ART restoration with high viscosity glass ionomers do not differ significantly.

TIPS ON WORKING

Operator's Work Posture and Positions

The operator's posture and position should provide the best view of the patient's mouth. At the same time, operator and patient both should be comfortable.

With straight back, the operator sits firmly on the stool, thighs parallel to the floor, and both feet flat on the ground. The head and neck muscle should be at rest, the line between the eyes parallel and the head bent slightly frontward to look at the patient's mouth.

The worker should be sat right behind the patient' head (Fig. 40.1). The accurate position depends on the tooth to be treated. Most commonly used positions for ART procedures are direct rear position, i.e. at 12 o'clock and the right rear position, i.e. at 10 o'clock.

Working Alone

The operator takes his comfortable posture behind the patient's head. Instruments and materials are arranged over a small table, which is placed either at the head end of the patient or on the right-hand side of the operator close to the operating area. However it will be ideal to have an assistant by the side of the operator close to the patient.

Patient Position

Similar to other oral treatment, ART also requires appropriate patient and operator positions. For lengthy periods of time, patient should be lying on the back on a flat surface. This provides safe and secure body support and a comfortable and stable position for patient.

Flat surface like bamboo or wooden bed would be an appropriate portable bed, or a table for ART procedure. A table would be available in most communities, added to this a very satisfactory patient position is produced by attaching a head support to the end of the table. The operating field is now over the operator's lap at the height of the operator's chest (Fig. 40.1). This is a routine practice when working outside the clinic environment (field programme, outreach programme rural camps etc.)



Figure 40.1 Operator's working position while working on patient.

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Operating Light

For working in the oral cavity, good vision is essential. Source of light can be sun (natural) or artificial. Compared to the natural light (sun), artificial light is more reliable and constant. Adding to this artificial light can be focused on a treatment area.

Dry Operating Area

Control of saliva around the tooth being treated is a very important aspect for the success of ART. For absorbing saliva cotton rolls are quite effective and can also provide short-term protection from moisture/saliva. Cotton rolls are either premade or prepared from cotton dressing pack.

Instruments and Materials

The correct instruments should be used for each treatment procedure. The success of any treatment depends on the operator knowing the functions of the various instruments and using them correctly. They must also be properly maintained in a good condition. The instruments used to perform the cavity preparation and restoration and how to keep them sharp are discussed in the following.

For each treatment procedure appropriate instruments should be used. Functions of the various instruments and using them correctly by operator are essential for the success of any treatment. Instruments also must be maintained in a good condition for better performance. The instruments used for ART procedures and how to maintain them in better function are discussed in the following.

Instruments for ART. Instruments used for ART are: (i) mouth mirror, (ii) explorer, (iii) pair of tweezers, (iv) spoon excavator—there are three sizes: small, medium and large, (v) dental hatchet, (vi) applier/carver and (vii) mixing-pad and spatula.

Materials for ART. In addition to glass ionomer cement, a list of other necessary materials essential for ART procedures are:

(i) cotton wool rolls, (ii) cotton wool pellets, (iii) petroleum jelly, (iv) plastic strip and (v) wedges (Table 40.1).

Treatment material. The material used for restoring cavities and sealing pits and fissures is glass ionomer. This material must be used correctly for achieving good results.

Glass ionomer as a restorative material

- **Mixing**

  It is essential to strictly adhere to the manufacturers' instructions particularly in regards to the powder liquid ratio. Take a spoonful of powder over glass slab or mixing pad. Divide powder in to two parts by spatula. Next to the powder dispense a drop of liquid. For a movement hold the liquid bottle horizontally to escape air from the tip, and then hold it vertically dispenses liquid onto the mixing pad. If necessary, apply a little pressure but do not squeeze the liquid out.

Mixing of powder and liquid: With the spatula spread the liquid over a surface of about 1.5 to 2 cm. Using spatula start mixing half of the powder in to the liquid.

Sway the powder in to the liquid, without spreading the particle around the slab, gently wet them. Soon the powder particles are wet, add second portion in to the mix. While keeping the mass together now mix firmly. Within 20-30 seconds mixing should be completed. Mixing time also depends on the brand of glass isonomer is used (Figure 40.2A,B).

The final mixed material should look smooth like chewing gum.

Precautions to Remember

- After you have dried the cavity properly and isolated, then only dispense both powder and liquid onto the slab.
- Immediately after every use replace the lid of powder and liquid bottle carefully back into position. This prevents evaporation of the water component from the liquid or uptake of moisture from the air.
- If liquid remains on the outside, wipe the nozzle of the liquid bottle with damp gauze.

Table 40.1 Essential instruments and materials for ART

Instruments	Materials	Other
• Mouth mirror	• Cotton wool roll	• Examination gloves
• Explorer	• Cotton wool pellet	• Mouth mask
• Pair of tweezers	• Clean water	• Operating light
• Dental hatchet	• Glass ionomer restorative material liquid, powder and measuring spoon	• Operation bed/head rest extension
• Spoon excavator, small	• Dentine conditioner	• Stool
• Spoon excavator, medium	• Petroleum jelly	• Methylated alcohol
• Spoon excavator, large	• Wedge	• Pressure cooker
• Applier/carver	• Plastic strip	• Instrument forceps
• Glass slab or paper mixing pad	• Articulation paper	• Soap and towel
• Spatula		• Sheet of textile Sharpening stone and oil

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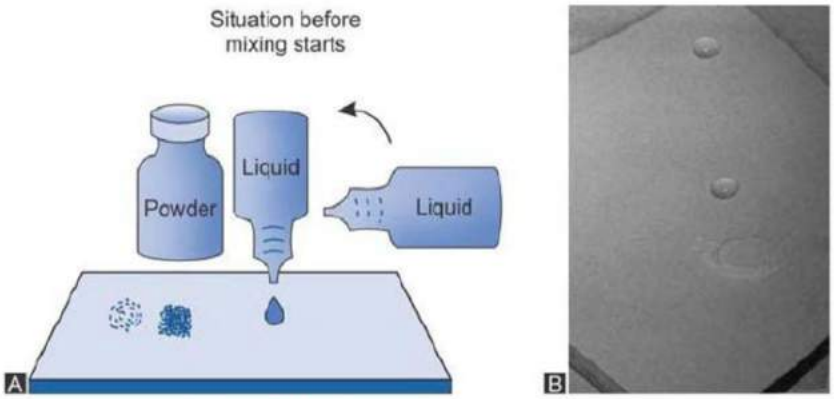


Figure 40.2 Mixing of powder and liquid.

- If mixing time is exceeding 30 seconds and the mixture looks dry, discard it, because there will be reduced adhesion to the tooth structure.
- Immediately after use before the material has hardened, remove all glass isonomer from the dental instruments. For easy cleaning of instruments put them in to water.

Preparing the Cavity

The procedure for caries removal for one-surface cavities step-by-step:

- Isolate the tooth to be treated by cotton wool rolls.
- With the wet cotton wool pellets remove plaque from tooth surface.
- With dry cotton wool pallets dry the tooth surface.
- If needed, widen the entrance of the cavity with a dental hatchet.
- Using excavators remove the carious dentine starting at the dentoenamel junction (Fig. 40.3). With the enamel hatchet, fracture off unsupported thin enamel. Ensure that the enamel does not contain any carious tissue (Fig. 40.4).
- Be careful while removing the carious lesions near the pulp.
- Again clean the cavity with wet cotton wool pallets. Verify the occlusion of the tooth to be restored with the opposing tooth.
- Dry-out the cavity with dry cotton wool pallets and complete the procedure.



Figure 40.3 Removal of the carious dentine.



Figure 40.4 Removal of the unsupported thin enamel with the hatchet.

Cleaning the Prepared Cavity

The cavity walls must be very clean to improve the chemical bonding of glass ionomer to the tooth structure. Wet cotton wool pallets are not effective to do this procedure; therefore, a chemical solvent is necessary to remove the smear layer.

Either this procedure could be done by: (i) a dentine conditioner or tooth cleaner/etchant especially developed for this purpose or (ii) the liquid supplied with the glass ionomer itself.

Generally 10% solution of polyacrylic acid is used as a dentine conditioner. Dispense a drop of conditioner on slab or pad and dip a cotton wool pellet in it and then wipe the entire cavity including adjacent pit and fissures for 10-15 seconds (Fig. 40.5). Do this with the pair of tweezers. Then, immediately, cleanse the cavity and fissures with wet cotton wool pellets for at least twice.

As glass ionomer liquid contains the same acid as is used for conditioning the dentine, it can be used for cleaning the cavity. Since the liquid is too strong, it need to be diluted. This can be done by dispensing a drop of glass ionomer liquid on a pad or slab. Then wet cotton wool pallet in a clean water and remove excess water by gently pressing it over dry cotton wool pallet or on a tissue/gauge. After this dip the half moist pellet in the glass ionomer liquid and then use it as dentine conditioner in the way it is described earlier. For appropriate result, read the manufacturer's instructions carefully as

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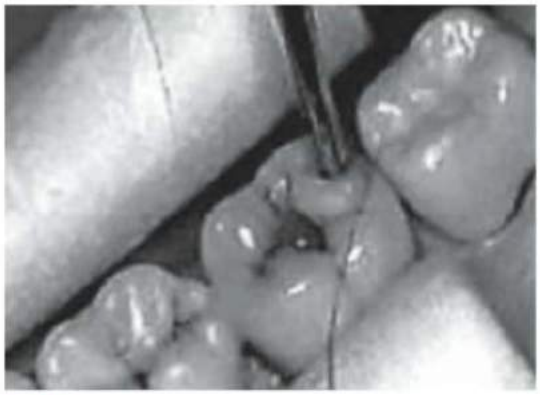


Figure 40.5 Cleaning the prepared cavity with dentine conditioner.

it may contain further information about the use of their product. For example, there are brands where all chemical components are in the powder while the liquid is only demineralised water. The liquid would therefore not be suitable for conditioning the cavity and a special conditioner must be used.

If blood is contaminated the cavity, arrest the bleeding by applying pressure on the wound with a cotton wool pellet. Rinse the blood with water and dry the cavity with cotton wool pellets. Isolate the tooth to prevent recontamination. Following this apply the dentine conditioner to the cavity as described earlier. If a cavity is contaminated again after having been conditioned, it is necessary to wash, clean and recondition the cavity again.

Note: The powder–liquid ratio would not be correct if drop of liquid contains air bubbles. It usually happens with first drop. Such a drop should be discarded for mixing with the glass ionomer powder. However, if the glass ionomer liquid is used as the conditioner, such a drop can well be used for conditioning.

It is sensible to place two drops of liquid on mixing pad; one for conditioning and another for mixing cement. It is wise to keep the liquid bottle in the vertical position between dispensing.

The cavity and adjacent pits and fissures are overfilled.

Removal of excess material by the carver blade of the applier/carver.

Procedure for restoring one-surface cavities
(Figs. 40.6 to 40.9)

1. All the instruments and materials have be checked for availability and workability.
2. Make sure that the tooth to be restored is isolated and dried during restoration phase.
3. Mix glass ionomer cement as explained earlier (20-30 seconds).
4. Using the blunt blade of the applier/carver, insert cement in small amounts in to the dried cavity and then to the adjacent fissures (Fig. 40.6). Using round surface of a medium excavator, push the cement in to deeper parts of cavity and under any overhanging.
5. Apply some petroleum jelly on the gloved index finger.
6. Index finger is pressed over restorative material and removed sideways after few seconds (figs 40.7 A, B).
7. Using medium or large excavator, remove visible excess of glass ionomer.



Figure 40.6 Filling of the prepared cavity.





Figure 40.7 Excess material is visible. Press the restorative material with gloved finger.



Figure 40.8 Restored one-surface cavity.

8. Wait for 2-3 minute till the material hardens, mean while maintain the tooth dry.
9. Using articulation papers check the bite and adjust the occlusion by correcting the restoration using applier/carver if needed.
10. Again apply a layer of petroleum jelly.
11. Remove cotton wool rolls.
12. Instruct the patient to avoid eating for at least one hour.

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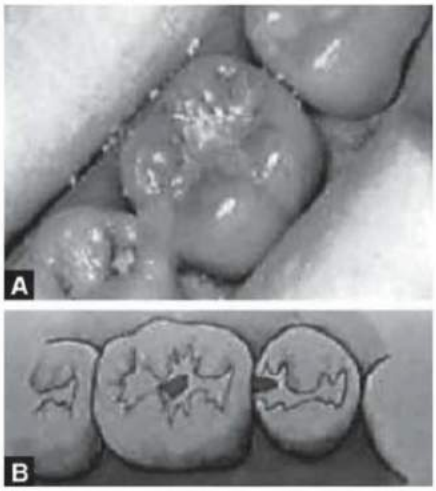


Figure 40.9 Sealed teeth.

Not only cavity is restored but also adjacent fissures are sealed in this procedure. Hence, it is called 'sealed restoration' (Fig. 40.6 and 40.9)—restored one surface.

Restoring multiple-surface cavities using ART

1. Using the spoon excavator to remove carious dentine in a multiple-surface cavity (Fig. 40.10)
2. The position of the dental hatchet for smoothing the proximal outline (Fig. 40.11)
3. Plastic strip and wedge in position (Fig. 40.12)
4. Restorative material pushed into place under unsupported enamel (Fig. 40.13)
5. Slightly overfilled sealed restoration (Fig. 40.14)
6. Finished sealed restoration (Fig. 40.15)

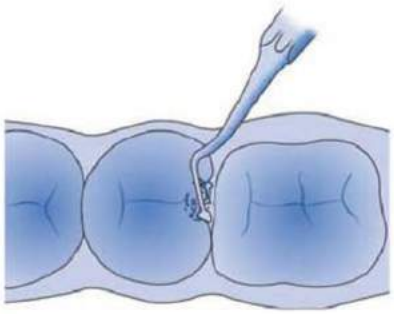


Figure 40.10 Use of spoon excavator to remove carious dentine.

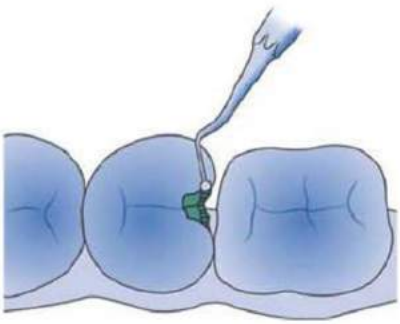


Figure 40.11 Position of hatchet to proximal outline.

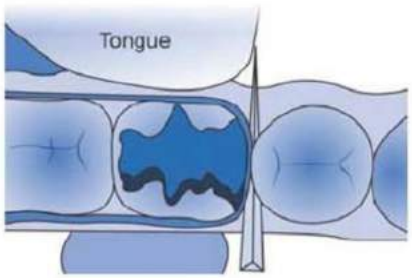


Figure 40.12 Plastic strip and wedge in position.

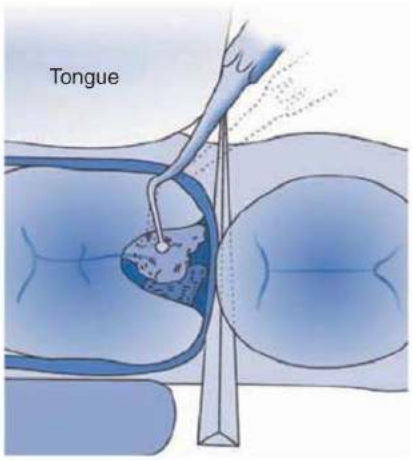


Figure 40.13 Restorative material pushed to undermined enamel.

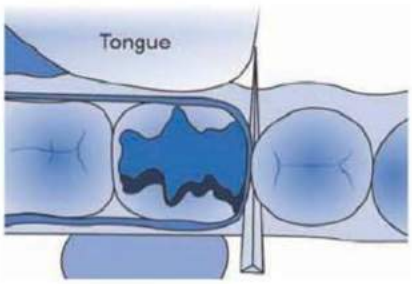


Figure 40.14 Overfilled restoration.

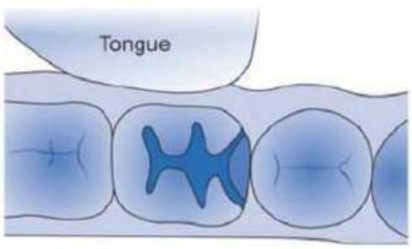


Figure 40.15 Finished sealed restoration.

Restoring the cavity (anterior teeth). Restoring a proximal surface cavity in various stages:

1. Positioning of the strip between the teeth (Fig. 40.16).
2. Insertion of a wedge with matrix band in position (Fig. 40.17).

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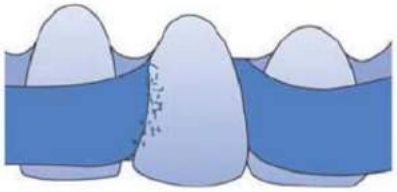


Figure 40.16 Positioning of strip in anterior teeth.

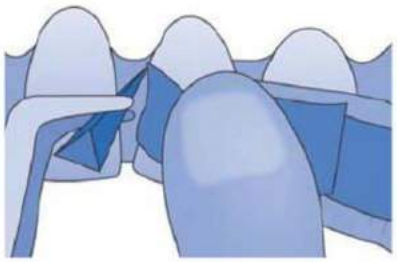


Figure 40.17 Insertion of wedge.

3. The strip is pulled around the tooth while the mixture is setting (Fig. 40.18).
4. Straight instrument is pressed against the strip to shape the restoration (Fig. 40.19).

Glass ionomer used as a sealant. Glass ionomer can be used both as a restorative material and as a sealent.

Monitoring ART Restorations and Sealants

Careful monitoring of restorations and sealants is important.

Atraumatic restorative treatment procedures can be carried out both in dental health care centre and in communities where no clinic exist. ART restorations and sealants can be easily done in schools and health centres in urban and also in remote rural areas.

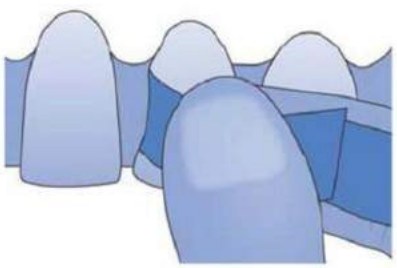


Figure 40.18 Strip pulled around the teeth with material placed.

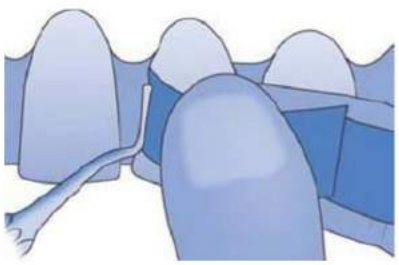


Figure 40.19 Pressing flat-surfaced instrument for shaping restoration.

Irrespective of the material used no restoration or sealant lasts forever. Some fillings will last for many years, while others may fail earlier. Faulty restorations and sealants need to be identified and repaired in time. As children are normally available in school, monitoring the ART restoration would not be as difficult as in case of dental clinics.

It is wise to have information regarding any pain experienced and acceptance of ART. For that reason, enquire the patient regarding experience of pain during and after treatment, and their overall satisfaction with treatment within a period of one month after being treated. After half a year the first clinical evaluation could be taken. Subsequent evaluations can be planned on an annual or biannual basis depending on circumstances like school, community or factors such as expected caries development.

For failed or defective sealants and restorations

1. **Failed or Defective Sealant**
   Sealant seems to be faulty or has dislodged completely. Restoration may not be acceptable or unsatisfactory for various reasons:
   - It may be completely missing.
   - A large portion of it has broken down.
   - Fractured restoration.
   - Worn out of restorative material.
   - Development of secondary caries at the restorative margins or somewhere else on the tooth.
2. **Completely Missing Restoration**
   Various reasons for failure can be:
   - Saliva or blood contamination during the restorative procedure.
   - Mixing of cement might be too wet or too dry
   - Under removal of soft caries.
   - Improper removal of undermined enamel during cavity preparation, and later this might have fractured.

Whatever might be the reasons for the afore-mentioned failures, take up the treatment for repairing such conditions. Start with cleaning the cavity completely, apply dentine conditioner and refill the cavity as discussed earlier. In case of fracture or missing of the part of the restoration, fill the gap with a new mixture of glass ionomer.

MODIFIED ART

The term "modified ART" refers to the modification of the original ART technique. Modification is with respect to use of rotary equipment – Drill to open the cavity and it is followed by routine procedure of ART with restoring the cavity. This is normally carried out in case the opening of the cavity for hand instruments is inaccessible or difficult.

ART is a minimally invasive approach to both for prevention and progression of stopping the dental caries. Hence, ART is the best example of MID concept, it has two components; sealing of caries susceptible pit and fissures with sealant and with this sealing of the pit and fissures restoring the cavitated lesion is also done.

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ART: IMPORTANT GUIDELINES

In total package of oral health care, restoration of decayed tooth is one part. Treating carious tooth should always be based on preventive measures, health education and health promotion activities.

Preventive and curative treatment should do side by side. To be simple, neither preventive nor curative treatment should be introduced to people separately.

- Restoring decayed tooth using the ART approach without addressing preventive treatment is a job only half done.
- It is essential to educate people and motivate them regarding prevention of dental caries affecting the other teeth.

There is an evidence for the high level of effectiveness of ART restoration, using high-viscosity glass-ionomer, to restore single-surface cavities, both in primary and in permanent posterior teeth and no difference in the survival of single-surface high-viscosity glass-ionomer ART restorations and amalgam restorations. ART approach that should also be taken into account refers to its potential to be less invasive to the dental tissues. Following the concept of minimal intervention dentistry (MID), only decomposed (**infected dentin**) dentine needs to be removed in order to stop carious lesion progression.

In general, prevention of dental caries can be taken up and managed effectively with well-maintained oral hygiene status, good dietary measures and appropriate use of various fluoride preparations.

CONCLUSION

The past few decades have witnessed huge developments in the prevention and management of dental caries and its sequelae. The innovative treatment approach of Atraumatic Restorative Treatment (ART) was originally developed to meet some of the problems of dental caries since it does not rely on expensive dental equipment. It is based on the excavation of caries with hand instruments followed by restoration with an adhesive filling material. The principal objective of managing dentinal lesion operatively is to remove mainly completely demineralised tooth tissues. This is best achieved through using hand instruments or slowly rotating drills if accessibility is not available. In doing so, only soft, completely demineralised tissue is removed without any preconceived cavity design. A very large proportion of dentine lesions can be treated using the ART approach, which causes less discomfort than conventionally placed amalgam restorations. The anatomy of the carious lesion dictates the size and shape of the cavity preparation, followed by restoration with an adhesive filling material into the cleaned cavity preparation, over the margin and over the adjacent pit and fissures. This sealant restoration arrests caries activity that is present in dentine and enamel. If it is supported by good oral hygiene and other preventive measures, it increases the survival of the restoration. Nevertheless, ART technique has a great potential of providing restorative care to many populations worldwide, especially in developing countries and in outreach situations. The success will be even higher in future, especially when better restorative materials are available.

REVIEW QUESTIONS

1. What are the principles of ART?
2. Write in detail about indications, contraindications, advantages, disadvantages and the procedure of ART.
3. What is press finger technique?
4. Dentine conditioner.
5. Discuss about smear layer.

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41 Minimal Invasive Dentistry (MID)

Hiremath SS and Ramya R Iyer

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INTRODUCTION

The term minimally invasive dentistry (MID) is self-explanatory and describes a contemporary concept relating to all procedures in dentistry, which underpins the philosophy of prevention and preservation. The practice of minimally invasive dentistry works on the principle of maximum gain with minimal loss. Particularly, in the context of management of dental caries, from reversal of lesion to restoration, minimally invasive dentistry has been a successful advancement. The concept of MID is in line with the biological principles of conservation of tooth structure and holds immense promise to minimize factors leading to failure of restoration.

DEFINITION

Minimal Intervention Dentistry encompasses a plethora of dental procedures directed to prevent, investigate or treat dental problems through ways and techniques which are least invasive, most conservative and the best in regard to patient's comfort.

Micro-dentistry is a concept of minimal intervention care. The meaning of this concept has broadened since the time of its introduction in 1990s. Although initially this concept focused on micro-management of occlusal pits and fissures, the scope of this concept has now expanded to include all methods and techniques employed in diagnosis, treatment and procedure in a tissue- conservative manner.

The World Congress of Micro-dentistry was formed in 2000 and micro-dentistry was defined as an evidence-based discipline dealing with oral hard and soft tissue saving procedures with the goal of improving the quality of life through optimal oral health.

The terms minimal intervention dentistry, minimally invasive dentistry and micro-dentistry are often confused (Fig. 41.1). Minimal Intervention Dentistry deals with early detection of disease, identification of risk factors and specific protection to prevent disease. Minimally invasive dentistry/micro-dentistry includes all operative procedures to ensure preservation of healthy tooth structure and minimize tissue loss. Minimally invasive dentistry/microdentistry is a subset of minimal intervention dentistry.

Minimally invasive procedures are preferably carried with optical aids viz. Magnification (Loupes), microscopes and intra-oral cameras. Minimally invasive operative dentistry which involves use of any optical device that magnifies the operative field is called "Micro-dentistry" or "Microscope-enhanced dentistry". Magnification and illumination are important to visualize smaller, less invasive procedures. A better visualization is pivotal to the preservation of healthy tooth structure during operating procedures such as caries removal and cavity preparation. Micro-dentistry operative procedures may also involve use of chemo-mechanical caries removal, air abrasion, sono-abrasion and lasers.

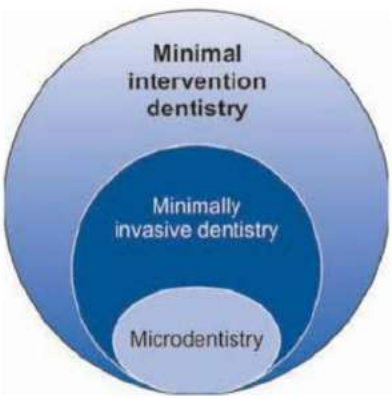


Figure 41.1 Micro-dentistry is a concept of Minimal Intervention Dentistry.

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PRINCIPLES OF MINIMALLY INVASIVE DENTISTRY

- Minimal operation or procedure should be involved.
- Minimal tooth structure loss as compared to conventional procedures should be adhered to.
- Dental materials that are suitable to perform successfully in conditions where minimum tooth preparation is done, conserving maximum tooth structure, should be used preferentially.
- Evidence-based use of materials and techniques for successful outcome are encouraged.
- Materials that do not require frequent replacements or subsequent tooth loss at an event of failure should be used.
- Techniques that require minimum appointments or operations should be preferred.
- Methods involved should cause minimal or no anxiety to the patient.

RATIONALE OF THE MID PHILOSOPHY

1. An important concept for the development of MID is the "Repeat Restoration cycle". This was demonstrated based on the study of the survival of amalgam restorations by Elderton and co-workers.
2. This was suggested that preventive or non-operative procedure should go hand in hand with restorative care and the caries lesion development and progression will play a vital role in the assessment of provision of adequate oral health care.
3. Advancements in dental materials viz. development of adhesive systems can help achieve objectives of MID.
4. This procedure in turn will lead to cavity preparation of smaller size and less destructive. There by the smaller restorations will have a better prognosis and long lasting.
5. Retaining the sound tooth structure along with maintaining its vitality and function is at most important achievement. This was demonstrated by Massler and Fusayama.
6. They demonstrated that only the "infected" (decomposed or necrosed outer carious tissue) dentin has to be removed as a part of preparation of the cavity and where as the "affected" (demineralised) dentin should be retained because the demineralised dentin can remineralised under good restoration with good sealing.
7. The aim of the MID to maintain and preserve the teeth healthier and functional for life.

PROCEDURES IN MID

Minimal Tooth Preparations

The philosophy of conventional cavity preparation is centered on the restorative materials, its properties and success, grossly oblivious of importance of conservation of tooth structure. Conservative cavity preparations and Preventive Resin Restorations are examples where minimal tooth preparations are required and have got rid of the traditional concept of "extension for prevention". Pit and fissure sealant application is also a minimally invasive procedure.

Principally all cases of tooth wear are treated by minimally invasive restoration. Furthermore, risk-based treatments have mandated the treatment planning in all specialty procedures to a large extent that it is now a rule of thumb to preserve the natural hard and soft tissue as much as possible.

Remineralizing agents other than fluorides

Remineralization is a non-invasive caries reversal process that counteracts the demineralization and dissolution of the tooth structure through a repair process aided by the deposition of calcium and phosphate ions. The remineralization process is facilitated by fluorides and other agents, which are known as remineralizing agents.

Zero(2006) listed the following requirements of an ideal remineralizing agent:

1. The agent should be able to diffuse into the subsurface or deliver calcium and phosphate into the subsurface.
2. The agent should not deliver an excess of calcium.
3. It should not favour calculus formation.
4. It should be able to work at an acidic pH.
5. The agent should also work in xerostomic patients.
6. The agent should boost the remineralizing properties of saliva.
7. For novel materials, should show a benefit over fluoride.

Some of the remineralizing agents other than fluorides include:

1. Beta tricalcium phosphate
2. Caesin phosphopetide – amorphous calcium phosphate (CPP-ACP)
3. Bioactive glass
4. ACP technology

Beta tricalcium phosphate (TCP): It has been considered as one of the ways of increasing the levels of calcium in plaque and saliva.

However, a problem with use of TCP is the formation of calcium-phosphate complexes. If fluorides are present, calcium fluoride will be formed, which would inhibit remineralisation by decreasing the bioavailability of calcium and fluoride.

To overcome this problem, TCP levels are kept low, less than 1%. TCP may also be combined with titanium oxide to limit interaction with calcium and phosphate. Organic coating of TCP will minimize interaction with fluoride.

Caesin phosphopeptide-amorphous calcium phosphate (CPP-ACP): Casein can steady calcium and phosphate ions by releasing small successions of peptides (CPPs) through partial enzymic digestion. This has given way to a remineralizing technology, developed by Eric Reynolds, based on casein phosphopeptide-stabilized amorphous calcium phosphate complexes (CPP-ACP) and casein phosphopeptide-stabilized amorphous calcium fluoride phosphate complexes (CPP-ACFP).

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Mechanism of Action: This protein nanotechnology combines the precise ratio of 144 calcium ions plus 96 phosphate ions and six peptides of CPP. The size and electro neutrality of the CPP nanocomplexes allows them to diffuse down the concentration gradient into the body of the sub-surface lesions. Once present in the enamel subsurface lesion, the CPP-ACP releases the weakly bound calcium and phosphate ions, depositing them into crystal voids. The CPPs have a high binding affinity for apatite. With increasing pH, the level of bound ACP increases, which stabilizes free calcium and phosphate and thus provides an anti-calculus action. Tooth crèmes using CPP-ACP are MI Paste and Tooth Mousse. Arrested white spot lesions should have a surface etching treatment before applying these creams.

Bioactive glass: Bioactive glass was developed by Dr. Larry Hench in1960s. It acts as a biomimetic mineraliser simulating the body's own mineralizing nature. Bioglass right away begins surface reaction in three phases namely, leaching and exchange of cations, network dissolution of SiO2 and precipitation of calcium and phosphate forming an apatite layer, in a hydrated environment.

Novamin, is a commercially available bioactive glass, which is manufactured by Novamin Technologies Inc. (Alachua, FL, USA). On exposure to bioactive glass powders, extracts or solutions, remarkable anti- bacterial effect has been observed toward *S. mutans* and *S. sanguis*, the important cariogenic bacteria.

ACP technology: Amorphous calcium phosphate (ACP) is formed by rapidly mixing calcium sulphate and dipotassium phosphate salts. ACP thus formed can precipitate over tooth surface, which can then dissolve in saliva and can be available for tooth remineralisation.

The ACP technology was invented by Dr Ming S Tung. In 1999, ACP was introduced into toothpaste called Enamelon. It was incorporated as an active ingredient as Enamel Care toothpaste in 2004.

Interesting to know

SELF-ASSEMBLING PEPTIDE

Self-assembling peptide, the "next generation peptide", is a bio-mimetic peptide, which can regenerate minerals. P114, a self-assembling peptide, when applied to the tooth, diffuses into the subsurface micro-pores and forms a 3-D scaffold. The scaffold, which is made up of small fibers, mimics proteins found in teeth development and supports hydroxyl apatite crystallization. This simulates the natural repair process.

Air Abrasion

Air abrasion is basically a procedure by which teeth can be prepared to receive restorations by abrading the target tooth surface through pressure by a jet of aluminum oxide particles. Depending on the purpose for which it is used, the pressure can vary; for etching, pressure required is 80 psi, whereas for cavity preparation, 100 psi is required. The nozzle of the device for targeting the tooth surface is held 0.5–2 mm from tooth. Particle size of aluminum oxide used for air abrasion ranges from 27–50 microns.

Air abrasion is a substitute for drill and may be used for the following:

- For removal of superficial defects in the enamel
- For removal of enamel stains in pits and fissures of teeth
- For preparing the fissures for receiving sealant as opposed to fissurotomy
- For preparing teeth to receive restorative materials as opposed to conventional cavity preparation when only a small section of tooth is involved in caries.
- For surface treatment of tooth wear facets and lesions enabling the structure to receive an adhesive restorative material.
- For removal of old restorative material on the tooth.

Contra-indications for use of air- abrasion are:

- Removal of large amalgam restorations, which can lead to unacceptable levels of mercury vapour release.
- Access cavity preparations
- Removal of caries from sub-gingival areas of teeth
- When there are open wounds/ non-approximated extraction sockets
- Patients suffering from Chronic Obstructive Pulmonary Disorders
- In patients with history severe hypersensitivity to dust

Advantages of air abrasion technique are:

- It is a more tissue-conservative approach.
- It is more comfortable to patients.
- It eliminates the need for local anaesthesia as it exerts a cooling effect.

Disadvantages of air abrasion technique are:

- Air abrasion is not effective in removal of soft caries.
- It must be used in caution when used adjacent to soft tissues as it may lead to surface injuries.
- The depth of preparation is not controlled.
- The preparation does not render a well-finished surface.
- It cannot be used to remove large restorations as it can splash the abraded particles of the restorative material, necessitating the use of rubber dam to prevent accidental swallowing of the same.

Arresting Caries Treatment (ACT)

Arresting Caries Treatment (ACT) is a technique to halt the progress of caries using a non-invasive approach. The technique is in particular useful to lessen the burden of untreated dental decay among children and underprivileged sections where there is poor access to dental health care and limited financial resources to afford high-cost restorative treatment.

The technique involves application of 38% silver diamine fluoride (SDF) on active dental caries. It is a simple and non-invasive procedure. The caries arresting mechanism is attributed to the silver component and the fluoride component. The silver component acts as an anti-bacterial/bactericidal and prevents the formation of new plaque. The fluoride component prevents further demineralization of tooth structure.

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The steps in ACT are as follows:

1. The teeth are brushed without paste and rinsed.
2. Isolation and drying of the carious teeth.
3. A drop of 38% SDF is applied on the carious lesions for two minutes using a micro-brush.
4. Excess SDF is removed.
5. Patients are instructed to not eat or drink for one hour.

Advantages of ACT:

a) Low cost of SDF and simplicity of the procedure makes it suitable in community settings.
b) No reported pulpal damage.

Disadvantages of ACT:

a) Black staining at the site of SDF application.
b) Unpleasant metallic taste.

ACT can be an effective technique for caries prevention and arresting caries in the primary teeth of the children. It can be used to arrest in children who are un- cooperative to restorative treatments.

Interesting to know

HALL TECHNIQUE

The Hall technique is a method of managing decayed deciduous molars by cementing preformed metal crowns (PMC) on to the teeth without anesthetic injection, caries removal or cavity preparation. The technique has been proven to be effective, and acceptable to the majority of children, their parents and clinicians through clinical trials.

Dr Norna Hall, a general dental practitioner from Scotland, developed this technique and practiced this technique for over 15 years throughout her career in clinical practice.

The rationale of the use of Hall Technique is based on the fact that plaque environment can be manipulated by sealing it into the tooth. By placing the PMC, plaque is separated from contact with the dietary substrates. The cariogenicity of plaque can alter in a sealed environment.

As long as the seal is maintained, it is less likely that the caries will progress.

Although this technique has been found to effective, it should be noted that it may not suit every tooth or every child. The success of Hall Technique depends on careful case selection, clinical expertise and excellent patient management.

Lasers

Laser treatment is appreciated by patients as they are more comfortable than drilling. Laser treatment with water-cooling appears to have less side effects such as vibration, heat, sound or iatrogenic damages of adjacent teeth.

Lasers (Nd: YAG, Er, Cr:YSGG) have been shown to remove caries safely and effectively. However, caries removal takes 2-3 times longer period than with rotating instruments. Laser irradiation causes minimal damage to surrounding tissues, minimal thermal changes of dental hard tissue composition, and creates favourable surface characteristics (e.g. reduced smear layer, smooth surface and little debris).

Laser treatment, particularly in combination with topical fluoride application (NaF, APF), increases resistance against caries, desensitisation of hypersensitive dentine (Er: YAG) and improve marginal seal under composite resin (Nd: YAG).

CO_2-laser = Caries inhibition up to 82.7%

Er: YAG-laser = Reduction in surface lesion depth (root surfaces 39%, primary enamel surfaces 56%)

Nd: YAG-laser (with Duraphat) = Caries inhibition (pits and fissures 43%, smooth surfaces 80%).

Ozone Application

This is one of methods of minimal tooth preparation, thereby the maximum tooth structure is saved. In this method an oxidant is used, which is toxic to cariogenic micro flora, thereby producing colony forming units.

Advantages

- It is very patient friendly
- Very minimal tooth/tissue loss
- Promotes remineralization

Disadvantage

- Lack of high-level evidence in support of ozone application

Clinical concept

Ozone (= oxidant) is toxic to cariogenic micro flora (*S. mutans, S. sobrinus)* and acts by oxidation of bacterial by-products and metabolites.

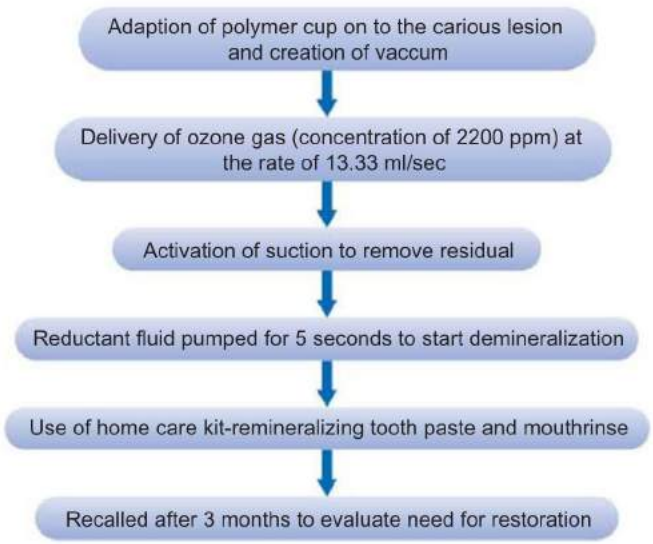
It reduces colony forming units, inhibits further demineralization, promotes and hastens remineralization process.

Clinical aspects

Clinical diagnosis and treatment is indicated by the use of 'clinical severity index - CSI' recommended (Lynch/Holmes) (Table 41.1).

Clinical procedure

Steps in ozone application are illustrated in Flowchart 41.1.



Flowchart 41.1 Steps in ozone application.

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Table 41.1 Classification of CSI with recommended treatment

CSI class I	Carious lesion with cavitation into dentine	MI Classification (G. Mount) = Size classes 2, 3, 4	Recommended treatment: 40 sec Ozone exposure
CSI class II	Carious lesion with cavitation and possible dentine involvement	= Size class 1-2	30 sec Ozone exposure
CSI class III	Carious lesion, no cavitation	= Size class 0	20 sec Ozone exposure
CSI class IV	Arrested carious lesion		10 sec Ozone exposure

Chemo-mechanical Caries Removal

The main drawbacks of conventional caries removal are the use of high-speed drills, which cause anxiety and unpleasant experience for the patient. Patients also experience high level of discomfort by the use of hand pieces. The mere noise of the hand piece can be a source of fear for child patients. Keeping in line with the principles of minimally invasive dentistry, several alternatives have been explored to overcome the aforementioned drawbacks.

"Chemo-mechanical caries removal is a method for minimally invasive, gentle dentine caries removal based on biological principles". The method involves use of a chemical mostly in the form of gel, which softens the carious dentin and subsequently enables excavation with special hand instruments, while leaving the sound tooth structure intact. The treatment is quiet and effective. Many patients and dentists call it 'a silent revolution' (Fig. 41.2).

Concept. Chemo-Mechanical Caries Removal is a method of caries removal using chemicals for dissolution of the carious dentin. Subsequent to the dissolution caries is removed manually with hand instruments using minimal mechanical force. Chemo-mechanical caries removal (CMCR) is the most documented alternative to traditional drilling for dentine caries removal. To summarise, the procedure involves application of a chemical solution to the carious dentine, followed by gentle removal with hand instruments. CMCR is currently the only approach that includes a selective caries softener.

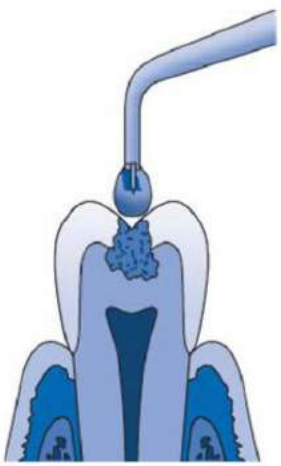


Figure 41.2 The gel is applied on the carious dentine with the help of hand instruments (Carisolv).

Various chemical systems have been introduced for Chemo-Mechanical Caries Removal. The following are some of them:

Caridex

In 1976, Goldman & Kronman reported the usefulness of N-monocloroglycine (NMG, GK-101) in chemo-mechanical removal of caries. Subsequent modifications led to the development of caridex system. Caridex contained N-monochloro D, L-2-aminobutyrate (NMAB, GK-101E). Most of caridex systems contain sodium hypochlorite and monoaminobutyric acid.

Carisolv

Carisolv is a two gel-based system for chemo-mechanical caries removal.

The composition of Carisolv is as follows:

Red Gel: Glutamic Acid, leucine, lysine, sodium chloride, erythrosine, water and sodium hydroxide.
Transparent gel: 0.5% Sodium Hypochlorite.

Procedure:

- The two gels are mixed in equal amounts at room temperature.
- The mixture is then applied using hand instruments on to the decayed dentine.
- Wait for 30 seconds to allow the dissolution of carious dentin.
- Special instruments are then used to remove softened caries. The instruments designed to scrape in two or in several directions, which reduce the friction during caries removal.
- When caries is excavated, remove all the gel, wipe with a cotton pellet and rinse with lukewarm water. Check with an explorer to ensure that no more soft dentin is remaining.

Types of Carisolv hand instruments (Fig. 41.3)

Carisolv hand instrument 1 (extra bend; star 3, flat 0): Used for crown margins and areas that are difficult to access.

Carisolv hand instrument 2 (multi-star, star 3): Used to apply gel and start removing caries. The multi-star tip promotes penetration of the gel. When getting closer to healthy dentin, again this is used, scraping in all directions.

Carisolv hand instrument 3 (star 2, star 1): To remove caries in smaller cavities e.g in root caries or primary teeth.

Carisolv hand instrument 4 (flat 3, flat 2): To be used to remove softened dentin, when close to pulp.

Carisolv hand instrument 5 (flat 1, flat 0): To remove caries at dentino-enamel junction.

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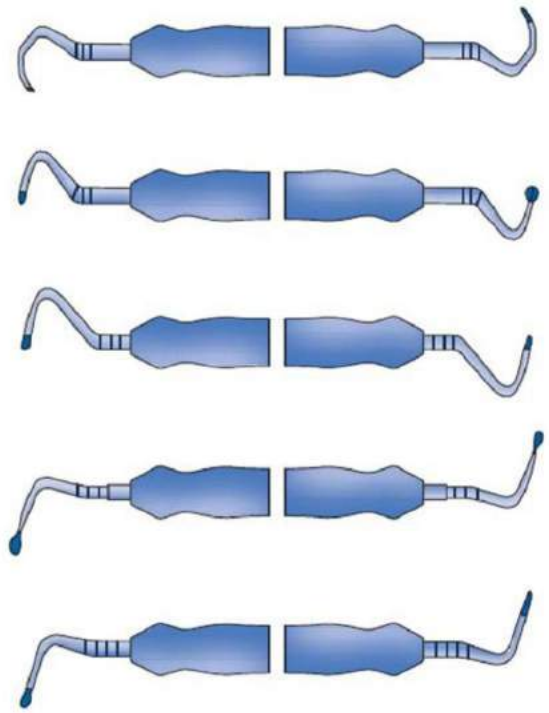


Figure 41.3 Special hand instruments for CMCR using Carisolv.

Mechanism of Action

The following mechanisms have been proposed for action of carisolv:

1. While mixing the gels, amino acids react with sodium hypochlorite and form chloramines. Chloramines lead to chlorination of partially degraded collagen and the conversion of hydroxyl-proline to pyrrole-2-carboxylic acid, which initiates disruption of altered collagen fibres in carious dentin.
2. The pH of the system is around 11 and it is possible that positively and negatively charged groups on the amino acids become chlorinated and further disrupt the collagen cross linkage in the matrix of carious dentine.
3. The gel serves as a lubricant for the hand instrument, which will also aid in the removal of the softened tissue.

Advantages of Carisolv:

1. Has been an effective method of caries removal.
2. Unlike the caridex system, carisolv dissolves only the caries dentin and keeps the healthy dentin intact.

Disadvantages of Carisolv:

1. It is costly as special instruments are required.
2. Needs extensive training.

Papacarie

Papacarie was introduced in 2003 in Brazil. It is a Chemo-mechanical caries removal reagent, available in syringe form. The syringe contains blue-colored gel (Fig 41.4).

Composition:

The gel contains:

1. Papain
2. Chloramines
3. Toluidine blue
4. Water
5. Salts
6. Thickeners

Mechanism of Action: Papain is an anti-inflammatory agent. As infected tissues do not have protease called alpha-1 anti-trypsin, papain can act only in infected tissues. Papain breaks the partially degraded collagen. The degraded portion of dentin is chlorated by Chloramines. This facilitates easy removal by the instruments. Toluidine blue is antimicrobial agent and water acts as a vehicle.

Procedure:

1. Apply Papacarie on the carious dentin.
2. Wait for the gel to act for 40-60 seconds.
3. Scrape the softened dentin using old/ blunt curettes as specified by the manufacturer.
4. The gel can be re-applied as many times till the colour of the gel remains unchanged.

Advantages of Papacarie:

1. Biocompatible
2. Smear layer is completely removed

Summary of Chemo-mechanical Characteristics

- The inner zone of demineralized dentin has the potential to remineralize if acid challenge is removed.
- The strategy for chemo-mechanical caries removal is to remove the outer zone of necrotic material, which is disrupted and which does not undergo remineralisation.
- Only demineralised dentine containing denatured collagen is affected. The three amino acids react with the sodium hypochlorite (NaOCl) to form chloramines. This neutralises its aggressive behaviour on healthy tissue. As the gel is applied at room temperature, it reduces the risk of pain. The gel consistency simplifies the control of the application and reduces the risk of spillage.
- The mechanical removal of the softened caries is performed with special hand instruments. The hand instruments are available with permanent or interchangeable tips that have different sizes and shapes. The unique designs of both Power Drive and Carisolv hand instrument tips enable effective caries removal and sometimes power operated instrument is used to gain access in hard-to-reach areas. The non-cutting characteristics of the instruments assure ultimate tissue preservation.



Figure 41.4 Papacarie gel.

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CONCLUSION

Many oral diseases are still posing greater challenges in clinical management and prevention, in spite of better understanding of their etiology and emergence of new materials and technologies in treating these diseases. However, very few modalities and techniques are promising in the management of common dental diseases; the dental caries is on the priority list. In the recent times, lot of importance has been given to practice the principles of minimal intervention dentistry, which is mainly concerned with least invasive surgical procedures and removal of minimal amount of healthy tissue. Minimal intervention dentistry gives an array of new techniques to treat cavitated and non-cavitated carious lesions while preserving healthy tooth structure. Minimal intervention dentistry also called as biological approach includes various modalities like air abrasion, lasers, ozone application, preventive resin restoration (PRR), atraumatic restorative treatment (ART) and chemo-mechanical caries removal (Carisolv). Thus, to practice the principles of minimal intervention dentistry, the sound and correct knowledge along with the skill in proper diagnosis and for subsequent treatment is required.

REVIEW QUESTIONS

1. Discuss about principles of MID.
2. What is the difference between minimum intervention dentistry and minimally invasive dentistry?
3. What is Arresting Caries Treatment (ACT)?
4. What is the role of remineralizing agents in reversing early carious lesions?
5. What is air abrasion? Write indications, contraindications, advantages and disadvantages of air abrasion.
6. Write in detail about the various chemical systems in CMCR.
7. Write notes on:
   a. Lasers in dentistry
   b. Minimal tooth preparations

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42 Prevention of Dental Caries

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INTRODUCTION

"Perhaps the word prevention seems itself a misnomer, as achieving this feat is next to impossible."

Dental caries is a destructive bacterial disease of hard tissues of the teeth, and there is good evidence that it is initiated by the acids produced by fermentation of carbohydrate substrates by bacteria and dental plaque.

Dental caries is a disease that can be prevented and treated at an early stage. By identifying the risk factors, the disease can be tackled through mass and targeted strategies. Due to the multi-factorial nature of the disease, several modes of prevention have been explored. In populations and individuals with a high prevalence of caries, poor standards of oral hygiene, and no exposure to fluoride, a restriction in frequency of intake of sticky, sugar-containing products would result in some decrease in caries incidence. Salivary stimulation is an important caries preventive measure in caries-susceptible patients who have a reduced salivary flow.

CARIES PREVENTIVE METHODS AND MEANS

The derangement in the demineralization-remineralization homeostasis as well as the role of protective factors viz. fluoride in the oral environment determines the susceptibility to caries. The frequency and duration of acid challenge, salivary flow, composition, oral hygiene, systemic illness and genetic factors interplay in the causation of dental caries. Frequent exposure of fluoride to the tooth surface can reverse caries. The remineralizing ability of fluoride has revolutionized the management of incipient carious lesions paving the path for the era of non-invasive caries management.

Methods and means for prevention of dental caries are: (i) dietary measures, (ii) oral hygiene measures, (iii) fluoride and different vehicles to provide fluoride, (iv) antimicrobial treatments, (v) saliva—quality and quantity improvement and (vi) fissure sealants.

DIETARY MEASURES

There are two components of diet: (i) its nutritive value (nutrition) and (ii) its action in the mouth, which have a significant relationship with dental caries prevalence.

Nutrition

Nutrition is very important, in general, for development, growth and health of the individual including oral health. It has been found that inadequate nutrition during childhood results in disturbance with tooth development leading to either hypoplasia or hypomineralisation. Such conditions will be more susceptible for caries development; hence, great emphasis has been placed on nutrition so that more perfectly formed tooth with less deformities will be more resistant to caries. Apart from fluoride other high levels of trace elements strontium, molybdenum, lithium and low levels of selenium have direct effect in influencing caries resistance. Even vitamin and calcium deficiency along with protein deficiency can cause delay in tooth eruption and later increased susceptibility to dental caries. Thus, good nutrition should certainly been encouraged especially during the development of dentition.

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Local Effects of Diet

Although nutritive value of the diet has a little effect on the dental caries, whereas food has a dramatic local effect on the teeth. Foodstuffs containing sugars, especially sucrose, are more cariogenic. If such types of foods are taken between meals, development of new carious lesions is more. And also sticky types of sugary items are more powerful as they stick to the teeth leading to increased oral sugar clearance time, hence development of more caries.

Carbohydrates. Carbohydrates are the main energy source for oral bacteria and thus directly involved in the pH drop. Nutrition influences are very effective and greatest during tooth development. Sugar is not a causative factor in dental caries but an external modifying risk factor, as previously discussed.

Frequent sugar intake increases the clearance time of sugar and increases the duration of time, the tooth is subject to acid challenge. Refined starch is also an important dietary risk factor for caries. Dietary evaluations usually include a comprehensive assessment of sugar and cariogenic foods intake supplemented by Lactobacillus test. Sugar intake can easily be assessed from a so-called 24-hour recall questionnaire or by using specially designed questionnaires for the estimation of sugar clearance time.

Some carbohydrates are of particular interest:

- Sugars; disaccharides and monosaccharides
- Starch
- Cellulose (not caries inducing)
- Pectin (not caries inducing)

Some general strategies for use of dietary measures in the prevention of dental caries. Points considered at the time of dental caries examination and measures adopted to reduce caries risk and/or to stop ongoing caries activity are depicted in Table 42.1.

Protective elements. Several food components have been tested on their ability to reduce the caries-inducing effects of carbohydrates.

Phosphates. Phosphates are found naturally in different cereals.

- Retain phosphorous in tooth enamel.
- Help in remineralizing the demineralized areas of enamel.
- Interfere with plaque adherence to the tooth surface.
- Exert anti-bacterial effect.

Fats

- Fats act as protective barrier on tooth surface.
- Some fatty acids may have anti-bacterial effect and deter colonization of plaque bacteria.

Cheese

- May reduce the levels of cariogenic bacteria according to some studies.
- The high calcium and phosphorus content also seems to be a factor in the cariostatic mechanisms of cheese as well as the casein and cheese proteins.

Table 42.1 General strategies for use of dietary measures in prevention of dental caries

Points considered at the examination	Measures to reduce caries risk and/or to stop ongoing caries activity
Frequency of meals	Number of meals + snacks should be kept on a low level
Amount and concentration of sucrose in meals	Alow sugar consumption is desirable from a cariological point of view
Elimination of sugars and consistency of food	Sugars should be eliminated as fast as possible from the oral cavity Foods needing active chewing lead to an increased salivation, which is desirable
Fermentable carbohydrates	Polysaccharides, disaccharides and monosaccharides can contribute to acid formationintheoral cavity, but the capacity differs between different products
Sugar substitutes	Use of sugar substitutes results in a lower acid formation
Protective and favourable elements in diet	*Example 1:* Fluoride in food or drinking water has a pronounced caries-inhibiting effect *Example 2:* Phosphates, calcium, fat, proteins etc. have beentested and found to have a certain caries-inhibiting effect in animals

- Eating of cheese increases the flow rate of saliva and its buffering capacity.
- Provides organic phosphates which help in remineralisation.

Tips for safe snacks

- Cheese
- Fresh fruits
- Fruit juice without sugar
- Nuts

Safe lunch box for children (tooth friendly)

- Vegetable sandwich
- *Chapathi, roti* and rice
- Fresh fruits and salad (seasonal)
- Avoid bakery products (bread, jam, biscuits) and sweets

The dietary items should contain good amount of proteins and vitamins, lesser amount of fats and very minimum amount of sugars. And also the diet should consist of as much as raw vegetables and less of refined fermentable carbohydrate, which will help in lesser retention and encourages more flow rate of saliva.

Tips on snacking

- Encourage intake of snacks which are less sticky and fast clearing
- No snacks (sucrose containing) between meals
- Eat all candies and chocolates once a week
- Brush the teeth immediately after eating

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Essential Dietary Recommendations for Caries Control

1. Breakfast should comprise of balanced inclusion of all nutrient sources.
2. The total daily number of meals, including between-meal snacks, should be limited to about four. This reduces the retention period of sugar and number of drops in pH. Patients should be made aware that, within 5 minutes, even a very weak sucrose solution (5%) results in a fall in pH to suboptimal levels beneath 2 to 3 day old plaque. Such conditions would apply to the proximal surfaces in a toothbrushing population.
3. Sticky sugar containing products, which result in prolonged sugar clearance times, should be eliminated. Sugarless sweets containing sugar substitutes, such as xylitol, sorbitol, saccharin and aspartame, should be used.
4. Diet with fibre rich products should be recommended as it encourages chewing and stimulates salivary flow.
5. Xylitol containing chewing gum when used regularly over long period can reduce the count of cariogenic bacterial in the oral cavity.

Diet Counseling

As frequency of sugar consumption and ingestion of sugary foods or cooked starches are strongly associated with dental caries, diet modification intervention through diet counseling seems to be a simple logical approach to prevention of dental caries.

The following are the principles of diet management:

- The diet prescribed should be adequate with respect to nutritional requirements of the given individual.
- There should be minimal deviation from the existing dietary pattern.
- The diet should contain all essential nutrients needed to for normal function and activity.
- The modified diet should take into consideration, the individual's tastes and preferences.

Procedure

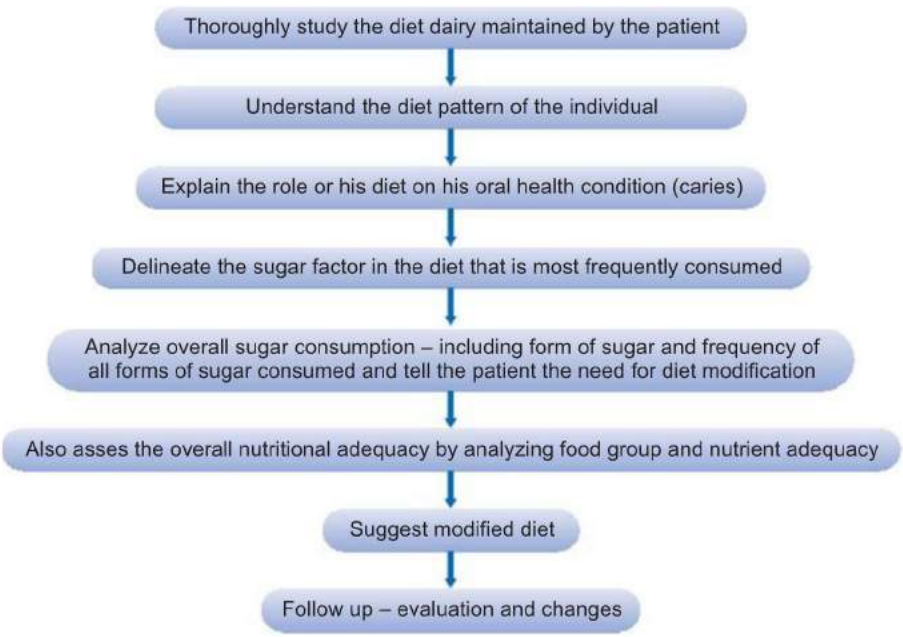
Diet modification intervention involves diet interviewing, teaching, counseling and motivating. Patients prefer a one to one closed-room counseling. This will help the patients to open up with the counselor without any inhibitions and hesitation. The information provided by the patient should be kept confidential. The health care personnel providing the counseling should modify the diet as warranted, tailor- made to suit the needs and preferences of the patients; there is no "one size fits all" policy in diet counseling.

On the first visit, patient may be asked to maintain a food diary, wherein he will be instructed to write the details of various foods and beverages consumed by him on every day basis. Reminders can be sent to the patient during the initial days and the second appointment may be scheduled after a week or 15 days.

There are eight steps in diet modification, described as follows (Flowchart 42.1)**:**

Strengths of diet counseling as a preventive approach are

a) It is simple and can be incorporated in clinical setting and in primary care settings.
b) It is economical.
c) Auxiliary personnel, school teachers and nurses/health workers can also be trained to provide diet counselling.
d) The dentist , physician, nutritionist, together or independently implement diet counselling by applying the common risk factor approach to tackle multiple diet associated diseases at the same time. Viz. Dental caries, diabetes and obesity can be addressed at the same time.



Flowchart 42.1 Steps in diet modification.

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Limitations of diet counseling as a preventive approach are

a) Knowledge and information on dietary implications of dental caries may not directly translate to behaviour modification.
b) Diet counselling may not be equally effective among all groups. Adolescents who are conscious of their appearance and image seem to be motivated more than young children in compliance to diet modification efforts.
c) The exact cariogenic potential of food cannot be easily estimated. As small amounts of cariogenic food also can result in dramatic changes in plaque pH based on host factors, fluoride concentration etc, it is difficult to predict cariogenicity of various foods.
d) There can be cultural barriers to the acceptance and implementation of diet modification.

In spite of these limitations, diet counseling can be beneficial in prevention of dental caries if patient is motivated thoroughly through awareness, interest, involvement and action, by which healthy diet will eventually become a habit. Diet counseling can be successful through a participatory approach and by constant reinforcement.

ORAL HYGIENE MEASURES

"A clean tooth never decays." Based on this concept importance should be given for efficient plaque control so that caries activity can be minimized. Many epidemiological studies have shown that, among large group of children, there is a significant correlation between caries prevalence and the range of oral hygiene levels. While different foodstuffs such as raw vegetables and apples have long been advocated for their cleansing effect, however, it has been shown that they are not effective plaque removing agents. There seems to be some evidence of increased cleanliness and reduced gingivitis and also reduced caries incidence.

On current evidence it appears that high standard of oral hygiene with brushing after every meal will have a significant anticaries effect due to its effect on cariogenic plaque. By disturbing the cariogenic plaque, the sequence of events leading to production of acids, fall of pH and initiation of demineralization is prevented or minimized.

Hence, plaque control must be combined with frequent re-application of fluoride. In this way, progression of enamel caries lesion will be halted and surface remineralized with fluorapatite.

FLUORIDE AND DIFFERENT VEHICLES TO PROVIDE FLUORIDE

Systemically Administered Fluoride

Community Water Fluoridation has been listed as one of the ten public health achievements of the twentieth century by the Centers for Disease Control and Prevention, owing to its role in the decline and prevention of dental caries. Apart from fluoride administration through water fluoridation, systemic fluoride has been delivered through salt, milk, tablets, lozenges, drops etc. To date, fluoride has been systemically administered in drinking water, salt, milk, tablets, lozenges, chewing gums, and drops.

The Pan American Health Organization (PAHO) has recommended implementing salt fluoridation in countries where water fluoridation is not feasible. Systemic fluoride deliveries through water and salt fluoridation are examples of whole population strategies for prevention of caries and so far, the most cost-effective approaches to prevention of caries.

Topically Applied Fluoride

The cariostatic effect of fluoride is very significant post-eruptively .The post-eruptive cario-static effects of fluoride are correlated with fluoride concentration as well as with total exposure time. The latter is also influenced by "substantivity" of fluoride in the oral cavity. For topical fluorides, such as dentifrices and mouthwashes, delivery of the fluoride to the site of action, and its subsequent retention, are as important for overall treatment efficacy as the chemical and biochemical interactions.

Potential reservoirs are the plaque, the soft tissues of the gingiva, the tongue, the cheeks, and stagnation zones between the teeth, under the tongue, and in the buccal sulcus. The relative importance of the different sites is currently unclear. Plaque is important because of its proximity to the teeth. However, soft tissues could be major reservoirs because of the relatively large surface area available.

However, fluoride also reduces acid formation in the dental plaque, may reduce plaque formation rate and plaque adhesion, and may change the ecology of the plaque micro flora. Of these effects, the most important is the reduction of acid formation. The fall in plaque pH following sucrose exposure is reduced when plaque fluoride content has been enhanced by repeated topical treatment.

Fluoride Agents and Compounds for Topical Use

Topical fluoride application is, without doubt, the most important means of fluoride administration for caries prevention and control. In particular, the widespread use of fluoride containing toothpaste in conjunction with improved oral hygiene is thought to be the major factor contributing to the decrease in dental caries in those populations where it has been commonly used. There is overwhelming scientific evidence that fluoride exerts its major cariostatic effect at the plaque-saliva-tooth interface during periods of caries dissolution and arrest. Topical fluoride agents are available for self-care or professional application. For self-care (by patient themselves), following fluoride agents can be used: toothpastes; toothpicks, dental tape, and dental floss; mouth-rinses; gels, artificial saliva, lozenges, and chewing gum.

Professionally applied fluoride agents (e.g. applied by dentists, dental hygienists, or dental assistants) are paints; gels; prophylaxis pastes; varnish glassionomer cement (GIC); and other slow release agents.

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Fluoride toothpaste is by far the most frequently used topical fluoride agent, used by 450 million people. Only 20 million people use mouth rinses or tablets, while 20 million receive professional applications of fluoride. However, although 450 million people use fluoride toothpaste regularly, more than 90% of the world's population does not have access to topical fluoride agents.

Toothpastes. Cariostatic effect of fluoride toothpastes was recognised more than 30 years ago. At present more than 90% of toothpastes in the industrialised countries contain fluoride (almost 100% in Scandinavia, but less than 50% in Japan). Although it is estimated that more than 450 million people use fluoride tooth-paste regularly, it is less than 10% of the world's population. Unfortunately, vast majority of the world's population is not exposed or inaccessible to the use of fluoride toothpaste. Hence, there is a lot of scope and opportunity for introduction of public dental health programme for majority of the world's population, based on inexpensive, effective fluoride toothpastes combined with improved oral hygiene habits.

The main functions of toothpastes are to facilitate mechanical plaque removal by brushing and to serve as vehicles for active agents (fluorides, chemical plaque control agents, anticalculus agents, etc.).

The cariostatic effects of fluoride toothpastes are also related to accessibility and fluoride clearance in the oral fluids. Accessibility may be improved by:

1. Frequent mechanical removal of dental plaque, particularly on the proximal surfaces of the posterior teeth
2. Deliberate application of fluoride toothpaste to the posterior interdental spaces before approximal cleaning
3. Thorough swishing with the remaining toothpaste slurry after cleaning, followed only by one brief rinse with water.

The following measures may prolong fluoride clearance time from oral fluids:

1. Using high fluoride concentration as much as possible.
2. Increasing daily frequency of fluoride toothpaste.
3. Filling the posterior interdental spaces with fluoride toothpaste after cleaning at bedtime. This method is especially recommended for high-risk adult caries patients.

Mouth rinses. Weekly school-based mouth rinsing with 10-ml neutral 0.2% NaF solutions for 1 minute are still very cost-effective for caries control in regions where water fluoride concentration is low, and also for populations with a high prevalence of caries, poor oral hygiene, and no daily use of fluoride toothpaste (Fig. 42.1).

Daily rinsing with 10 ml of fluoride solution (0.025% F) for 1 minute after every tooth cleaning procedure is an efficient supplement for caries control in caries-susceptible children. Fluoride mouth rinses containing chemical plaque control agents (triclosan + copolymer + sodium lauryl sulphate chlorhexidine, amine fluoride + SnF_2, etc.) should have a greater cariostatic effect than pure neutral NaF solutions. However, in patients with high caries risk and particularly in those with impaired salivary function



Figure 42.1 School mouth rinsing programme.

(hyposalivation or xerostomia less than 0.7 ml of stimulated saliva per minute), the combined use of fluoride and chlorhexidine chewing gums as a dessert for 15 to 20 minutes after every meal is a much more efficient cariostatic alternative than fluoride mouth rinsing and daily use of fluoride toothpaste.

Gels and solutions. Fluoride gels and solutions are suitable for individuals with high risk of caries. They are important professionally applied modes of fluoride delivery.

Fluoride gels

Fluoride gels for professional use contain a similar assortment of fluoride compounds as gels for self-care, namely neutral NaF, acidulated phosphate fluoride, SnF_2, amine fluoride plus NaF and NaF + chlorhexidine. For optimal fluoride accessibility, plaque must be removed by professional mechanical tooth cleaning. The gel is pushed into the posterior interproximal spaces, followed by gel application in a customized tray for 4 minutes. Fluoride gels are recommended for use at strictly needs-related intervals in selected patients who are at risk for developing caries. Gels containing SnF_2, amine fluoride plus NaF, and particularly NaF + chlorhexidine have combined anticaries and antiplaque effects.

Fluoride solutions. The most common fluoride solutions for painting the tooth surface are neutral 2%, NaF, 8% SnF_2 and AFP (1.23% F). Amine fluoride solutions are also used. Although use of 8% stannous fluoride is uncommon nowadays, however, it is very effective in the management of nursing caries, rampant caries and root surfaces and also patients susceptible to root caries. It is relatively cost-effective method, because of the combined anti-caries and antimicrobial effect.

Prophylaxis pastes. Prophylaxis pastes are used mainly for professional mechanical tooth cleaning but also for finishing and polishing the restorations. Although all prophylaxis pastes contain fluoride, the fluoride effect should not be overestimated. In caries susceptible patients, more efficient agents such as fluoride prophylaxis paste are recommended to use along with professional mechanical tooth cleaning.

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Semi-slow release fluoride agents. Semi-slow release and slow release fluoride agents such as fluoride varnishes and glass ionomer cements are also increasingly used for the effective management of dental caries. Glass ionomer cements have an added advantage of being cost-effective.

Common commercially available fluoride varnishes are: Duraphat (5% NaF; 2.3% F), Fluor Protector (Amine fluoride; 0.1 % F) and Bifluorid 12 (6% NaF + 6% CaF_2: about 6% F). Fluoride varnishes have been reported to bring about 20-70% caries reduction. Fluoride varnishes have proven to reduce caries in the range of 20-70%.

The caries-inhibitory effect of fluoride varnish is influenced by plaque accumulation rate and rate of fluoride release. Therefore, it is recommended that initial varnish application be repeated three times within 7 to 10 days in patients with high caries risk, thereby reducing the plaque formation rate, and to arrest the initial enamel caries. Thereafter, the varnish should be reapplied at needs-related intervals, two to four times per year. The glass ionomer cements also release significantly most fluoride, followed by resin-modified GICs, GIC-modified resin composites (compomers) and fluoridated resin composites. In addition to the benefit of slow release of fluoride, particularly from GIC materials, such materials can be 'recharged' with fluoride from other sources, such as daily use of tooth-pastes, lozenges, and chewing gums. The fastest and most efficient method of recharging GIC restorations and sealants with fluoride would be by application of fluoride varnish with a high fluoride concentration, such as bifluorid 12 (6% NaF plus 6% CaF_2).

Slow-release fluoride devices. Distribution of dental caries in the population is skewed with a small group of people bearing the brunt of large share of the disease. Advancement in fluoride delivery therefore is moving towards the direction of prevent of caries at people of high risk. Slow release intra-oral fluoride devices have been researched with an intention to prevent caries among population with high caries, in lower socio-economic sections, in areas with low drinking water fluoride levels and other groups with increased risk of dental caries. A sustained high level of intra-oral fluoride concentration has been found to be important in inhibiting caries. Slow-release fluoride devices hold a promise of prevention of caries in high risk group by mechanisms that release fluoride and maintain sustained fluoride levels in the saliva for a long period. With good retentive rates of these devices, patient compliance problems can also be surmounted.

The different types of intra-oral slow- release fluoride devices are:

- Copolymer membrane devices
- Glass device
- Hydroxyapatite RS100 system
- Slow-release fluoride tablets

The following table illustrates the salient aspects of the various slow release fluoride systems (Table 42.2).

- Advantages: Potentially valuable fluoride delivery method in patients with high caries risk
- With improved retention rates, can improve patient compliance issues.
- Disadvantages: Poor retention rates (48%) of the slow release fluoride devices
- Low quality evidence exists in the literature on the caries preventing effect of the slow release fluoride devices.

Table 42.2 Slow release fluoride systems

	Copolymer Membrane Devices	Glass Device	Hydroxyapatite Rs 100 System	Slow-Release Fluoride Tablets
Formulation	It consists of sodium fluoride containing copolymer matrix encased in a rate controlling acrylic polymer membrane	Fluoride glass (17.4 %/14.8 mg F)	It consists of hydroxy-apatite, 18 mg of sodium fluoride	It consists of 160-200 mg tablets containing hydroxyapatite and eudragit/ethylcellulose, in which sodium fluoride has been mechanically impregnated
Mechanism	Based on the principle of hydration. The membrane contains 8.7% water and matrix contains 20.3% water. The water absorption controls the sustained release of fluoride	The device slowly dissolves when hydrated releasing sustained amounts of fluoride	Information related to mechanism and application of Hydroxyapatite RS 100 system not available in the literature	The bioadhesive property of the tablet is responsible for the retention of the tablets and sustained release of fluoride
Application	8mmx3mmx2mm device attached pn the buccal surface of first permanent molar through orthodontic band or bonded with adhesive resin	6mmx 2.5 mmx 2.3mm bonded to the tooth surface		Fixed on a tooth surface or buccal/ labial sulcus
Fluoride released	0.02-1 mg/day for 4-6 months	Maintains 1-1.2 ppm Fluoride concentration at 6 months	0.15 mg/day for 1 month	0.1 mg Fluoride for 7-8 hours

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ARGININE AND DENTAL CARIES PREVENTION

Recently, Arginine has been incorporated as caries preventing agent in dentifrice formulations. Arginine metabolism has been considered to contribute to the pH balance in the oral environment, thereby reducing the risk of dental caries (Flowchart 42.2).

Mechanism of anti-caries effect of Arginine. A constant low pH is a precondition for demineralization of enamel and progression of caries. An alkaline plaque environment can neutralize the acids causing tooth mineral loss resulting from caries by acting on the dynamics of the demineralization-re-mineralization cycle. Plaque bacteria catabolize Arginine through the Arginine De-iminase System. The sequence of Arginine metabolism is explained as follows:

Ammonia produced in the Arginine metabolism is considered to be responsible for the anti-caries effect because

- Ammonia increases pH and neutralized the acid produced by cariogenic bacteria.
- As pH becomes neutral, aciduric bacteria are unable to grow in the environment.
- Alkaline environment favours the growth of micro-organisms that grow in basic environment.

In this way, Arginine exerts its anti-caries effect by influencing the plaque microbial ecology.

ANTIMICROBIAL AGENTS AND TREATMENTS

Anti-microbials inhibit bacterial colonization of caries producing bacteria. They should be non-toxic and should not interfere with the other processes. Appropriate dosage and route of administration, duration of the course and patient compliance are important factors for successful outcome following anti-microbial therapy. Anti-microbials can be categorized as follows (Table 42.3).

Probiotics and caries prevention: WHO defines probiotics as, "live micro-organisms which, when administered in adequate amounts, confer a health-benefit on the host".

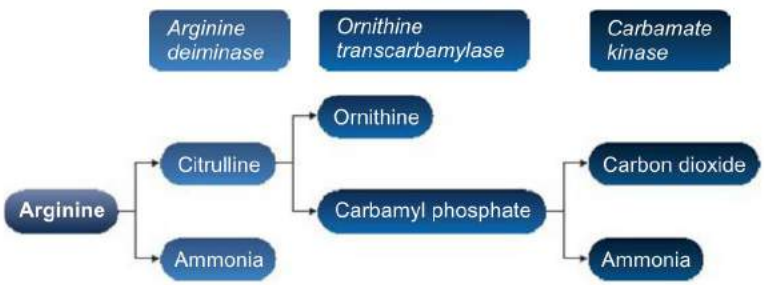
- Probiotic therapy has been successful in the treatment of gastro-intestinal diseases. Subsequently, the benefits of probiotics use for other diseases have been explored since a decade. Probiotics have been conventionally delivered through various vehicles, viz., milk, yoghurt, ice-cream etc. In the context of dental caries, the following are some of the strains that have been found to be potentially efficacious:
  - *Lactobacillus reuteri*
  - *Lactobacillus rhamnosus*
  - *Lactococcus lactis*
  - *Bifidobacterium*
  - *Streptococcus thermophilus*
  - *Streptococcus salivarius*
  - *Streptococcus oligofermentans*
  - *Streptococcus rattus*

Table 42.3 Antimicrobial agents—Short descriptions

Agent	Description
Cations	Positively charged ions which act by hindering the bacterial membrane function, bacterial adhesion and glucose uptake, e.g. chlorhexidine gluconate
Anions	Negatively charged ions which act by hindering with bacterial membrane functions, glycolytic metabolism and glucose uptake, e.g fluoride preparations
Non-ionic agents	Reduce glucose uptake by inhibiting membrane enzymes, e.g. phenol, listerine, triclosan
Enzymes	Interference with bacterial adhesion
Sugar alcohols	Polyols are believed to interfere with bacterial glycolysis, e.g. xylitol

Mechanisms of Action

- **Binding to the tooth surface and incorporation into biofilm:** *Lactococcus lactis* and *Streptococcus thermophilus* have been found to have the potential to colonize in the plaque environment by adhering to the pellicle and to the tooth surface. By this, they compete with cariogenic micro-organisms for nutrients and inhibit the proliferation of the latter. L. *reuteri* has been found to have good binding properties with mucin that helps binding and colonization and competes for habitat in the micro-ecosystem with *S. mutans*. Lactate dehydrogenase deficient strains of *Streptococcus rattus* have been found to compete for S. *mutans* for habitat.
- **Anti-microbial activity against *S. mutans*:** *L. reuteri* has been found to have anti-microbial activity against *S. mutans*. *Streptococcus oligofermentans* breaks down lactic



Flowchart 42.2 Arginine metabolism.

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acid to hydrogen peroxide which inhibits S. *mutans*. Certain strains of Streptococcus *salivarious* have been reported to produce inhibitory substances like bacitracin which prevent the colonization of cariogenic strains. *Lactobacillus rhamnosus* has also been found to have inhibitory activity against *S. mutans*. Bifidobacterium strains have been reported to reduce the cariogenic bacteria in the oral cavity.

- **Other mechanisms:** Other mechanisms proposed for probiotics action include modulation of immune system, by inducing local and systemic immunity. Further research is required in this area to understand the intricacies of the mechanism.

Probiotic therapy, therefore, can alter the plaque micro-flora by selectively inhibiting or modifying the caries causing bacteria and preserving the non-pathogenic micro flora.

Interesting to know

'Probiotic effect' can also be achieved by:

- Using anti-microbials that only target the cariogenic bacteria, and allowing the non-pathogenic strains to survive, which will in effect, not disturb the oral micro-eco-system.
- Genetically engineered strain of *S. mutans* using Recombinant DNA technique, which will replace the normal cariogenic strain of *S. mutans* to prevent dental caries.
- Interfering with the signal system of cariogenic bacteria, especially that of *S. mutans* in the dense microbial community of dental plaque. (Interference in the communication process [Quorum sensing] of *S. mutans* that determine the virulence, host adaptation and provide competitive advantage of the strain among other strains that co-exist in the dental bio-film can derange and inhibit *S. mutans*).

REMINERALIZING AGENTS

Novamin

Novamin falls into a newer category of bioactive glass ceramic material. The active ingredient is a calcium sodium phosphor silicate that reacts when exposed to aqueous media, thus providing calcium and phosphate ions to the applied surface.

Novamin containing dentrifice is statistically more effective than regular dentrifice and this is more useful in treating and managing initial caries lesions by helps in remineralisation.

CPP-ACP

Recent developments in the area of remineralisation include casein phosphopeptide amorphous calcium phosphate (CPP-ACP). Dairy products such as milk, milk concentrates and cheese are recognized as non-cariogenic or cariostatic agents. CPPs form amorphous calcium phosphate by stabilizing the calcium phosphate ions in solution. Sugar-free chewing gums, tooth paste or dental cream containing CPP-ACP have ability to promote enamel subsurface remineralisation.

SALIVARY STIMULATION

The subjective sensation of dry mouth, referred to as xerostomia, is said to occur when salivary flow rate is less than loss of fluid rate from mouth. Patients with low salivary flow may experience many problems which include: xerostomia; an increase in caries, often at sites not normally prone to caries, reduced clearance of bacteria and food, leading to mucosal soreness, gingivitis, chelitis and infection of salivary ducts; recurrent yeast infection; problems in mastication, deglutination and speech; increased frequency of calculus deposition in salivary ducts; burning mouth and difficulty in retention of dentures (Sreebny et al, 1992).

Interesting to know

Usually, the rate of fluid input exceeds the rate of fluid loss by evaporation or absorption through oral mucosa, and the excess is periodically swallowed. Evaporation can only occur during mouth breathing but can reach a maximum rate of about 0.21 ml/min at rest although normally it would be much less. Water absorption through the mucosa can occur because saliva has 1/6th the osmotic pressure of extracellular fluid, thus creating a water gradient across the mucosa. Saliva in the residual volume is present as a thin film which varies in thickness with site. The volume of saliva in the mouth varies from mean of 1.07 ml (range 0.5-2.14 ml) prior to swallowing to a mean of 0.77 ml after swallowing, which is the residual volume. When flow is un-stimulated the volume of saliva swallowed is about 0.3 ml/min, the swallowing frequency could be about 1 ml/min. The swallowing frequency is less during sleep, when the salivary flow rate is reduced.

1. Xerostomia is the subjective sensation of dry mouth, while hyposalivation is the objective finding of a reduced salivary flow rate. Saliva is an indispensible body fluid and essential for maintaining oral health. Saliva has various functions as listed in the following. It protects the teeth from continuous wear by coating the teeth with salivary mucins and proline-rich glycoprotein.
2. Salivary proteins and statherin promote remineralization by attracting calcium ions.
3. The minerals in saliva–calcium and phosphate inhibit demineralization.
4. Salivary proteins also play a role in inhibiting colonization of cariogenic micro-organisms.
5. The buffers in the saliva namely carbonates and bicarbonates help neutralize an acidic oral environment.

Reduced salivary flow is a very important internal modifying risk factor and prognostic risk factor for dental caries. Thus, salivary stimulation is very important in caries susceptible patients with reduced salivary flow.

In cases of xerostomia, where glandular function is not completely impaired, salivary stimulation will be a rational option to enhance saliva quantity and flow.

Some of the salivary stimulants are:

1. Systemic sialogogues

Pilocarpine 5 mg thrice daily and cevimeline 30 mg thrice daily are widely used para-sympathomimetic

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drugs administered as sialogogues. However, caution must be exercised and consultation with physician should be done prior to prescription as these drugs are contra-indicated in patients with cardiac disease, chronic obstructive pulmonary diseases and in narrow angle glaucoma.

2. Topical agents
   - Sugar-free chewing gums
   - Sugar-free lozenges
   - Sugar-free natural pastilles
3. Other remedies
   - Vitamin C/ascorbic acid (occurring naturally in citrus fruits)
   - Malic acid (found in pears and apples)

For patients with chronic dry mouth and severe xerostomia following radiotherapy, artificial saliva or saliva substitutes may be more useful. Oxygenated glycerol triester (OGT) saliva substitute spray is recommended over water based mineral sprays. Artificial saliva containing NaF can improve physical and subjective symptoms with added therapeutic effect of fluoride to reduce the risk of rampant caries in these extremely high risk patients. However, in these patients, meticulous mechanical and chemical plaque control and combinations of the most efficient fluoride agents are also essential. Fluoridated artificial saliva is formulated either as a gel or as a spray.

FISSURE SEALANTS

Data on the decline of caries prevalence among children and young adults in most industrialized countries over the past two decades show a relative increase in the proportion of caries on the occlusal surfaces of the permanent molars. Even in developing countries with relatively low caries prevalence, the occlusal surfaces of the permanent molars are decayed more frequently than the proximal surfaces.

Fissure caries is partly attributed to the extremely plaque retentive morphology of the fissure systems. To prevent the accumulation of cariogenic plaque in the depths of the fissures, and thereby prevent the development of caries, so-called fissure sealants are introduced to obliterate occlusal morphology, i.e. sealing the fissure system.

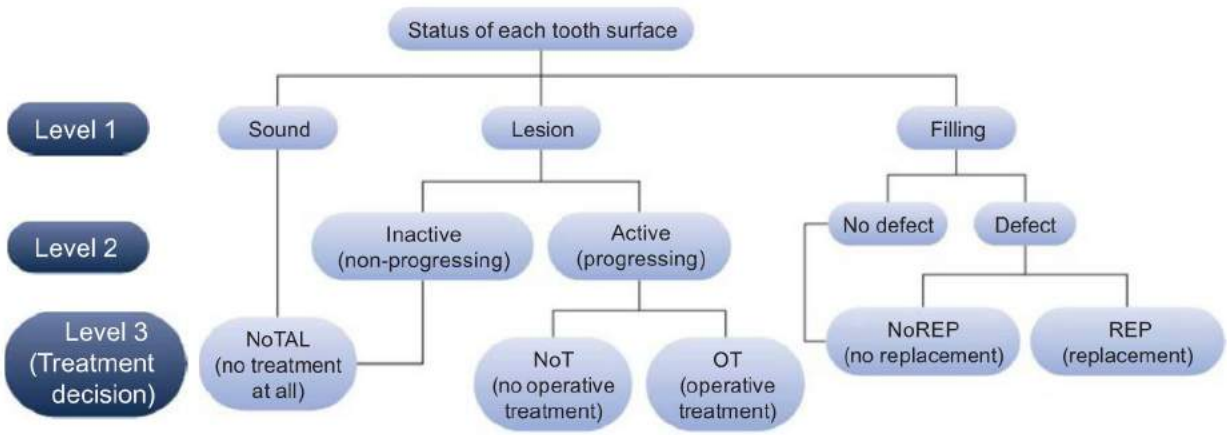
Fissure sealants can be used in a cost-effective manner when applied to patients with high risk of caries and when applied to teeth as early as possible after complete eruption.

Clinical Caries Diagnosis

On account of low rates of lesion progression in many western countries over the past decade, there has been an interest in developing clinical diagnostic criteria for assessing the activity state of noncavitated carious lesions. The theoretical foundation of once such system (Nybad et al, 1999) in assumption that lesion activity, defined as net progression or net regression (Fejerskov and Manji), will be reflected in the surface features of the lesion: Matt, "chalky" and rough enamel lesions being "active", and shiny, smooth enamel lesions being "inactive" or "arrested". Such distinction has no bearing on what may occur to the lesion over time. If an active lesion is exposed to fluorides and oral hygiene measures over time, the activity of the lesion can change. Only if the local environmental conditions of a lesion remain unchanged then the activity state be expected to stay the same. The "active" non-cavitated lesions are at a definitive risk of progressing to caries than "inactive" non-cavitated lesions (Flowchart 42.3).

GENERAL RECOMMENDATIONS FOR PREVENTION OF DENTAL CARIES WITH RESPECT TO USE OF SUGARS

- In presence of adequate exposure to fluoride, intake of free sugars should be limited to 15 to 20 kg/per year (equivalent to 40-55 g/day). In the absence of fluoride, intake of free sugars should be below 15 kg/year (40 g/day). These values equate to 6-10% of energy intake. The intake of sugar-containing foods should be limited to four times a day.
- Emphasis on financial burden of treating caries has to be pointed out to government bodies.
- Impact on quality of life that can occur due to dental caries, the functional, esthetic and emotional effects of the condition need to be highlighted.



Flowchart 42.3 Treatment decision tree for dental caries.

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- The myth that a high sugar intake is important for energy intake and growth needs to be dispelled, especially in developing countries where under-nutrition is prevalent.
- Regular monitoring of the prevalence and severity of dental caries should be encouraged using WHO global guidelines in different countries in all age groups.
- More national information on the dietary intake of sugars, sugar availability and soft drink should be collected.
- Governments should support research into prevention of dental caries through dietary means.
- Nutritional training should be made mandatory of dental professional courses. This is essential if advice for dental health is to be consistent with dietary advice for general health.
- Departments of education must ensure that teachers, pupils and health professionals receive adequate education on diet and dental health issues.
- Food manufacturers should continue to develop and produce low sugars/sugar-free alternatives to products rich in free sugars, including drinks.

RECOMMENDATIONS (FOR CHILDREN AT HIGH RISK OF DENTAL CARIES)

Primary Prevention of Dental Caries

Caries risk can be made based on the following factors:

- Presence of restorations/missing teeth because of previous caries
- Diet and sugar consumption pattern
- Socioeconomic status
- Fluoride therapy
- Self and professional plaque control measures
- Salivary quantity, composition and type
- Cariogenic microbe count
- Systemic conditions
- Special needs

Health education for behavior modification in High Caries Risk Children

Dental health education for children with high risk of caries should emphasize on:

- Brushing teeth twice daily with fluoridated toothpaste containing 1000 ppm fluoride.
- Detrimental effects of sugar containing foods and avoidance of snacking between meals.
- Use of sugar substitutes.
- Use of sugar fee chewing gums.

Tooth Protection in Children at High Caries Risk

The following protective measures are recommended for children at high risk of caries:

- Pit and fissure sealant application with regular follow up and prompt reapplication failed sealants.
- Resin based sealants should be preferred to glass ionomer sealants.
- Fluoride supplements in the form of tablets/wafer should be considered.
- Frequent application of fluoride varnish based on caries risk.
- Chlorhexidine varnish can also be considered as an option for preventing caries.

Secondary and Tertiary Prevention of Dental Caries

1. Early diagnosis and prompt treatment of caries
2. Pulpal therapy and structural and functional rehabilitation of teeth affected with caries

Diagnosis of Dental Caries

Proximal caries should be ascertained by bitewing radiographs. DiagnoDent can be used in the clinical diagnosis of caries.

Management of Carious Lesions

Occlusal caries. Dental caries on occlusal surfaces can be conservatively restored with composite restorations. Silver amalgam restorations also continue to be used in clinical and public health practice.

Approximal caries. When proximal caries is incipient, a fluoride varnish is recommended. Cavitated proximal caries are treated by conventional Class II restorations.

Re-restoration. Careful clinical examination should be done to ascertain secondary caries. Re-restorations should be placed to halt the progression of caries.

CONCLUSION

Dental caries is widely prevalent in most parts of the world. A major determinant in the initiation of dental caries is the colonization of tooth surfaces by *mutans streptococci*. The caries process can be arrested by meticulous plaque control, dietary modifications, judicious use of different types of fluorides, salivary stimulation and appropriate use of preventive-restorative materials. Each of these approaches requires an active co-operation of the patient. The patient is in control of his or her own dental destiny because it is the patient, not the dentist, who influences the caries process. The dentist should show the patient the white spot, carious root surface, the cavitated lesions and the new cavity forming next to a filling. Disclosing solution should be applied to demonstrate the presence of plaque in the specific position. The dentist should explain the role of plaque and the dietary factors in causing caries. And also the dentist should explain about relative importance of the high-risk patient management with respect to their past caries experience,

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CONCLUSION—cont'd

unsatisfactory dietary habits, lack of use of fluorides and poor oral hygiene status. Hence, dentists and patients together have to modify the risk factors so that the carious lesions can be arrested or reversed.

The clinical evidence implicating frequent consumption of sugar in the aetiology of caries is much stronger than the evidence supporting the widely held belief that caries is an infectious disease caused by mutans streptococci. Dental caries still remains the most costly and widespread disease that in many industrialized countries affect mainly disadvantaged individuals and is of serious concern in many developing countries. At the population level, in industrialized countries, measures to educate the public on the dangers of frequent sugar consumption in conjunction with recommendation for proper oral hygiene and fluoride use are still warranted. On an individual basis dietary counselling is highly recommended for patients that show signs of caries activity and/or are at high caries risk (hyposalivation, iatrogenic factors such as orthodontic brackets). Given that dental caries is a preventable disease, each country must decide what level of disease is the society willing and able to tolerate.

REVIEW QUESTIONS

1. Discuss how we can intervene in the dietary practices of patients/community to help prevent dental caries.
2. What is the role of slow fluoride release delivery systems in prevention of caries in high caries risk individuals.
3. 'A clean tooth never decays.' Justify.
4. Explain the anti-caries mechanism of Arginine.
5. Write a short note on role of probiotics in the prevention of dental caries.
6. Write a short note on the management of caries in patients with xerostomia.

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43 Prevention of Periodontal Diseases

Hiremath SS

CHAPTER OUTLINE

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Oral Hygiene Aids 391
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INTRODUCTION

Periodontitis, one of the most common diseases of humans, is an infectious condition that can result in the inflammatory destruction of periodontal ligament and alveolar bone. Gingivitis is an infectious inflammatory process limited to gingiva whereas periodontal diseases are generally chronic in nature and can persist in the absence of treatment. These diseases are the result of exposure of the periodontium to dental plaque and biofilms that accumulate on the teeth at or below the gingival margin. Dental plaques are complex with more than 400 bacterial species. The periodontal destruction probably results from the reaction of various toxic products released from specific pathogenic sublingual plaque bacteria, and from the host responses elicited against plaque bacteria and their products.

The chronic nature of periodontal disease and infections may influence overall health and course of some systemic diseases. The periodontal diseases are considered as infections because there is bacterial aetiology and a subsequent immune response. Microbial challenge often results in subclinical infection because the host response prevents the bacterial challenge from reaching the threshold necessary to cause symptoms. However, when subgingival bacteria overwhelm the host response, tissue destruction occurs. On the whole, relatively very little attention has been paid to the impact of periodontal infections on human health.

Periodontal disease is almost universal in its occurrence affecting 95% of the population and is intimately related to plaque and pocket formation.

Supragingival plaque formation and the onset of early periodontal diseases can be successfully controlled by scruplous mechanical oral hygiene procedures and effective antiplaque agents.

IMPLICATIONS FOR PREVENTION

As gingivitis is caused by supragingival plaque accumulation and as gingivitis is a prerequisite for the development of periodontitis, both diseases can be prevented by an adequate standard plaque control (Figs. 43.1A to C).

Unfortunately so far with definite dependable predictive test are available which can help in identifying individuals at risk of developing a periodontitis of aggressive type at community level. Hence, frequent dental visits are required based on regular basis to maintain healthy oral hygiene and also to diagnose early inflammatory changes, which can be reversed. During the regular dental visits, periodic reinforcements can be induced through effective oral hygiene education normally given at the chairside (Fig. 43.2).

FACTORS PREDISPOSING TO PLAQUE ACCUMULATION

Inadequate Oral Hygiene

Inadequate maintenance of oral hygiene is one of the most powerful factors indicated by many cross-sectional and longitudinal studies directly influencing the plaque accumulation on tooth surface.

Tooth Malalignment

Gingivitis is more common and severe around malaligned teeth because they are difficult to clean (Figs. 43.3–43.4).

Restorations

Overhanging restorations, defective margin (more so in case of subgingival margins of restorations) and rough surface of the restoration are more predisposed to plaque accumulation and has a profound effect on the periodontal health.

Prosthesis

Patients provided with partial dentures, fixed prosthesis, accumulate more plaque on abutment teeth along with the denture margins and even the rate of change of

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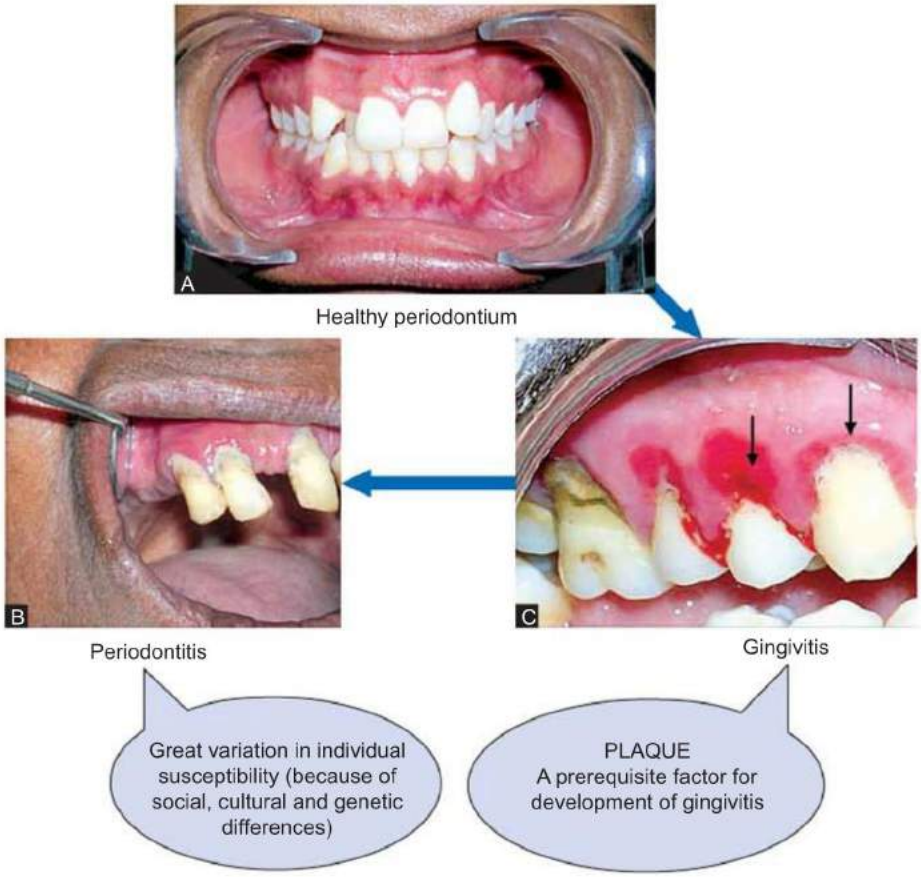


Figure 43.1 Stages of progression of gingival inflammation to periodontitis.

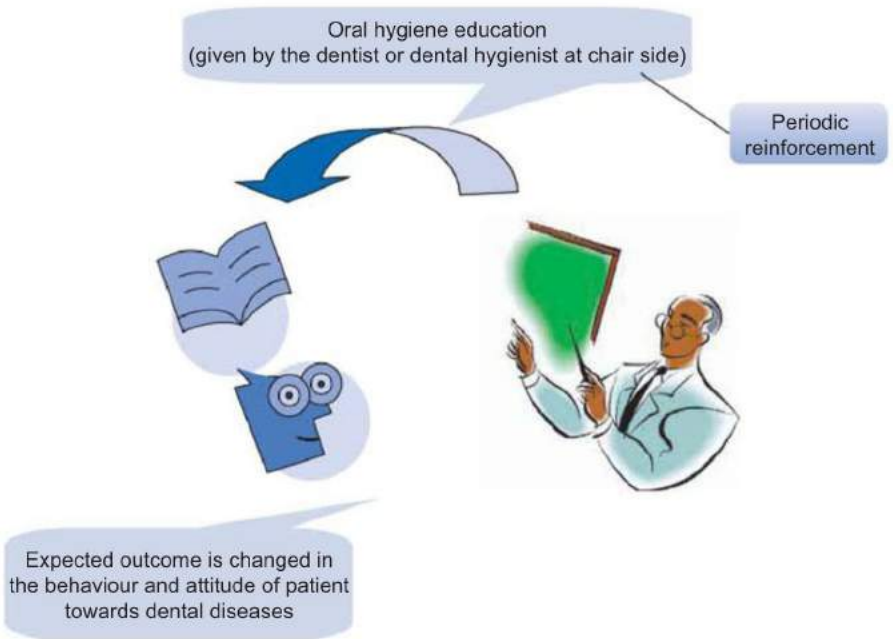


Figure 43.2 Services offered by the hospital.

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Figure 43.3 Crowded lower anterior teeth region.



Figure 43.4 Edentulous space with plaque and calculus deposition.



Figure 43.5 Calculus deposition in mandibular teeth.

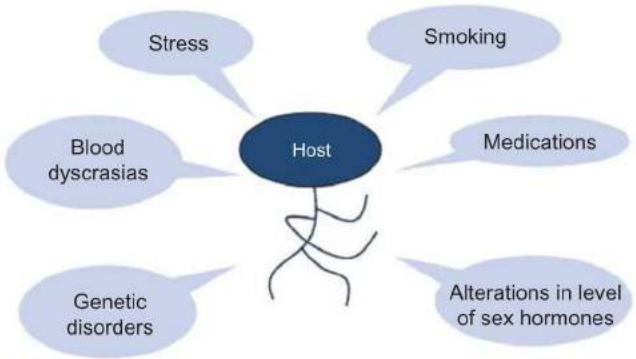


Figure 43.6 Various host factors modifying inflammatory response.

microbial composition is more so in denture subjects than in non-denture subjects.

Calculus

The surface texture of the calculus itself promotes plaque accumulation and retention (Fig. 43.5).

Periodontal Disease Risk Assessment

Assessment and use of risk status in prevention and management of periodontal disease is very difficult and also more complicated. Individual risk factors will greatly differ either in disease enhancing susceptibility or multiple risk factors appear to be having a synergistic effect; hence, assessment of risk factor for periodontal disease still remains a subjective and it is a matter of conflicting entity from one patient to another patient. Risk factors for the assessment of initiation or progression of periodontal disease can be grouped under the following headings:

1) **Demographic data**
   - Age
   - Gender
   - Duration of exposure
   - Risk elements
   - Preventive practices/oral hygiene behavior
   - Socioeconomic status
2) **Medical history**
   - Diabetes mellitus
   - Use of tobacco
   - HIV/AIDS
   - Osteoporosis
   - Alcohol consumption
3) **Dental history**
   - Family history of early tooth loss
   - Frequency of dental care
   - Oral hygiene practices
4) **Clinical examination**
   - Plaque accumulation
   - Calculus
   - Bleeding on probing
   - Extend of loss of attachment
   - Faulty restorations

Factors Modifying Inflammatory Response

There are several host factors, which might directly or indirectly modify the inflammatory response in case of gingivitis or periodontitis. They are namely stress factor, smoking habits, congenital disorders, blood dyscrasiasis systemic diseases, etc. (Fig. 43.6).

Prevention of periodontal disease. Can be of two types:
1. **Professional care**
2. **Self-care**

Professional care
a) Dental health education
b) Scaling and root planning (mechanical plaque control)

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c) Surgical pocket therapy

(i) **Dental education** is given on maintenance of good dental hygiene status, which in turn results in the reduction of accumulation of plaque. This depends on change in the oral hygiene behavior of the patient based on effective oral health education.

(ii) **Scaling and root planning** are done to remove the plaque and calculus from the enamel and root surface but some amount of contaminated cementum (endotoxin-laden cementum by subgingival bacteria and calculus impregnated within cemental irregularities) is also removed so that it

- creates favourable plaque-free environment.
- helps in the renewal of junctional epithelium and epithelial attachment.

Polishing

- Where plaque removal is obviously inhibited by surface roughness.
- Smooth surfaces are difficult to get attached from plaque accumulation.
- Removal of extrinsic tooth stains for cosmetic reasons.

(iii) **Surgical pocket therapy.** Surgical pocket therapy is done usually in cases where pocket depth is more than 5 mm to gain better access to plaque infected root surface. Plaque control must be given highest priority when prevention and control of periodontal disease should be considered. Plaque control programmes based on needs related combinations of these methods are to date the most successful means of prevention of periodontal disease.

Self-care. Effectiveness depends on: A dentist should first assess individual needs of the patient and then should recommend appropriate aids for oral health care (Fig. 43.7).

ORAL HYGIENE AIDS

Different oral hygiene aids used are

Toothbrushes

Toothbrushing is one of the most widely used mechanical means of personal plaque control globally (accounts for less than 17% of usage in India), but has a very limited access to the wide approximal surface of the molars and premolars (Fig. 43.8).

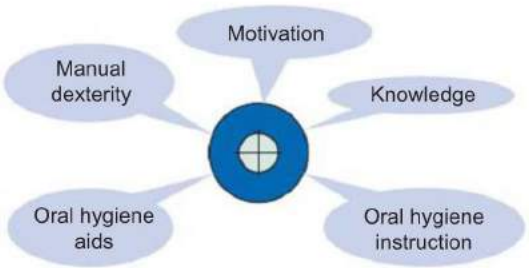


Figure 43.7 Factors influencing effectiveness of self-care.

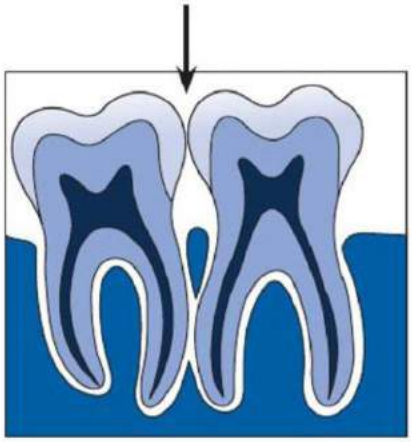


Figure 43.8 Inaccessible approximal surfaces of molars.

Manual toothbrush

1. Design characteristics
   a. Straight handle
   b. Angulated handle
2. Hardness of bristles (diametre of bristle)
   a. Soft (0.007 inch)
   b. Medium (0.009 inch)
   c. Hard (0.012 inch)

   Current opinion favours use of soft textured or medium texture bristle, nylon, multitufted toothbrush with short head.
3. Toothbrushing methods: Based on the direction of brushing stroke, Green (1966) grouped the toothbrushing methods into following groups: **(i) vertical, (ii) horizontal, (iii) roll on technique, (iv) vibrating technique, (v) circular technique, (vi) physiological technique, and (vii) scrub technique.**

   Each technique has its own pros and cons. But no technique is superior to the other. Current opinion favours the use of Bass method or a modification of it. However, choice is left to the patient as long as he/she is able to brush properly his/her teeth without injuring hard and soft tissues.

Electric toothbrush or powered toothbrush. Electric toothbrush is primarily advocated for physically and mentally handicapped patients (see Fig. 38.2).

Manual toothbrushes are as effective as the traditional electrical toothbrush in hands of well informed individuals.

Interdental cleaning aids. It is well-established fact that periodontal conditions are worst in interdental areas where standard toothbrushes are ineffective in removing proximal surface plaque leading to further progress in disease in those areas.

Wood points (toothpicks). Wood points are effective only where sufficient interdental space is available to accommodate it. Triangular wood points are superior to round or rectangular ones.

Dental floss. Dental floss is used to clean the normal interproximal space and to maintain the health of gin-giva although manually more demanding and time consuming than wood points (see Fig. 38.8).

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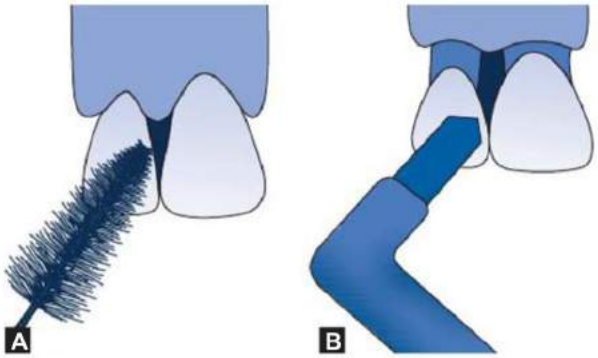


Figure 43.9 Use of interdental brush for interdental cleaning. (A) Attached to wire, (B) Attached to a metal plastic handle.

Interspace brush (unitufted tooth brush). Interspace brush is introduced to improve access to tipped, rotated or displaced teeth and teeth affected by gingival recession. It is usually used as an adjunct to wood points, but seldom used alone.

Interdental brush (bottle brush). Interdental brush is indicated in cases of open interdental spaces. It is available in different sizes (Figs. 43.9A, B).

Interdental brush is superior to dental floss in cleaning large interdental spaces (maintain both supragingival and subgingival spaces free of plaque).

Irrigation Devices

Irrigation devices provide a pulsating stream of water escaping through nozzle under pressure (see Fig. 43.10). They remove only the surface layer of soft plaque. These are used in cases of:

- Areas of dentition not readily accessible to conventional mechanical plaque removal
- Delivery of chemical agents to the oral cavity (in special cases).

They are only adjuncts to mechanical plaque control and never should be used as a substitute to the same.

Toothpaste

The prime effect of toothpaste is therapeutic delivery of various antimicrobials, e.g. fluoride. Brushing with conventional fluoride toothpaste is a more effective means of plaque control than brushing with water alone. Although degree of abrasiveness does not influence the amount of plaque control, but abrasive property of toothpaste keeps pellicle layer thin and prevents accumulation of surface stains. Some recently formulated toothpastes with crystallisation inhibitors that have been shown to reduce supragingival calculus formation are being advocated now.

- The interval between tooth-cleaning sessions should be not less than 12 hours and not more than 48 hours depending on the prevalence of gingival conditions and individual susceptibility to periodontal disease.
- The person should brush until all the surfaces are cleaned.

CHEMICAL PLAQUE CONTROL

By far the most efficient plaque control programmes are those combining mechanical and chemical methods, e.g. the toothpaste used usually contains not only an abrasive agent but also antiplaque or antimicrobial agents such as sodium lauryl sulphate, stannous fluoride, triclosan plus zinc citrate, tri-closan plus copolymers etc.

Chemical plaque control should always be regarded as needs-related supplement to and not a substitute for mechanical plaque control. Therefore, based on individual patients' predicted risk for oral disease, the choice of agent and frequency of use for self-care and professional care should be decided.

Goals of Chemical Plaque Control

1. To prevent plaque formation.
2. To control plaque formation.
3. To reduce, disrupt or remove existing plaque.
4. To alter composition of plaque flora.
5. To exert bactericidal or bacteriostatic effects on micro flora implicated in caries and periodontal disease.
6. To alter surface energy of the tooth, in turn, affecting the plaque adherence.

Although many antimicrobial agents would appear to be suitable for plaque control, only few have demonstrated clinical efficacy, because of inherent problems in the mode of action of agents in the mouth and difficulties in incorporating in dental products.

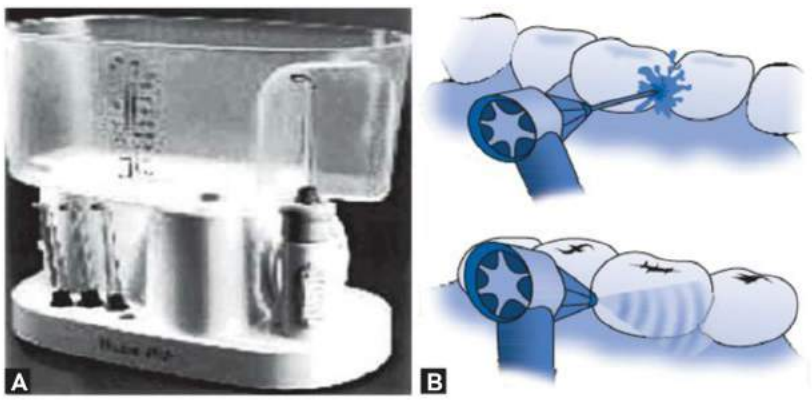


Figure 43.10 Irrigation device—pulsating water jet.

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To increase antibacterial effectiveness, agents with complementary modes of action should be used. Long-term use of these products should not

- disrupt the natural balance of oral micro flora
- lead to colonisation of exogenous microorganisms
- lead to the development of microbial resistance.

Several products satisfy these criteria, the challenge in front of our profession is to increase the efficacy of these agents while preserving homeostasis in the mouth.

Self-care

1. Agents are applied with high frequency one to three times per day, regularly or intermittently.
2. Accessibility and efficacy are good supragingivally but very limited subgingivally.
3. The type of care is compliance dependent and relatively costly for daily use.

Professional chemical plaque control

1. The frequency should be need related. Chemical plaque control is more frequent during initial intensive period to arrest initial enamel caries and to heal inflamed periodontal tissues as soon as possible.
2. Accessibility is high as it is professionally advised.
3. The duration of effect can be extended by using slow releasing agents, such as chlorhexidinethymol varnish (Cervitec).

Factors Influencing Effects of Chemical Plaque Control

Substantivity. It is the ability of an agent to bind to the tissue surfaces and release over time delivering an adequate dose of the active principal ingredient in the agent.

Penetrability. It is efficiency of an agent in penetrating deeply into the formed plaque matrix.

Selectivity. It is the ability of the agent to affect specific bacteria in a mixed population.

Solubility. It is the property of the active agent to be soluble in its delivery vehicle to allow rapid release into the oral environment.

Stability. The agent should not undergo chemical breakdown or modification during storage.

Accessibility. It is critical to the effect of chemical plaque control. For efficacy the agent should reach the site of action and be maintained at that site long enough to have sustained effect.

A good chemical plaque control agent should have right blend of all these factors, e.g. the agent should have *high* substantivity, penetrability and accessibility and *a balanced blend* of solubility and stability.

Antiplaque Effects

Formation of the dental plaque can be prevented by these chemical agents by one of the following principles: (i) inhibition of bacterial colonisation, (ii) inhibition of bacterial growth, (iii) disruption of mature plaque, and (iv) modification of plaque biochemistry and ecology.

Most chemical plaque control agents used today are broad-spectrum antimicrobials that exert direct bactericidal or bacteriostatic effects. They bind to bacterial membrane and interfere with normal membrane functions such as transport, thereby disturbing bacterial metabolism and ultimately killing them. They also alter permeability resulting in the leakage of intracellular components, along with protein denaturation.

They interfere with adsorption of the bacteria on the tooth surface by modifying surface characteristics of the tooth surface, e.g. surface energy, surface tension.

Delivery Vehicle

Various delivery vehicles are used for delivery of these chemicals. The delivery vehicle should

1. Be compatible with the active agent
2. Provide optimal bioavailability of the agent at the site of the action
3. Should be independent of the patient compliance, e.g. do not require the modification of patient's existing habits

Various delivery vehicles used are: (i) mouth rinses, (ii) gels, (iii) toothpastes, (iv) chewing gums and lozenges, (v) irrigants, (vi) varnishes and (vii) controlled release devices.

The most commonly used chemical plaque control agents are: (i) cationic agents, (ii) anionic agents, (iii) non-anionic agents, (iv) other agents, and (v) combination agents.

Cationic agents. These are more potent antimicrobials than anionic and non-anionic agents, because they bind readily to the negatively charged surface. The following groups of these agents are tested and used as antimicrobial agents:

- Bisbiguanides; chlorhexidine and alexidine; Quaternary ammonium compounds: cetylpyridinium chloride, benzethonium chloride and domiphen bromide
- Heavy metal salts: copper, tin, zinc
- Pyrimidines: hexitidine
- Herbal extracts: sanguinarine.

Most effective is bisbiguanide followed by heavy metals. Most widely tested and used agent is chlorhexidine.

Chlorhexidine

History. Chlorhexidine was developed in the 1940s by Imperial Chemical Industries, England, and marketed in 1954 as an antiseptic for skin wounds. Later, the antiseptic was more widely used in medicine and surgery including obstetrics. More specific use of chlorhexidine as an oral rinse came with the acknowledgement that plaque was the etiologic agent in gingivitis (Löe et al. 1965). Plaque inhibition and prevention of gingivitis by chlorhexidine was initially investigated by Schroeder in 1969. One year later the efficacy of chlorhexidine was confirmed by Löe and Schiött in 1970 in a pioneering clinical study.

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Figure 43.11 Chlorhexidine solution.

Antibacterial spectrum. Antibacterial activity of chlorhexidine in vitro is not outstanding but the spectrum of activity is broad (Fig. 43.11).

- In general, gram-positive bacteria are more susceptible than are gram-negative bacteria.
- *Streptococcus mutans* seems to be particularly sensitive (Emilson 1977) whereas *Streptococcus sanguis*, e.g., exhibits a great variation in susceptibility between and among various strains.
- The variation between and among strains of the same species has been used to argue that changes in the oral flora after prolonged use of chlorhexidine are due to selection of the less sensitive strains and not due to the development of resistance.
- Chlorhexidine shows different effects at different concentration, bacteriostatic at low concentration and bactericidal at higher concentration.

Antibacterial mode of action

1. Bacterial cell wall is characteristically charged negative.
2. The cationic chlorhexidine is rapidly attracted to the cell surface, with specific and strong adsorption to phosphate containing compounds.
3. The integrity of the bacterial cell membrane is altered and chlorhexidine is attracted to the inner cell membrane.
4. Chlorhexidine binds to the phospholipids and thereby increasing the permeability of the membrane leads to leakage of the low molecular weight components such as potassium ions.

Antibacterial activity

1. Chlorhexidine is an antibacterial agent. It is a cationic bisbiguanide with
   a. Broad antibacterial activity
   b. Low mammalian toxicity
   c. A strong affinity for binding to skin and mucous membranes
2. It has a wide spectrum of activity encompassing
   a. Gram-positive bacteria
   b. Gram-negative bacteria
   c. Yeasts
   d. Dermatophytes
   e. Some lipophilic viruses
3. Its antimicrobial activity is of membrane active type, which damages the inner cytoplasm membrane.

Antiplaque effect: Besides its anti bacterial property, chlorhexidine has a strong anti-plaque effect due to its great *substantivity* (Kornman 1986 a,b). Even after a single rinse, persistence at the oral surfaces has shown to suppress salivary counts for over 12 hours (Schiött 1973). This substantivity is the result of specific di-cationic nature of the chlorhexidine molecule, which allows the agent to attach with one cation to different surfaces within the mouth (saliva, teeth, mucosa and the anionic tooth pellicle). These sites act as "reservoirs" from which chlorhexidine can be desorbed. The other end of the chlorhexidine molecule binds to the bacterial cell membrane of the bacteria attempting to colonize the tooth surface.

Side effects

1. Taste disturbances
2. Staining
3. Desquamation and soreness of oral mucosa

Clinical indications for its use

1. As an adjunct to mechanical oral hygiene, particularly in the oral hygiene regime, and phase of periodontal treatment. The various formulations in use are
   a. Mouth rinses are widely used.
   b. Chlorhexidine sprays are found to be useful in handicapped individuals.
   c. Chlorhexidine chewing gum (Ainomo, Smith 1995) could be more beneficial.
   d. Chlorhexidine has been formulated into effective toothpaste products (Yater 1993) as a 1% concentration.
2. Secondary prevention following oral surgical procedures, including periodontal therapy, periodontal surgeries root planning, gingivectomy and after extraction.
3. In patients with intermaxillary fixation, chlorhexi-dine significantly improves oral hygiene and reduces the bacterial load of saliva.
4. Chlorhexidine formulations—mouth rinse and spray have demonstrated to be of value for plaque control among physically and mentally handicapped individuals.
5. In medically compromised patients predisposed to oral infections with particular reference to oral candidiasis, chlorhexidine has been shown to be useful in combination with antifungal agents. Alone, chlorhexidine is slow to improve candida infections and is particularly useful in preventing recurrence. The value of chlorhexidine appears to be greater to when initiated before oral or systemic complications arise.
6. In high-risk patients interestingly chlorhexidine appears to offer synergistic effect to fluoride in caries prevention.
7. Chlorhexidine has been used in management of recurrent aphthous ulceration due to bacterial contamination.
8. In removable and fixed orthodontic appliance wearers, more particularly fixed orthodontic appliances can create two problems, i.e. plaque accumulation and traumatic ulceration. Chlorhexidine has been found to be useful.

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9. In implant dentistry, evidence of improvement in implant success with chlorhexidine rinse in irrigation has been encouraging.
10. In long stay hospital patients, elderly and terminally ill patients, some bacterial changes including reductions in *Streptococcus mutans* has been noted with chlorhexidine rinses.
11. To limit bacteraemia and operatory contamination by oral bacteria.

Anionic agents. Sodium lauryl sulphate is the most frequently used. These agents are inactivated by the anionic agents.

Non-anionic agents. Non-anionic agents are
a. Phenol
b. Thymol
c. Listerine (thymol, eucalyptol, menthol and methyl-salicylate)
d. Triclosan
e. 2-Phenylphenol
f. Hexyl resorcinol

The most frequently used agents in this category are triclosan and listerine, both belong to the category of non-charged phenolic compounds.

Other agents. Other agents are
a. Delmopinol—a surface active agent (substituted amino alcohol)
b. Enzymes

Combination agent. Plaque is a complex aggregation of various bacterial species. Therefore, combining two or more agents with complementary inhibiting modes of action may enhance the efficacy and reduce adverse effects of chemical plaque control.

CONCLUSION

The concept of periodontal diseases as localised entities affecting only the teeth and supporting apparatus appears to be oversimplified and in need of revision. Rather than being confined to the periodontium, periodontal diseases may have widespread systemic effects. It is currently recognised that periodontal diseases are infections that may have both local and systemic consequences. Accordingly, elimination of periodontal infections has to be undertaken through effective mechanical and chemical plaque control measures and appropriate management of systemic diseases. And also it requires proper management of the periodontal patients and understanding the risk factors, and systemic modifiers of the diseases process. Hence, early diagnosis and treatment management are most essential and disease condition should be intervened or intercepted in the very early stage to prevent further damage and also to minimize irreversible damage. Ultimately, the goal of periodontal therapy is retention of teeth in healthy status and comfort. Hence, the periodontal disease has become more and more prevalent in disadvantaged population, especially in developed countries, the only possible solution to such kind of problem is "prevention".

REVIEW QUESTIONS

1. Discuss the factors predisposing to plaque accumulation.
2. Discuss the rationale for prevention of periodontal diseases.
3. Discuss the different types of oral hygiene aids used.
4. Write a note on electric tooth brushes.
5. Write a note on different types of dental floss indications and its uses.
6. Discuss about oral irrigation devices.
7. What are the factors influencing the effects of chemical plaque control?
8. Write note on bisbiguanides.
9. Discuss mechanism of action of chlorhexidine in the prevention of plaque.

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44 Prevention of Malocclusion

Hiremath SS

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INTRODUCTION

Malocclusion of the teeth is not really a disease in the way that dental caries and periodontitis are, it is more a reflection of the natural variation that occurs in any biological system. True prevention of malocclusion is difficult to envisage as there is a strong genetic component in the make-up of most malocclusions. Preventive measures may be effective in dealing with environmental factors, but are unlikely to influence the outcome in cases where the genetic background is one of the more important determining factors.

The interception and early treatment of developing malocclusions have come to be regarded as being almost synonymous with prevention of malocclusion, but interception is, of course, early treatment of malocclusion rather than prevention. True prevention is virtually impossible, but early treatment may prevent full expression of a malocclusion or may result in easier treatment or less treatment. The decision as to whether to prevent a malocclusion early rather than late has to be taken bearing in mind the likely benefit to the subject, balanced against the costs. In this chapter, various situations will be considered in which interceptive or early treatment of a developing malocclusion is likely to prove helpful.

PREVALENCE OF MALOCCLUSION

The malocclusion is commonly noticed among growing children specially those who are having oral habits like mouth breathing, thumb sucking etc. The prevalence of malocclusion among children in some countries has been reported as given below:

Country	% of Malocclusion
Chinese children	67.82%
Nigeria children	84% class I malocclusion 1.7% class II malocclusion
Indian children	19.6%
American children	34% whites 15% black

AETIOLOGY OF MALOCCLUSION

Skeletal Factors

The skeletal pattern (i.e. relationship of maxilla to mandible in anteroposterior, transverse and vertical plane) is one of the most important factors governing the presence or absence of malocclusion of the teeth being intimately related to both incisor over jet and overbite and to the occlusion of the teeth in buccal segments. Two important elements of skeletal pattern are:

- Size of mandible relative to the size of the maxilla
- Position of the mandible relative to the position of maxilla.

Soft Tissues Form and Function

Dental arches and skeletal pattern develop within a soft tissue environment. Growth and development of skeletal elements are greatly influenced by the muscular envelop (i.e. muscular activity in the lips, cheeks and tongue and in the muscles of mastication) around them, which, in turn, has a profound effect on occlusion of the teeth. Modification of developmental pattern of these muscular structures during the growing period of the child using various myofunctional appliances has a significant effect on the growth and development of skeletal patterns, and in turn, on dentoalveolar structures.

Oral Habits

Oral habits in children have concerned dentists for many years. Dentists see in these habits the possibility of

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harmful unbalanced pressures, which may be brought to bear upon the immature, highly malleable alveolar ridges, the potential changes in position of teeth, and occlusion which may become decidedly abnormal if habits are continued for a long period of time.

Habits such as digit sucking (Fig. 44.1), tongue thrusting, mouth breathing have profound effect on development of the jaws and eruption pattern of the teeth resulting in malocclusion.

The permanency of the damage to the oral structure is dependent on three factors: (i) duration, (ii) frequency and (iii) intensity.

$$I = F \times D$$

Where, I = intensity, F = frequency and D = duration. Oral habits are of different types: (i) thumb sucking, (ii) pacifier, (iii) nail biting, (iv) lip sucking, (v) abnormal swallowing or tongue thrusting, (vi) abnormal muscle habits and (vii) mouth breathing.

Thumb sucking: Many children have this habit for short period during infancy or early childhood with the habit considered normal upto 2 years of age. If the intensity of the habit persists or increases and adverse dental and skeletal changes are noted beyond age 4 years, corrective measures may be needed to avoid undesirable occlusion problems. For 4 to 6 year age group psychological ploys and reward systems may help some children to cease digit sucking in this age group. If the habit persists even after 6 years, a palatal crib appliance can be considered.

Appliance Therapy

Palatal crib. This is a type of an orthodontic appliance, which is normally used to prevent thumb sucking and other habits (Fig. 44.2).

Mouth breathing. Mouth breathing can be caused by physiologic or anatomic conditions. It can be transitional

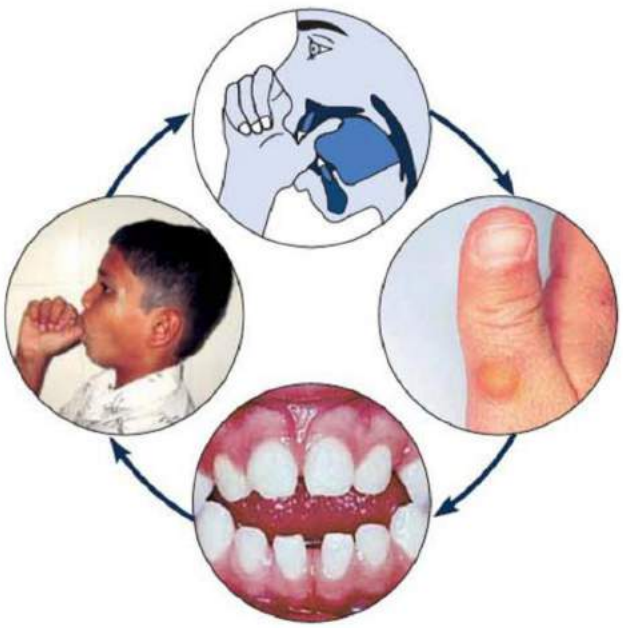


Figure 44.1 Anterior open bite due to thumb sucking.



Figure 44.2 Palatal crib appliance.

when it is exercise induced or due to a nasal obstruction. It is considered as true mouth breathing when the habit continues even after the obstruction is removed.

Signs and symptoms of mouth breathing

1. Adenoid facies
   - Long narrow face
   - Narrow nose and nasal airway (Fig. 44.3)
   - Flaccid lips with short upper lip
   - Upturned nose exposing nares frontally.
2. Skeletal open bite or "long face syndrome" (Fig. 44.4)
   - Excessive eruption of posteriors
   - Constricted maxillary arch



Figure 44.3 Mouth breathing patient.



Figure 44.4 Skeletal open bite patient.

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Figure 44.5 Constricted arches of mouth breather.

- Excessive over jet
- Anterior open bite
- Mandibular downward/forward growth is poor

Constricted arches of mouth breathers occur because of lower tongue position and negative air pressure in the oral cavity (Fig. 44.5).

Appliance Therapy

Oral screen: This is a type of an appliance, which is normally used to prevent mouth breathing among children (Fig. 44.6).

Tongue thrusting *(Figs 44.7A, B)*

It is the protrusion of the tongue against or between the anterior dentition and excessive circumoral activity during deglutition.

It is considered as the universal infant oral behaviour for children under the age of 6 years. It is caused due to the delayed transition between the infantile and adult swallowing pattern.Transition usually begins to happen around the age of 2 years. By the age of 6 years, 50% would have completed the transition. It is estimated that around 10–15% will never fully complete the transition. It is commonly associated with mouth breathing and anterior open bite although it is not a causative factor for anterior open bite. It can cause speech problems leading to lisping. Most of the cases (80%) will self-correct by 12 years of age.

Appliance Therapy

Palatal crib: This is a type of orthodontic appliance, which is normally used to prevent tongue thrusting and other oral habits (Fig. 44.8).



Figure 44.6 Oral screen appliance.



Figure 44.7 Sequence and profile of tongue thrusting habit.

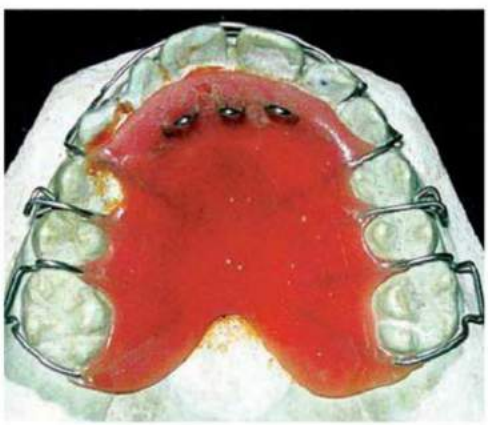


Figure 44.8 Palatal crib appliance in place.

NEED FOR DEFINITE ORTHODONTIC TREATMENT

Protrusion, malocclusion teeth or irregularly placed, which can cause three types of problem for the patient.

1. Discrimination of oral facial appearance
2. Problems of oral function and temperomandibular disorders
3. Greater susceptibility to trauma, periodontal disease or tooth decay

Global Epidemiologic Estimate of Orthodontic Treatment Need

About 35% young adults are perceived either by parents or peers as wanting orthodontic treatment. Whereas orthodontist recommending for definite treatment is about

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20%. Generally, more orthodontic treatment need is observed in urban areas than rural areas.

Strategy for Prevention of Malocclusion

- **Early identification** of local and environmental factors that can induce malocclusion.
- **Coordination with** medical professionals to identify congenital conditions.
- **Diagnose** potential malocclusion in the deciduous dentition at the age of five or six.
- **Correct** malocclusion like cross-bites, distal occlusion, space problems and deep bites in early mixed dentition at the latest, without the need for fixed orthodontic treatment later.
- **Guide** the growth of the jaws with myofunctional/orthopaedic appliances in early or late-mixed dentition.
- **Ensure** the proposed preventive/interceptive treatment should have long-term benefits.

PREVENTIVE MEASURES

Different modalities practiced under the preventive orthodontics are as follows:

Parent Education

For expectant mothers, health education regarding importance of good nutrition, right feeding practices and oral hygiene measures should be given. Sometimes, this type of health education is given through postal or telephonic communication.

Prevention of Habits

Prevention of common oral habits like thumb sucking, mouth breathing can be done through effective health education along with motivation for parents, school teachers and children. And also use of appropriate orthodontic interceptive appliances wherever it is needed.

Maintenance of Quadrant Wise Shedding Time Table

The extraction of retained teeth is often carried out to guide the eruption of permanent successors. Serial extraction can be defined as, the correctly timed, planned removal of certain deciduous and permanent teeth in mixed dentition cases with dentoalveolar disproportion. The indications for serial extractions are: (i) Class 1 anterior crowding, (ii) lingual eruption of the lateral incisors, (iii) crowded arches accompanied with extreme proclination, (iv) lack of developmental spaces and (v) anomalies such as ankylosis, ectopic eruption.

Timely extraction. This is similar to serial extraction wherein sequential removal of deciduous teeth is carried out, but differs in that no permanent teeth are removed (Fig. 44.9).

Space maintenance. In case of early loss of deciduous tooth or teeth, maintaining the space is done to accommodate erupting permanent successor (Figs 44.10A, B).



Figure 44.9 Serial extraction (Kjellgren 1948).

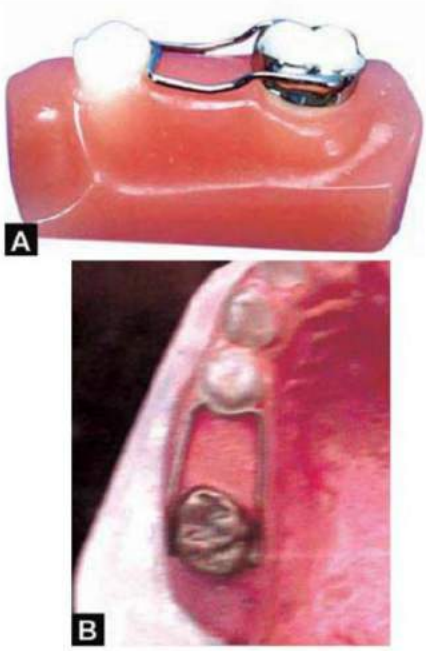


Figure 44.10 Space maintainer appliance.

Regular Dental Check-up

For maintenance of existing appliance and for development of any abnormal oral habits.

Management of Abnormal Frenal Attachments

These conditions have to be attended to prevent the spacing between the upper incisors, i.e. median diastema (Fig. 44.11).

Management of Ankylosed and Supernumerary Teeth

Sometimes ankylosed or supernumerary teeth might interfere with normal eruption of permanent successor. Hence, it is important to take care of such conditions to prevent crowding or malalignment (Fig. 44.12).

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Figure 44.11 Abnormal frenal attachment.



Figure 44.12 Ankylosed and supernumerary tooth.

INTERCEPTIVE MEASURES

Definition: Interceptive orthodontics is that "That phase of the science and art of orthodontics employed to recognise and eliminate potential irregularities and malpositions in the developing dentofacial complex (By American Association of Orthodontics).

Concept of interceptive orthodontics evolves around the minor problems present during developmental conditions which if left untreated may increase in terms of complexity and may be, consequently difficult to treat at a later stage. It may be considered as the secondary level of prevention. The common problems which can be interceptive would be space regaining, crowding, crossbites, midline diastemas and orthopaedic guidance.

Primary Dentition

Relatively little interceptive orthodontics is carried out in primary dentition.

Conditions in which interceptive orthodontics is carried out are:

- Early loss of primary first molar
- Loss of primary second molar before eruption of permanent first molar

Mixed Dentition

Conditions in which interceptive orthodontics is carried out (Fig. 44.13):

- Early loss of primary first molar teeth and if teeth are crowded
- Early loss of primary second molar teeth and if teeth are crowded
- If primary first molar or canine is lost and the teeth are crowded
- Midline shift as a result of tooth loss on one side in a crowded dentition (especially in class I malocclusion)
- Disruption of buccal segment occlusion as a result of tooth loss in one arch (especially in class I malocclusion)
- Insufficient space to accommodate anterior teeth following eruption of permanent lateral incisor in crowded class I malocclusion
- Congenital disorders (e.g. cleft lip and palate)
- Diastema
- Habits (thumb sucking, tongue thrusting etc.).

Methods Used in Interceptive Orthodontics

1. *Balancing extraction* (Fig. 44.14)
2. *Compensating extraction* (Fig. 44.15)
3. Occlusal equilibration
4. Slicing
5. Stripping
6. Space regaining
7. Muscle exercise
8. Habit breaking appliance
9. Removal of soft tissue and bony barriers

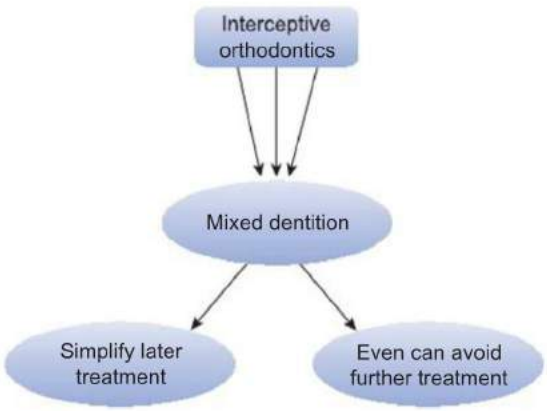


Figure 44.13 Application of interceptive orthodontics in mixed dentition.

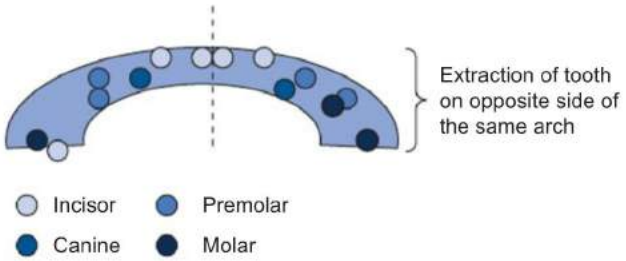


Figure 44.14 Balancing extraction.

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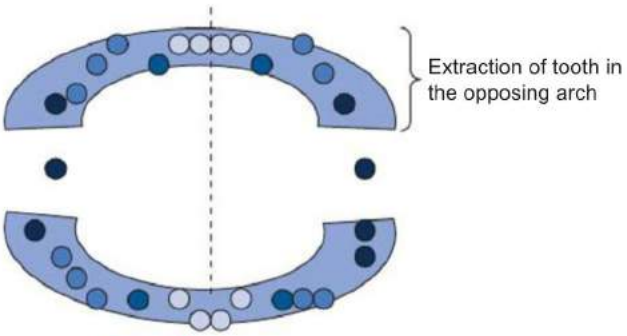


Figure 44.15 Compensating extraction.

SCOPE AND LIMITATIONS OF INTERCEPTIVE ORTHODONTICS

1. It is difficult to prevent malocclusion—most of the effort that is expanded on interceptive orthodontics is directed towards early treatment rather than prevention.
2. Early treatment of developing malocclusion certainly has beneficial effect in terms of minimizing the severity of malocclusion and reducing the treatment time at a later date or in some cases even avoiding it.
3. The distinction between preventive and interceptive orthodontics may not be helpful, rather the aim should be to minimise the total amount of treatment that need to be provided.

CONCLUSION

Preventive approach to be truly effective, needs to be applied at its earliest stage. The key difference between 'prevention' and 'interception' lies primarily in the matter of timing. Many irregularities or deviations from the normal, leading to the development of malocclusion, must be noticed at the earliest stage. Oral habits may be a part of normal development: a symptom with deep-rooted psychological basis. A wide array of oral habits like thumb sucking, lip and nail biting, bruxism, mouth breathing, tongue thrusting etc. are considered as some of the common habits seen in children. These habits may bring about harmful unbalanced pressures to bear upon the immature, highly malleable alveolar ridges, the potential changes in position of teeth and occlusions which may become decidedly abnormal if these habits are continued for a long time. One of the most valuable methods that can be rendered as part of interceptive orthodontic procedures is the elimination of abnormal habits. If the malocclusion is already developed, appropriate treatment with judicious use of appliances has to be taken up at the earliest stage so that the consequences like abnormal facial growth, unacceptable aesthetics and psychological stress can be prevented or minimised.

REVIEW QUESTIONS

1. Discuss the role of adverse oral habits in the aetiology of malocclusion.
2. Discuss the various modalities practised to prevent malocclusion.
3. Write notes on:
   a. Importance of serial extraction
   b. Methods used in interceptive orthodontics
   c. Scope and limitations of interceptive orthodontics

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45 Prevention of Dental Trauma

Hiremath SS

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INTRODUCTION

Dental trauma is regarded as one of the most traumatic experiences one may have to encounter in his childhood days. The repercussions can be many ranging from distorted aesthetics, compromised function (mastication, speech) and, of course, not to forget the pain and trauma it leaves behind on the face of the child.

Teeth can be traumatised due to a number of causes including accidental falls, automobile accidents, blow during fights, contact sports activities etc. Children and more so boys during the growing period are more prone for such injuries. Trauma to the oral structures can range from fractures involving the tooth crown, root, or both, and injury affecting the supporting structures or surrounding tissues. Sometimes it may result even in complete dislodgement of the tooth from its socket. They may also be accompanied by injury to the facial structures.

The traumatic dentoalveolar injuries among the young children are tragic but often an ignored problem. Children with such type of injuries and their concerned parents pose a greatest challenge for the dentist because there is no single dental disturbance that has a greater psychological impact on both the parents and the children.

Traumatic injuries to children's teeth occur quite frequently (Todd and Dodd 1985).

PREVALENCE OF DENTAL TRAUMA

Trauma to the oral region occurs frequently and comprises 5% of all injures for which people seek treatment. In preschool children the figure is as high as 18% of all injuries. Amongst all facial injuries, dental injuries are the most common of which crown fractures and luxations occur most frequently.

The most common cause of injury and type of injuries are as follows:

1. All types of sports – 18–32%
2. Bicycles/Tricycles – 9–15%
3. Falls – 35–55%
4. Road traffic accidents – 6–11%
5. Assault – 10–13%
6. Unspecified – 5–10%

Crown fractures and luxations occur most frequently of all dental injuries.

They involve factures of enamel and dentine with or without dental pulp affecting maxillary central and lateral incisors. The maxillary teeth are involved most commonly.

ETIOLOGY

- Falls in and around the home
- Falls and collisions while playing & running, bicycles being a common accessory
- Sports injuries
- Injuries due to road traffic accidents and assaults.
- Physical abuse or non accidental injury (NAI)

PREDISPOSING FACTORS

- Children who are careless and come from broken homes
- Children with accident-prone facial profiles (Increased over jet with protrusion of the upper incisors and insufficient lip closure.)
- Children with cerebral palsy
- Epileptic patients

Most Vulnerable Periods or Peak Periods

- 1 to 3 years (usually unsteady on their legs and lacking in proper sense of caution)
- 7 to 10 years (most of the injuries because of participation in contact sports, e.g. football, hockey, *kabbadi,* basketball etc.)
- Adolescence

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Figure 45.1 Fractured upper central incisor.

Increased over jet and inadequate lip coverage has been shown to be linked with increased prevalence and severity of dental trauma. Most commonly involved teeth are maxillary central incisors.

Accidents within and around the home are the major sources of injury to the primary dentition while accidents outside home and school are accounted for most of the injuries to the permanent dentition. The most frequent type of injury could be a simple crown fracture of the maxillary central incisors in both primary and permanent dentition (Fig. 45.1), especially if anterior teeth are proclined.

A thorough dental and medical history has to be taken along with intraoral clinical examination for better management of the patients with dental trauma.

HISTORY AND EXAMINATION

Dental history

a. When did the injury occur?
b. Where did the injury occur?
c. How did the injury occur?
d. Lost teeth/fragments?
e. Concussion. Headache, vomiting or amnesia?
f. Previous dental history?

Medical history

i. Congenital heart disease, a history of rheumatic fever or severe immunosuppression?
ii. Bleeding disorders?
iii. Allergies?
iv. Tetanus immunization status?

Intra-oral examination

- Laceration, haemorrhage and swelling of the oral mucosa and gingiva.
- Abnormal mobility of the tooth, displacement of the crowns or cracks in the crowns.
  1) Mobility
  2) Reaction to percussion
  3) Colour of the tooth
  4) Reaction to sensitivity tests

Extra-oral examination

a) Extra oral injuries
b) Examination of maxilla and mandible
c) TMJ

Radiographic examination

- Periapical
- Occlusal
- Orthopantamogram

PREVENTION OF DENTAL TRAUMATIC INJURIES

- High risk sports
  - American football, ice hockey, lacrosse, martial arts, rugby
- High risk individuals
  - Maxillary over jet
  - Inadequate lip coverage
    1. Primary prevention
       Early treatment of large over jet
    2. Secondary prevention
- Provision of mouth guards
  - Prompt intervention following accident
- Protective Agents
  - Helmets
  - Face masks
  - Mouth guards

PRIMARY PROTECTION

Playground Surfaces

The most common cause of dentofacial trauma in children is falling on hard surface (especially true in case of most of primary schools in India). A fall on to an impact absorbing surface means that a fall is cushioned, and the child is less likely to be seriously hurt.

The ability of a surface to absorb an impact is measured by its critical fall height (CFH), which represents the greatest height of a head—first fall from which a child, landing on a surface, could be expected to avoid sustaining a critical head injury.

1. A well-cushioned grass-laden resilient surface will serve the purpose (Fig. 45.2).



Figure 45.2 Safe place for playing.

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2. Indoor games (e.g. badminton, basketball, etc.) should be played on a good non-slippery surface.
3. Supervision of the small children during play is probably the most effective way of preventing the dentofacial trauma in small children.

Early Treatment (Mixed Dentition) of Large Over Jet

The incidence of dental injuries increases significantly with over jet greater than 9 mm. It should be the aim of any caring society to prevent disfigurement from loss of or damage to a permanent incisor and therefore early treatment of a large over jet is often justified.

SECONDARY PREVENTION

Provision of Mouth Protection in Sports

Majority of dental injuries occur in upper front teeth, sometimes involving more than one teeth. Rarely these injuries heal on their own and if not treated especially the injuries occurring during the developmental stages of jaws and dentition can lead to facial disfigurement in later part of the life.

The use of mouth guards has been made mandatory by the controlling bodies of some sports in different countries. Various cross-sectional studies all over the world have shown decrease in the prevalence of dental injuries with introduction of mouth guards. So, advocation of mouth guards by dental profession to all person, especially children and adolescent involved in contact sports, is justified (Fig. 45.3).

Mouth Guard

Design. Mouth guard was designed by Turner in 1977. It is fitted to maxillary arch except in case of class III malocclusion. It should be close fitting and should cover the occlusal surface of the teeth (except in areas of anticipated exfoliation) (Fig. 45.5).

Functions (Stevens, 1981)

1. They hold soft tissues of the lip and cheeks away from the teeth, preventing laceration and bruising of the lips and cheeks against the hard and irregular teeth during impact.
2. They cushion the teeth from direct frontal blows and redistribute forces that would otherwise have caused the fracture or dislocation of anterior teeth.
3. They prevent opposing teeth from coming into violent contact reducing risk of tooth fracture and damage to supporting structure.
4. They provide the mandible with resilient support, which absorbs impact that might fracture the unsupported angle or condyle of the mandible.
5. They heal to prevent neurological injury by holding the jaws apart and act as a shock absorber to prevent upward and backward displacement of the mandibular condyles against the base of skull.
6. They are psychological assets for contact sport athletes (Fig. 45.4).

Mouth Guard Materials

The most commonly used material is polyvinyl acetate-polyethylene copolymer (PVAc-PE).

Type of Mouth Guards (Figs. 45.5 and 45.6)

a. Stock
b. Mouth-formed
c. Custom-made (most satisfactory in terms of accept ability and comfort)

Care of Mouth Guards

1. Mouth guards should be washed with soap and water immediately after use.
2. These should be dried thoroughly and stored in a perforated box.
3. Rinsed in a mouthwash or mild antiseptic (0.2% chlorhexidine) immediately before use again.



Figure 45.3 Contact sports like rugby and hockey.



Figure 45.4 Use of mouth guards in contact sports.



Figure 45.5 Mouth guards: ready-made.

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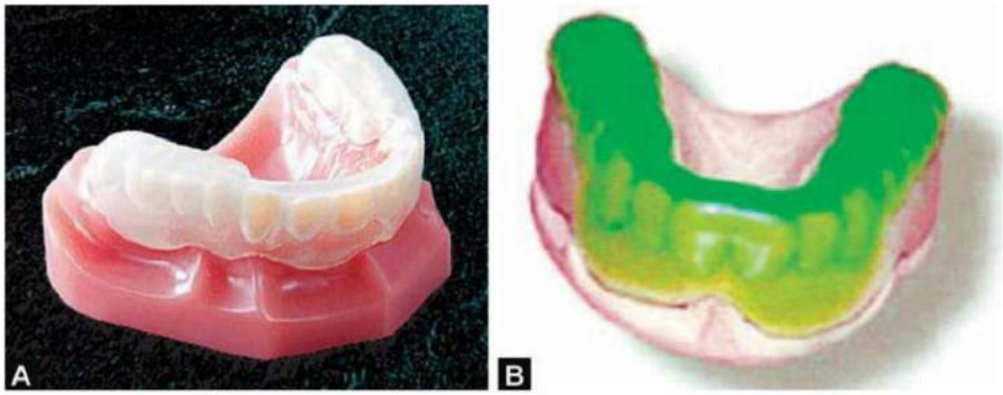


Figure 45.6 Mouth guard made to order for individuals.

Life of mouth guards

A mouth guard constructed for a child in the mixed dentition may need to be renewed once a year. Once the occlusion is established, there is no reason why a polyvinyl acetate-polyethylene mouth guard, if well looked after, should not last for two and three years.

Prompt intervention following accidental damage to the teeth will have secondary preventive effect by reducing complications of trauma. Advent of acid-etch technique, dentine bonding agents and the recognition that non-setting calcium hydroxide (capable of allowing continued root growth and apexification in non-vital immature incisors) has made treatment and prognosis more favourable.

Knocked-out Tooth (Dental Avulsion)

First aid for an avulsed tooth

i. Primary tooth
   - A primary tooth that has been avulsed is usually not reimplanted. The risk of injury to the developing permanent tooth bud is high.

ii. Permanent tooth
   - Do not touch the root of the tooth. Handle the tooth by the crown only.
   - Rinse the tooth off only if there is dirt covering it. Do not scrub or scrape the tooth.
   - Attempt to reimplant the tooth into the socket with gentle pressure and hold it in position.

   If unable to reimplant the tooth, place it in a protective transport solution, such as Hank's solution, milk or saline. This will hydrate and nourish the periodontal ligament cells, which are still attached to the root. A small container of Hank's Balanced Salt Solution (BSS) can be purchased in dental emergency kit from any drug stores.
   - Contact lens solution is not an acceptable storage medium.
   - The tooth should not be wrapped in tissue or cloth.
   - The tooth should never be allowed to dry.
   - Take the child to a dentist or hospital emergency room for evaluation and treatment.
   - Radiographs may need to be taken of the airway, stomach and mouth if the tooth cannot be found.
   - Tetanus prophylaxis should be considered if the dental socket is contaminated with debris.

Other conditions that need due attention by the dentist are

- Tooth displacement (luxation, lateral displacement, extrusion)
- Tooth fracture (infraction, Ellis class I, Ellis class II or III)
- Tooth pushed up (dental intrusion)
- Root fracture (apical, mid-root, cervical)
- Dental bone fracture (alveolar process fracture)

TERTIARY PREVENTION

Advances in dental materials science, especially in the fields of implantology and porcelain technology, has made the treatment procedure for dental injuries much easier and effective. Subsequently, the restoration of the damaged tooth structure will be done along with restoring the lost function and bringing back esthetic component of the patient.

CONCLUSION

Orofacial trauma, though rare in occurrence, can have significant immediate and long-term implications for the children. It may occur at home, school or at work place. Along with physical risk factors, carelessness at home and workplace accounts for a significant number of these hazards, which can be appropriately tackled by primary preventive strategies involving effective health education, for teachers, parents and school authorities. Environmental modification, especially the physical environment at school like staircases, and the playground, use of mouth guards and other personal protective gears at school/workplace should be undertaken. Dental injuries are multifactorial in aetiology and that is what makes it difficult to implement proper preventive measures. Perhaps, a multipronged approach has to be used to manage and prevent these problems.

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REVIEW QUESTIONS

1. What are the functions of mouth guard?
2. Write about first aid for an avulsed tooth.
3. Discuss various levels of prevention of malocclusion.

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46

Occupational Hazards in Dentistry

Pushpanjali K and Shwetha KM

CHAPTER OUTLINE

Introduction 407
Occupational Hazards 407
Musculoskeletal Disorders and Diseases of the PNS 411
Recommendations 412

INTRODUCTION

Occupation is a person's job or principal work or business, exclusively as a means of earning a living. Any occupation as its own advantages and challenges that may affect health of an individual, hence the care for workers in all occupations is considered by Joint ILO/WHO committee. This aims to promote and maintain the highest degree of physical, mental and social well-being of workers in all occupations. It is also necessary to understand the best practices and follow the guidelines given by the professional bodies.

Dentistry has existed since the dawn of time, but only in recent years it has achieved the status of profession. Dental care has been revolutionized due to information explosion and technological advances. As a result of these advances quality care can be provided to the population, but while doing so, dentists and their teams are exposed to a number of hazards peculiar to this profession, leading to various ailments specific to the profession that develop and intensify with years. These hazards can be grouped into

1. Physical
2. Chemical
3. Biological
4. Mechanical
5. Psychosocial

The occupational hazards depending upon the particular type of occupation can have impact on the general health in long run. So, the occupational health and its maintenance to the highest degree of physical, mental and social wellbeing of all personnel working in all occupations is important. Moreover, the occupational health depends on occupational environment. Occupational health represents a dynamic equilibrium or adjustment between the worker or personnel and his occupational environment.

OCCUPATIONAL HAZARDS

Physical Hazards

1. Heat
2. Light
3. Noise
4. Ultraviolet radiation, computers, lasers
5. Sharps

Heat electrical hazards: It causes either due the lack of maintenance to any electrical equipment or lack of understanding of the equipment and its controls.

Effects—painful shocks, burns, etc.

Light. Poor illumination or excessive brightness.

- Poor illumination
  Effects—eye pain, eye strain, headache, eye fatigue
- Excessive brightness
  Effects—discomfort, annoyance, visual fatigue
  Prevention: Sufficient and suitable lighting—natural or artificial is advised.

Noise Source: Use of high-speed turbines, compressor, suction, ultrasonic dental scaler.

Effects

- ***Auditory-H***earing loss (temporary or permanent).
- ***Non-auditory***—fatigue, interference during speech, annoyance.

Noise level depends upon the intensity, frequency, duration of exposure and individual susceptibility.

Ultraviolet radiation, computers, lasers. *Effects*— eyes are affected causing intense conjunctivitis and keratitis.

Radiation: X-rays

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Effects—Somatic (body) or genetic (off springs). The radiation effects are cumulative and this damage is totally painless yet life threatening.

The maximum permissible level of occupational exposure as recommended by International Commission of Radiological Protection is set at 5 rem/year to the whole body

Effects

Acute—erythema and dermatitis.

Chronic—skin cancer and bone marrow suppression. Genetic effects may lead to congenital defects in the employee's offsprings.

Radiation Protection and Prevention

The goal is to minimise the radiation exposure of office personnel and patients during radiographic examination.

Following are the *recommendations for safety* of the practitioner:

- Buying of standard radiographic equipment, which rigidly follows the National Council on Radiation Protection and Measurements (NCRP) and ISI recommendations.
- Well-collimated and filtered beam of at least 1.5 mm of aluminium filtration should be available.
- Use of lead barriers between the dental surgeon and the X-ray machine is mandatory. Lead should be at least 2 mm thick. The lead should extend at least 12 inches below the floor level.
- Special conch shell designs are recommended for the X-ray departments.
- During construction use a special barium plaster, which absorbs the scattered radiation.
- Lead aprons should be routinely used for all patients, and for all children special thyroid shield should be used.
- Use of fast films, i.e. Ekta speed to lower exposure times.
- Dental surgeons must use a film badge service provided by the Bhabha Atomic Research Centre (BARC), Mumbai for personnel monitoring.
- Justification of radiographic examination.

The following are the radiation safety procedures to be followed by all personnel to limit the possibility of occupational exposure:

a. Operator should leave the room or take a position behind a suitable barrier or wall during exposure of the film.
b. Walls must be of sufficient density or thickness.
c. The operator should stand at least 6 feet from the patient at an angle of 90° to 135° to the central ray of the X-ray beam.
d. Films should never be held in place by the operator (use film holding instruments).
e. The radiographic tube should never be stabilised by the operator or patient during the exposure.

To ensure the earlier-mentioned, advise to use film badges. These badges contain a piece of sensitive film or radiosensitive crystal by which the quantity of radiation exposure or dose can be determined. The instrument used to measure radiation dose is known as dosimeter.

Sharps.

Injury due to sharps are mainly from glassware and sharp needles, lancets, B.P Blades, broken ampoules, test tubes are hazardous. Cuts, scratches, abrasions are potential locations for infections.

Prevention

- Handle with care.
- Manage and dispose waste sharps as per the guidelines given by 'biomedical waste management and handling rules, 1998'.

If injuries occur with the sharps, stop the procedure immediately and report to the concerned personnel in the hospital.

Chemical Hazards

Dentists are exposed to various types of chemicals that are hazardous while providing care. They include mercury, beryllium, armlets, silica, latex.

These chemicals act in three ways: (i) local action, (ii) inhalation and (iii) ingestion.

Mercury. Mercury is an element of mystery, which in its metallic form is an enticing silvery liquid that is as fascinating as it is dangerous.

Average daily take of mercury from amalgam restorations is estimated to be 1.2 to 1.3 mg in subjects with seven to eight restorations. The maximum level of exposure considered to be safe is 50 mg/cc of air. Incidents of mercury poisoning among dental personnel have been reported in literature. Mercury is hazardous not only to dental personnel but also to the environment. Excess mercury if released into waste water stream accumulates in the aquatic food chain (Fig. 46.1).

Effects—Mercury poisoning.

Prevention

- Use of precapsulated alloys
- Good ventilation
- Excess and spilled mercury should be collected in fixer containing break resistant bottles

Methylacrylates

Effects—Irritation to skin, eyes or mucous membrane, allergic dermatitis, asthma and paraesthesia in fingers.

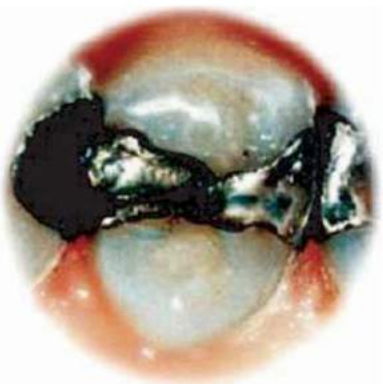


Figure 46.1 Old amalgam restoration.

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Additionally, disturbances of the central nervous system (CNS) such as headache, nausea, fatigue, sleep disturbance, loss of memory etc. may also be noted. When acrylate allergy is suspected, it is suggested to use nitrile or 4H gloves.

Silica. Inhalation of dust containing free silica or silicon dioxide in ceramic laboratories leads to silicosis. The incidence depends upon the chemical composition of the dust, size of the particles, duration of the exposure, and individual susceptibility. The higher the concentration of free silica in the dust, greater is the hazard.

Beryllium. Beryllium is a corrosion-resistant, rigid, and light weight metallic element. Susceptible groups are dental laboratory technicians. Some of the dental alloys contain beryllium and they inhale dust containing beryllium when working on items such as dental crowns, bridges and partial denture framework, and they develop chronic beryllium disease (CBD). As per Occupational Safety and Health Administration (OSHA) specification, employees cannot be exposed to more than 2 micrograms of beryllium per cubic metre of air for an 8-hour time weighted average.

Prevention: Enquire about the contents of the alloys they are using, improved engineering control and work practices.

Variety of chemicals for sterilisation, disinfection and cleaning are routinely used in the health care setups. Some of these can cause explosions or damage pipelines when led into sewage.

Formaldehyde. It is one of the chemical agents routinely used in the clinical set-up mainly for disinfection purpose (Fig. 46.2).

Effects: Acute— Irritation from the liquid and vapors to eyes and respiratory system. There may be severe abdominal pain, nausea, vomiting and possible loss of consciousness could occur.

Chronic—Laryngitis, bronchitis.

Xylene. It is a chemical agent routinely used in the clinical set-up mainly for sterilization purpose.

Effects—Dizziness, headache, mental confusion from inhalation of vapour.

Acute—Eye and mucous membrane irritation from vapour and liquid forms.

Chronic—If xylene contains benzene as an impurity, repeated breathing of the vapour over a long period may cause leukaemia.

Latex glove. Latex gloves dusted with cornstarch powder are most often used. It forms an efficient barrier against most pathogens, and they also constitute a very good barrier against viruses, provided they are intact. Unfortunately, most of the professionals are allergic to this product (Fig. 46.3).

Effects—Urticaria.

Prevention: Identify non-latex gloves, which are suitable for dental work, e.g. vinyl or nitrile gloves.

Biological Hazards

The biological hazards are constituted by infectious agents of human origin and include prions, viruses, bacteria and fungi. The dentist is prone for these infectious agents either directly or indirectly. This may be due to a cut or wound, needle stick injury, aerosols of saliva, gingival fluid and natural organic dust particles. This will enter the body through the following: epidermis of hands, oral epithelium, nasal epithelium, epithelium of upper airways, bronchial tubes, alveoli and conjunctival epithelium (Table 46.1).

Transmissible diseases currently of greatest concern to the dental professional are HIV, HBV, HCV, HSV and Mycobacterium tuberculosis.

Human Immunodeficiency Virus (HIV)

It is estimated that about 40 million people are living with HIV and 4.9 million people have acquired HIV in 2004 (WHO 2005). Healthcare workers are susceptible to HIV infections. The risk of transmission through



Figure 46.2 Formaldehyde solution.



Figure 46.3 Latex gloves.

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Table 46.1 Occupational health problems in dentistry

Risk	Health Problem	Agents	Major Control Strategies
Infection	• Infectious bio aerosols- dental procedures, patients and staff, air-conditioning and the environment	• Bacteria • Viruses • Fungi • Prions	• Proper ventilation system design • Ventilation system maintenance activities • Local Exhaust Ventilation (LEV) • Isolation/segregation of work processes that may create contaminants
	• Infectious body fluid exposures from percutaneous exposure incidents	• Hepatitis B, C and D • HIV	• Proper use of Personnel Protective Equipment (PPE)
	• Respiratory and other communicable illness from patients and staff, e.g. influenza, warts, cold sores	• Influenza, cytomegalovirus, measles, mumps, rubella, wart virus, herpes simplex virus	• LEV
Chemicals	• Toxicity from dental materials, including respiratory hypersensitivity	• Mercury • Cyanoacrylate • Methyl methacrylate	• Substitution of chemical hazards: • Replacing of mercury. • Containing amalgams with less harmful materials. • Use of dental alloys without beryllium. • Replacing glutaraldehyde with accelerated hydrogen peroxide-based disinfectants. • Instead of chlorine- based cleaners Use of hydrogen peroxide-based cleaners. • Adequate general ventilation.
	• Toxicity from sterilization methods	• Alcohol • Aldehydes • Iodine	
	• Toxicity from anaesthetic gases	• Nitrous oxide • Halothane	
	• Toxicity from airborne particulates	• Mineral/fibrous dusts	
	• Contact dermatitis Irritation	• Hand cleaning agents • Solvents • Powder	
	• Allergic or latex dermatitis	• Latex • Acrylics • Mercury • Sterilisating agents • Medicinal agents	• Non-latex gloves: nitrile, neoprene, copolymer, etc. • Gloves, eye protection and face shields while using acrylics • LEV
Physical	• Injury due to Ionising or non-ionising radiation • Noise induced hearing loss • Peripheral neuropathy • Burns and scald from autoclaves	• Due to X-Rays • Blue or Ultraviolet light • Noise • Vibration • Heat	• lead aprons • protective eyewear • Noise reduction can be reduced using new/ renovated facilities. • Padded chart holders and pneumatic tube systems • Sound-masking technology
Ergonomic	• Musculoskeletal disorders (including back, neck and shoulder disorders) • Varicose veins, haemorrhoids	• Poor posture • Prolonged standing	• Correct posture • Ergonomically designed furniture and equipment • Take breaks and sit for a while
	• Carpel tunnel syndrome and other occupational overuse disorders	• Repetitive tasks	• Stretches and micro-breaks
Injury	• Eye injury, conjunctivitis • Cuts on finger/hand • Fall	• Flying debris • Sharp objects like scalpel, needle • Spillage on floor, slippery floor, inappropriate shoes	• Protective eyewear • Cut-resistant gloves • Wear flat shoes with gripping soles
Psychological	• Stress	• Surgery hours • Procedural intricacy • Staff and patient relationships • Financial	• Programs to maintain or build resilience or coping skills • Work-life balance programs are utilized • Appropriate sleep habits • Use of mediation and/or counselling services

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parental and mucosal exposures approximately range from 0.2 to 0.3% and 0.1% or less respectively.

Causative agent: Human Immunodeficiency Virus
Prevention: Proper use of personnel protective equipment. If accidental injury due sharps during or after procedures should be reported and prophylactic treatment till the investigation of the patient is done.
Complications: Candidiasis, Kaposis sarcoma, Acute Necrotizing Ulcerative Gingivitis (ANUG), hairy tongue.

Hepatitis B

Causative agent: Dane particle virus: 0.00001 ml can transmit the disease. 30% of the infected cases complain of vague abdominal discomfort, myalgia, diarrhoea, jaundice, lack of appetite and low-grade fever. 80% of individuals infected with the virus are asymptomatic and unaware that they are infected though both the groups can transmit HBV.
Prevention: HBV vaccine—3 doses to confer immunity: an initial dose followed by a second dose, at 1 month, and then third dose 6 months after the first dose.
Complications: Cirrhosis of liver, hepatocellular carcinoma.

Hepatitis C. Transmission is similar to HBV in the parenteral routes identified and mostly is associated with IV drug use or administration of blood products; less with sexual or vertical transmission. HCV has been found in saliva. The clinical course of the disease is similar to HBV. 50% will have chronic hepatitis; 20% of these chronic carriers will have cirrhosis or even hepato cellular carcinoma. Blood transfusion is thought to be the most efficient route of transmission and 2 to 3% by needle stick injury.

Tuberculosis. The outbreak of tuberculosis over recent years including some multidrug-resistant strains has placed this disease in the forefront. It has not been demonstrated that oral health care procedures generate TB droplet nuclei. Therefore, the risk for transmission of *Mycobacterium tuberculosis* in most dental settings is probably quite low.

Prevention
1. The treatment for suspected case of infectious TB can be deferred till the physician confirms.
2. Patients with TB should be instructed to cover their mouth nose while coughing and sneezing in the dental clinic.
3. If emergency care is required it should be rendered in a facility that can provide TB isolation.

Legionella. Aerosols generated in dental operations are a source of exposure to microorganisms proliferated within dental unit water lines (DUWL).

Effects: Immunological reactions.

Mechanical Hazards

Though not alarming, it can be reduced or avoided by being careful while operating, e.g. traumatic injuries due to projectiles, carelessness while using sharp instruments, airotors etc.

Psychosocial Hazards

Stress situations form an inherent part of a dentist's everyday work. Establishment of good relation with patient forms an important aspect of practice by which patient compliance can be achieved (Fig. 46.4). This interaction along with meeting patient's high expectation and emergency clinical situations, procedures with uncertain prognosis all lead to stress. This leads to development of increased tension, high blood pressure, tiredness, depression, and sleeplessness. Dentists with their busy schedules will be deprived of social interaction, spend less time with family leading to 'burn out syndrome'.

Prevention
- Space out professional work
- Sufficient rest
- Allot time for social interaction and family
- Various courses are currently available to overcome stress—Yoga, meditation, art of living etc.

DISORDERS OF MUSCULOSKELETAL AND DISEASES OF PERIPHERAL NERVOUS SYSTEM (PNS)

During the work, the dentist has to take up some of the strained posture either in standing or sitting close to a patient while providing care, which causes an overstress of the spine and limbs, and the peripheral nervous system (PNS). This results in back pain syndrome, neck discopathy, cervico-acromial pains, and carpal tunnel syndrome.

Low back pain is the most common musculoskeletal complaint among dentists. Severe chronic back pain is reported in more than 25% of dentists with back pain the reason is attributed to prolong sitting position. The alternate shifting between sitting and standing will be beneficial to reduce the strain on muscles.

Carpal tunnel syndrome is a defect of the median nerve and cubital nerve. In its early phase, it is manifested as paraesthesia of the thumb and index finger, which is accompanied by disorders of the thumb and index finger as well as by the atrophy of the thenar.

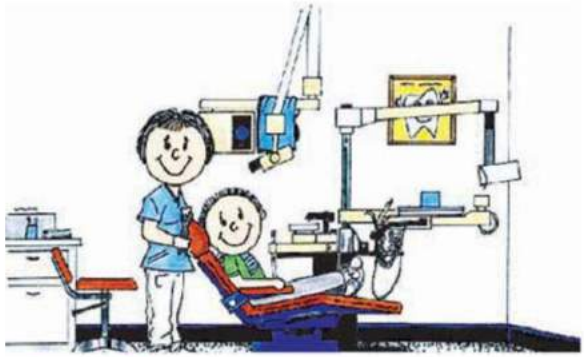


Figure 46.4 Dentists' and patients' friendly clinic.

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RECOMMENDATIONS

- Continuing dental education.
- Universal precautions.
- Understand and follow the science of ergonomics while designing the clinic.
- Alertness while providing care.
- Sufficient and suitable lighting, natural or artificial.
- Good administrative measures to control work practice.
- Engineering control measures.
- Appropriate personal protective equipment.
- Training good housekeeping procedures (Fig. 46.5).



Figure 46.5 Ideal working environment in dental clinic.

CONCLUSION

Risks for health due to occupation are present in every profession. Dentists are one such professional group. Though we are aware of these hazards, we cannot withdraw from providing care and serving community. Once identified and recognized as risk, new guidelines, precautions and protocols should be rapidly instituted to reduce or even eliminate the hazards and provide quality care to patients without any doubt. As dental public health professionals, our mission is to fulfill society's interest in assuring the conditions in which people can be healthy.

REVIEW QUESTIONS

1. Classify occupational hazards in a Dental health care setting. What are the features of mercury poisoning? Discuss strategies for its safe management in dental health care setting.
2. Discuss prevention of biological hazards in a dental clinic.
3. Discuss the transmissible infections and their prevention in dentistry.
4. Explain ergonomics in dentistry.

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47 Infection Control in Dental Care Setting

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INTRODUCTION

Hospitals are multidisciplinary settings to provide health care, but poor sanitation and unhygienic practices can give certain infections to its patients, personnel and visitors. Jhonbell in 1801 remarked that a hospital infection exists in every type of hospital. The nature of dental care is such that it exposes patients and DHCP to a variety of microorganisms of which some are pathogenic. But infection prevention and control in a dental set up never was a priority until the outbreak of human immunodeficiency virus (HIV), Objective of any dental health care is to prevent both cross infection (patient to patient) and occupational exposure (patient to personnel).

Infectious diseases transmission is an evolving subject in dentistry. Also, the continual review of infection control procedures is necessary in understanding the way of transmission of certain diseases such as HIV, HBV and hepatitis C.

Dental health care personnels (DHCP are persons who have special education on dental health care and who are directly related to provision of health care services. DHCP includes all paid and unpaid persons working in dental health-care settings.) include dentists, dental hygienists, dental assistants, dental laboratory technicians (in-office and commercial), students and trainees, contractual personnel and other persons not directly involved in patient care but potentially exposed to infectious agents (e.g. administrative, clerical, housekeeping, maintenance or volunteer personnel.

In a dental setting patients and dental health care personnel (DHCP) are at a verge of exposure to pathogenic microorganisms including HBV, HCV, cytomegalovirus (CMV), HIV, *Mycobacterium tuberculosis*, herpes simplex virus types 1 and 2, staphylococci, streptococci and other viruses and bacteria that colonize or infect the oral cavity and respiratory tract. These organisms can be transmitted in dental settings through:

1. Direct contact with oral fluids like saliva, GCF, blood or other patient materials;
2. Indirect contact with contaminated equipment, instruments or environmental surfaces like dental chair, trolley;
3. Contact of conjunctival, nasal or oral mucosa with droplets containing microorganisms generated during oral prophylaxis or by coughing, sneezing or talking from an infected person and
4. Inhalation of air-borne microorganisms that can remain suspended in the air for long periods.

Infection through any of these routes requires that all of the following conditions be present:

1. A pathogenic organism in adequate numbers and of sufficient virulence to cause disease;
2. A reservoir or source that allows the pathogen to survive and multiply (e.g. blood); mode of transmission from the source to the host;
3. A portal of entry through which the pathogen can enter the host; and
4. A susceptible host with systemic disorder likes diabetes or autoimmune disorder.

Occurrence of these events provides the chain of infection (Fig. 47.1). By interrupting one or more links in the chain, effective infection control strategies can prevent disease transmission. Recommendations are designed to prevent or reduce potential for disease transmission from DHCP to patient, patient to DHCP and patient to patient. The recommended infection control practices can be applied to all dental health-care settings.

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Figure 47.1 Chain of infection.

INFECTION CONTROL PROCEDURES

Appropriate infection control procedures to prevent transmission of pathogens in the dental setting are:

1. Medical history
2. Universal precautions/standard precautions
3. Personnel health elements
   a. Education and training
   b. Immunisation programmes
   c. Exposure prevention and post exposure management
   d. Hand hygiene
   e. Personal protective equipment
   f. Barrier techniques:
      - Masks, protective eyewear, face shields
      - Protective clothing
      - Gloves and gloving
      - Rubber dam
      - High-velocity air evacuation
4. Sterilisation and disinfection of patient-care items
5. Dental unit waterline (DUWL) contamination.
6. Environmental infection control

Medical History

Medical screening provides information about many aspects of a patient; some of these may alert us to pre-medicate or refer the patient for speciality medical or dental care.

Sometimes warning regarding infectious disease status can be obtained from medical screening.

A thorough medical history should be obtained for all patients at the first visit and updated at subsequent visits. The medical history cannot reliably identify all infectious patients without further testing.

The Centres for Disease Control (CDC) and American Dental Association (ADA) recommend that we treat all patients as potentially infectious and routinely use *standard* /universal precautions to protect ourselves from exposure to HIV and other blood-and body fluid-borne pathogens. The goal of infection control for dentistry is to block cross-infection through use of standard/ universal precautions.

Universal Precautions/Standard Precautions

For infection control in dentistry, CDC recommendations focused primarily on the use of universal precautions to reduce that risk of transmission of blood-borne pathogens. According to universal precautions, all blood and body fluids blood should be treated as infectious, because patients with blood borne infections can be asymptomatic or unaware about the infection status.

The relevance of universal precautions to other aspects of disease transmission was recognised, and in 1996, CDC has expanded the concept and changed the term to *standard precautions.*

Standard precautions include universal precautions to protect HCP and patients from pathogens that can be spread by blood or any other body fluid, excretion or secretion: (i) blood; (ii) all body fluids, secretions and excretions (except sweat), regardless of whether they contain blood; (iii) non-intact skin; and (iv) mucous membranes.

Saliva has always been considered a potentially infectious material in dental infection control; thus, no operational difference exists in clinical dental practice between universal precautions and standard precautions.

Elements of standard precautions include: Hand washing, use of personal protective equipment (PPE), aseptic management of patient-care equipment, environmental infection control, injury prevention and management, respiratory hygiene and safe injection practices.

Personnel Health Elements

Education and training. For the prevention of cross-infection and cross-contamination, all DHCP engaged in providing any aspect of the care to patients should receive thorough training and understand the policies adopted in the practice. Training content should be updated periodically. Training of staff should be planned in the way so that they can recognize situations where exposure might be likely and to know how to avoid or minimize risks to patients, staff and others. Training should include:

(a) Proper use of protective clothing and equipment and their removal, handling and decontamination including personal exposure protocol (PEP)
(b) Importance of safe disposal and transport of health care waste and hazardous waste
(c) Significance of environmental and general hygiene within the practice
(d) Significance of latest immunisation of HCW's
(e) Review of work restrictions for the exposure or infection

Under law care has to be provided by the dentist/dental hygienist to those in need. It is unethical to not to provide treatment to a patient diagnosed with HBV or HCV or HIV seropositive.

DHCP who believe that they have been infected with HIV or other blood-borne virus has the ethical responsibility to obtain medical advice, including any necessary testing, and to place themselves under specialist medical care if found to be infected.

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Such DHCP should modify their practice according to medical advice given, by excluding the exposure prone procedures or to cease the practice of dentistry altogether or adhere to work restriction policies of institution/organization.

Exposure prone procedures: They are invasive procedures where there is a risk for a HCW to get injured and may result in exposure of the patient's open tissues to the blood of the HCW. For example, handling of sharp instruments or removal of sharp tissues (e.g. boney spicules or teeth) from a confined anatomical space (e.g. mouth) where the hands or fingertips of the HCW may not be visible at all times.

A dentist infected with hepatitis B or hepatitis C or HIV or Tuberculosis or HSV or influenza etc. should not continue in clinical practice considering ethical principles of dental practice *"To Do No Harm"*.

Since the students get exposed to clinics and patients in their third year of dental education, it is very necessary for them to get immunized against hepatitis in their preclinical years to prevent them from the infection (Table 47.1).

Exposure prevention and post-exposure management

Exposure prevention methods: **Use of personal protective equipment—PPE (e.g. gloves, masks, protective eyewear or face shield and gowns)** comes under standard precautions, which are intended to prevent skin and mucous membrane exposures. Finger guards while suturing is one of the other protective methods, which might reduce injuries during dental procedures.

Work practice controls for needles and other sharps include placing used disposable syringes and needles, scalpel blades, (endodontic instruments like files,

Table 47.1 Healthcare personnel vaccination recommendations

Vaccine	Recommendations
Hepatitis B	If HCP don't have documented evidence of a complete hepatitis B vaccine series, or if HCP don't have an up-to-date blood test that shows you are immune to hepatitis B (i.e., no serologic evidence of immunity or prior vaccination) then you should get • 3-dose series at 0, 1 and 6 months • Route: Intramuscular • Anti-HBs serologic testing 1–2 months after third dose.
Infuenza	• 1 dose of influenza vaccine annually. • Inactivated injectable influenza vaccine intramuscularly or live attenuated influenza vaccine (LAIV) intranasally.
MMR (Measles, Mumps,& Rubella)	For HCP born in 1957 or later without serologic evidence of immunity or prior vaccination, • 2 doses of MMR, 4 weeks apart. • Route: Subcutaneous
Varicella (chickenpox)	For HCP who have no serologic proof of immunity, prior vaccination, or history of varicella disease, give • 2 doses of varicella vaccine, 4 weeks apart. • Route: Subcutaneous
Tetanus, Diptheria, pertussis	• One-time dose of Tdap as soon as feasible to all HCP who have not received Tdap previously. • Td boosters every 10 years thereafter. • Route: Intramuscular
Meningococcal	One dose to microbiologists who are routinely exposed to isolates of N. meningitidis. Route: Intramuscular or subcutaneous

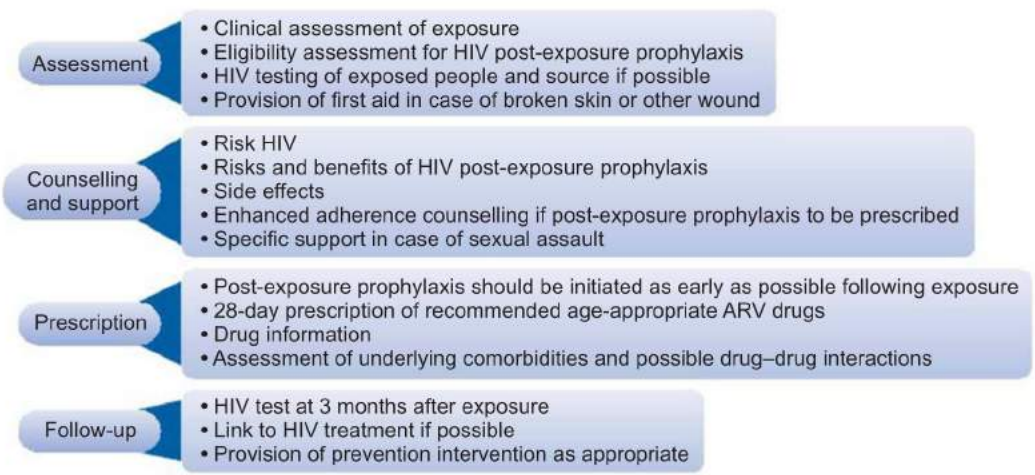


Figure 47.2 Care pathway for people exposed to HIV.

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Table 47.2 Steps to be taken when an exposure incidence occurs

When an exposure incident occurs	
DONT'S:	**DO'S:**
• Do not panic.	• Stop all the procedures and perform first aid.
• Do not put, cut/pricked finger in mouth.	• Wash with soap/water.
• Do not scrub the affected area.	• Encourage bleeding without applying pressure.
• Do not squeeze finger as it will lead to spread of infection due to pressure.	• Report the injury to the Member of Hospital Infection Control Committee (HICC)*.
• No added advantage with antiseptic.	

*Member of HICC has to report to the nodal officer of dental institution to analyze the prevalence of needle stick injury in hospital and to frame future policies.

reamers, spreaders, etc.) and other sharp items in appropriate puncture-resistant containers.

In addition, used needles should never be recapped or otherwise manipulated by using both hands, or any other technique that involves directing the point of a needle towards any part of the body. Instead scoop technique using one hand should be employed for recapping needles between uses and before disposal.

Post exposure management and prophylaxis: According to CDC, Post Exposure Prophylaxis is the use of antiretroviral drugs after a single high-risk event to stop HIV from making copies of itself and spreading through your body. PEP must be started as soon as possible to be effective—and always within 3 days of a possible exposure (Fig. 47.2).

Hand hygiene: By routine hand washing transient flora, which colonize the superficial layers of the skin, can be easily removed. During direct contact with patients or contaminated environmental surfaces, DHCP acquired these organisms.

Hand washing and hand antisepsis for **routine dental examinations and non-surgical procedures** is achieved by using both a plain or antimicrobial soap and water. An alcohol-based hand rub is adequate if the hands are not visibly soiled (Fig. 47.4).

Surgical hand antisepsis is performed to eliminate transient flora and reduce resident flora for the duration of a procedure to prevent introduction of organisms in the operative wound if gloves become punctured or torn (Fig. 47.3).

Agents used for surgical hand antisepsis should have the following properties:

- substantially reduce microorganisms on intact skin
- non-irritating antimicrobial preparation
- broad spectrum activity
- fast acting,
- persistent effect

Fingernails and artificial nails: Majority of flora on the hands are found under and around the fingernails, so nails should be short enough to allow DHCP to thoroughly clean underneath them and prevent glove tears.

Jewellery: Skin underneath rings is more heavily colonized with microorganisms than comparable areas of skin on fingers without rings. Worn rings and decorative finger jewellery can make donning gloves more difficult and cause gloves to tear more readily.



Figure 47.3 Guidelines for needle stick and sharp injury.

Personal protective equipment (PPE): This is designed to protect the skin and mucous membranes of mouth, nose and eyes of DHCP from exposure to blood or other potentially infectious material (OPIM).

Use of hand pieces, ultrasonic scalers and air-water syringes creates a visible spray rich in large-particle droplets of water, microorganisms, saliva, blood and aerosols (i.e. particles of respirable size < 10ljim). This spatter travels a short distance and settles down on the floor, nearby operatory surfaces, DHCP or patient. Aerosols can remain air borne for extended periods and can be inhaled. Appropriate use of dental dams and high-velocity air evacuation minimise dissemination of droplets, spatter and aerosols.

Barrier techniques. ***Masks, protective eyewear, face shields:***

- A surgical mask that covers both the nose and mouth and protective eyewear with solid side shields or a face shield should be used.

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Figure 47.4 Hand hygiene technique with soap and water.

- A surgical mask protects against microorganisms generated by the wearer, with > 95% bacterial filtration efficiency.
- If the mask becomes wet, it should be changed between patients or even during patient treatment, when possible.

Protective clothing: e.g. gowns, laboratory coats, gloves, masks and protective eyewear or face shield should be worn and should be changed when it becomes visibly soiled and as soon as feasible if penetrated by blood or other potentially infectious fluids. Before leaving the work area, all protective clothing should be removed.

Gloves and gloving: DHCP wear gloves to prevent transmission of microorganisms from the hands of DHCP to patients and vice versa during surgical or other patient-care procedures. Gloves should be changed between patients and when torn or punctured.

Wearing gloves does not eliminate the need for hand washing. Hand hygiene should be performed immediately before donning gloves.

Contaminated Instrument Processing

Decontamination and sterilization of all instruments and equipment should be appropriately performed after use.

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Decontamination of equipment or instruments is a multi-step sequential process (Fig. 47.5).

Step 1 Transportation
Step 2 Cleaning and decontamination
Step 3 Preparation and packaging
Step 4 Sterilization (or disinfection of equipment not suitable for sterilization)
Step 5 Storage

All instruments and equipment should be cleaned and sterilised after use. Disinfection eliminates most microorganisms but not necessarily all microbial forms (for example, bacterial endospores and some viruses). All forms of microorganisms, including viruses, bacteria, fungi and spores, are destroyed by sterilisation.

Sterilization and disinfection of patient-care items. Spaulding in 1968 devised a logical approach to disinfection and sterilization of patient-care instruments and equipment based on risk of transmitting infection during use as critical, semicritical or noncritical.

- Critical: Surgical and other instruments used to penetrate soft tissue or bones are classified as critical and should be sterilised after each use. These devices include forceps, scalpels, bone chisels, scalers and burs.
- Semicritical: Instruments such as mirrors and amalgam condensers that do not penetrate soft tissues or bone but contact oral tissues are classified as semi-critical. These devices should be sterilised after each use. If, however, sterilisation is not feasible because the instrument will be damaged by heat, the instrument should receive, at a minimum, high-level disinfection.
- Noncritical: Instruments or medical devices such as external components of X-ray heads that come into contact only with intact skin are classified as non-critical. Because these noncritical surfaces have a relatively low risk of transmitting infection, they may be reprocessed between patients with intermediate-level or low-level disinfection.

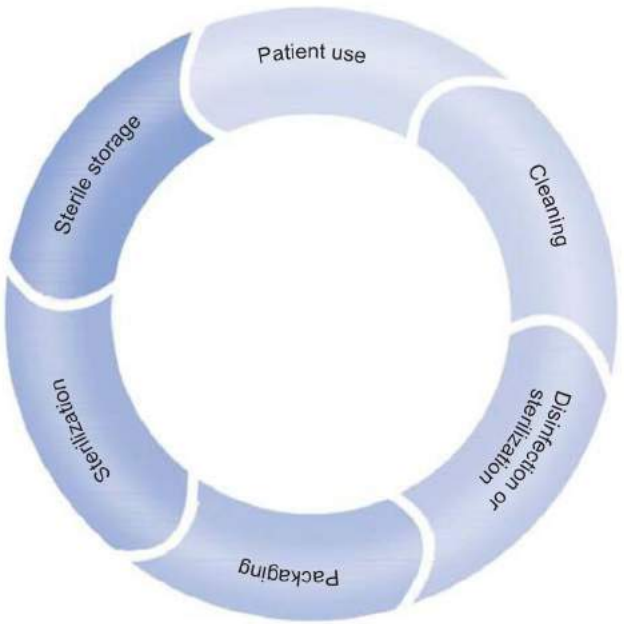


Figure 47.5 Sequence in process of the decontaminations of instruments.

In 1991, noncritical category was expanded to include environmental surfaces to define more clearly the relative risk of disease transmission, which was further divided into clinical contact surfaces and house-keeping surfaces.

Three levels of disinfection—high, intermediate and low—are used for patient-care devices that do not require sterility and two levels, intermediate and low, for environmental surfaces. The intended use of the patient-care item should determine the recommended level of disinfection.

Transportation

- Minimal handling of instruments/ equipment after use to avoid spread of infection
- Carry instruments in a covered container
- One way flow to avoid them in coming contact with sterilized instruments

Receiving, cleaning, and decontamination. Reusable instruments, supplies and equipment should be received, sorted, cleaned and decontaminated in one section of the processing area.

Before disinfection and sterilisation processes, cleaning should be done to remove debris as well as organic and inorganic contamination, either by scrubbing with a surfactant, detergent and water, or by an automated process (e.g. ultrasonic cleaner or washer-disinfector) using chemical agents. If visible debris, whether inorganic or organic matter, is not removed, it will interfere with microbial inactivation and can compromise the disinfection or sterilisation process. Instruments should be rinsed with water after cleaning to remove chemical or detergent residue.

Concerns in selecting cleaning methods include:

(i) efficacy of the method, process and equipment
(ii) compatibility with items to be cleaned
(iii) occupational health and exposure risks

Preparation and packing

- After cleaning all the instruments should be dried
- Check for debris, function and damage
- Packing of instruments for sterilisation

Sterilisation

Sterilisation procedures: Heat-tolerant dental instruments are usually sterilised by: (i) steam under pressure (autoclaving), (ii) unsaturated chemical vapour and (iii) dry heat (Table 47.3).

The sterilisation time, temperature and other operating parameters as well as instructions for correct use of containers, wraps and chemical or biological indicators, as recommended by the manufacturer of the equipment used should always be followed.

Instrument packs should be allowed to dry inside the steriliser chamber before removing and handling. The

Table 47.3 Different sterilization procedure

Option	Temperature (°C)	Minimum Hold time (minutes)
A	134-138	3
B	126-129	10
C	121-124	15

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ability of equipment to attain physical parameters required to achieve sterilisation should be monitored by mechanical, chemical and biological indicators.

Steam sterilisation: is most widely used for wrapped and unwrapped critical and semicritical items that are not sensitive to heat and moisture. Steam contact at a required temperature and pressure for a specified time needed for each item in steam sterilisation to direct to kill microorganisms. Two basic types of steam sterilisers are: (i) the gravity displacement and (ii) the high-speed prevacuum steriliser.

- Prevacuum sterilisers: These are fitted with a pump to create a vacuum in the chamber before the chamber is pressurized with steam. This procedure allows faster and more positive steam penetration throughout the entire load compared to gravity displacement.
- *Dry heat sterilisation:* Materials that might be damaged by moist heat (e.g. burs and certain orthodontic instruments) are sterilized by Dry heat.

Advantages:

- Low operating cost
- Non-corrosive,

Disadvantage:

- Prolonged process
- High temperatures required not suitable for certain patient-care items and devices.

Oral health care providers must exercise universal precautions for preventing contamination with infective agents when performing dental treatment procedures. It is the responsibility of the oral health care provider to protect the patients, him/her and auxiliary personnel from possible cross infection during provision of dental services. **The difficulties encountered by oral health care providers, including volunteers, that travel to remote areas where in most cases there are limited facilities for the proper provision of oral health services are acknowledged**; however, there is no excuse for not exercising universal precautions even in remote areas. **The availability of utensils such as pressure pots, cookers or caners is a viable alternative that can be used for sterilizing clinical instruments in absence of an autoclave**. Instruments placed in bags or packs can be successfully sterilized achieving 103 kPa (15 psi) at 121,Å∞C, provided that instruments are placed above the water surface so that saturated steam reaches all instrument surfaces; this is an important requirement since if instruments are submerged in water, boiling temperature is not enough to destroy all forms of microbial life including spores. A modification of the pressure regulating weight by adding a 30 grams weight so that the total weight is increased to 120 + 1 grams permits increasing pressure to 138 kPa (20 psi) and 127°C reducing the time required and ensuring sterilization. Bacillus Stearothermophilus contained in a "Spor-Ampule" can be used as biological indicator.

Sterilisation of unwrapped instruments: Sometimes called flash sterilisation is a method for sterilizing unwrapped instruments for immediate use. The unwrapped cycle is preprogrammed to a specific time and temperature setting by the manufacturer and can include a drying phase at the end to produce a dry instrument with much of the heat dissipated.

Other sterilisation methods. Heat-sensitive critical and semi-critical instruments can be sterilised by immersing them in liquid chemical germicides registered as sterilants. After using liquid chemical germicide for sterilisation, items need to be: (i) rinsed with sterile water to remove toxic or irritating residues; (ii) delivered to the point of use in an aseptic manner and (iii) handled using sterile gloves and dried with sterile towels.

Low-temperature sterilisation with ethylene oxide gas (ETO) has been used to sterilise heat- and moisture-sensitive instruments in larger health care facilities. Stringent health and safety guidelines required because of extended sterilisation times of 10–48 hours and potential hazards to patients and DHCP. Hand pieces cannot be effectively sterilised with this method because of decreased penetration of ETO gas flow through a small lumen.

Sterilisation monitoring. Combination of *mechanical, chemical and biological* parameters required for monitoring of sterilisation procedures. These parameters evaluate both the procedure's effectiveness and the sterilizing conditions.

Mechanical techniques include assessing temperature, cycle time and pressure by observing the gauges or displays on the steriliser and noting these parameters for each load. Correct readings do not ensure sterilisation, but incorrect readings can be the first indication of a problem with the sterilisation cycle.

Chemical indicators, internal and external, use sensitive chemicals to assess physical conditions (e.g. time and temperature) during the sterilisation process. Although chemical indicators do not prove sterilisation has been achieved, they allow detection of certain equipment malfunctions, and they can help identify procedural errors.

Biological indicators (BIs) (i.e. spore tests) are the most accepted method for monitoring the sterilisation process because they assess it directly by killing known highly resistant microorganisms (e.g. *Geobacillus* or *Bacillus* species) rather than merely testing the physical and chemical conditions necessary for sterilisation. Manufacturer's directions should determine the placement and location of biological indicator in the steriliser.

Storage of sterile instruments and equipment

- All sterilised instruments should be stored in dry, covered conditions in an enclosed room with minimum workflow so as to minimise re-contamination.
- Ensure wrapping has not be damaged or torn and prevent packs from falling.
- Sterilised instruments should also be dated, before which it can be used.

Dental Unit Waterline (DUWL) Contamination

Microbiological quality of water used in dental care delivery may not be acceptable for dental treatment. Documented levels of microbial contamination is as high as 10,000 to 10,000,000 (colony-forming units) CFUs/ml. The major problem is the formation of microbial bio-film along the walls of the long, narrow-bore tubing that provides cooling and irrigating water to dental hand instruments.

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Environmental Infection Control

Biofilm is defined as an organised mass of microorganisms attached to a surface exposed to moisture.

Both water-borne and human oral microbes have been found in dental unit water, indicating that both incoming community water and patient's mouths are sources of these microbes.

Hospitals and medical-dental buildings have detrimentally long water lines. Most of the microbes detected are of very low pathogenicity or are opportunistic pathogens that cause harmful infections only under special conditions or in immunocompromised people eg in diabetic patients.

The CDC has recommended that:

- High-speed hand pieces should be flushed for a minimum of 20 to 30 seconds to discharge water and air after use on each patient;
- Use of an enclosed container or high-velocity evacuation should be considered to minimise the spread of spray, splatter and aerosols generated during discharge procedures;
- There is evidence that overnight or weekend microbial accumulation in water lines can be reduced substantially by removing the hand piece and allowing water lines to run and discharge water for several minutes at the beginning of each clinic day;
- Sterile saline or sterile water should be used as a coolant/irrigator when surgical procedures involving the cutting of bone are performed.

Hard surfaces disinfection: All hard surfaces including dental chair shall be cleaned and disinfected with a disinfectant like torcilol or physical barriers should be used like aluminium foil and plastic wrap as per the resource availability.

Special considerations. *Dental hand pieces and other devices attached to air and water lines:* Because retraction valves in dental unit water lines may cause aspiration of patient material back into the hand piece and water lines, antiretraction valves (one-way flow check valves) should be installed to prevent fluid aspiration and to reduce the risk of transfer of potentially infective material. Routine maintenance of antiretraction valves is necessary to ensure effectiveness; the dental unit manufacturer should be consulted to establish an appropriate maintenance routine.

Handling of Biopsy Specimens

Each biopsy specimen should be carried in a sturdy container with a secure lid to prevent any leakage. Outside contamination should be avoided while collecting specimens. If outside of the container is visibly contaminated, it should be cleaned and disinfected or placed in an impervious bag.

Use of Extracted Teeth in Dental Educational Settings

Universal precautions should be adhered to whenever extracted teeth are handled.

In addition, hepatitis B vaccine should be given to all persons who handle extracted teeth in dental educational settings. Extracted teeth first should be cleaned of adherent patient material by scrubbing with detergent and water, following which it should be stored in a fresh solution of sodium hypochlorite.

Preprocedural mouth rinses. Number of microorganisms introduced in the patient's blood stream during invasive dental procedures can be reduced by preprocedural rinsing with an antimicrobial product (e.g. chlorhexidine gluconate, essential oils, or povidone-iodine). It can also reduce the level of oral microorganisms in aerosols and spatter generated during routine dental procedures with dental hand pieces or ultrasonic scalers.

Dental Radiology: The potential for cross contamination exists during the exposure and processing of dental radiographs. Standard precautions and measures must be taken to reduce or eliminate the cross contamination. Just as with other procedures same infection control measures to protect both patients and staff are necessary. Few tips are to use plastic barriers to protect films during exposure, touch as few surfaces as possible to minimize contamination of environmental surfaces. In case of digital radiography since intraoral digital sensors come in contact with mucous membranes, therefore it should be heat sterilized or use of high level disinfected between patients as per the manufacturer's instructions.

DISINFECTION AND DENTAL LABORATORY

Laboratory materials and other items (e.g. impressions, bite registrations, fixed and removable prostheses, orthodontic appliances) that have been used in the mouth should be cleaned and disinfected before being manipulated in the laboratory and also after being manipulated in the dental laboratory and before placement in the patient's mouth.

A chemical germicide having at least an intermediate level of activity (i.e. "tuberculocidal hospital disinfectant") is appropriate for such disinfection.

HEALTH CARE WASTE MANAGEMENT

Hospital waste is a potential reservoir of pathogenic micro-organisms and requires appropriate, safe and reliable handling. Hospital waste is considered as biomedical waste as it is generated during the diagnosis, treatment or immunization of human beings or in research activities. Bio-Medical Waste (Management and Handling) Rule 1998 prescribed by the Ministry of Environment and Forests, Government of India, came into force on 28th July 1998 (Fig. 47.8). This rule applies to those who generate collect, receive, store, dispose, treat or handle bio medical waste in any manner.

It shall be the duty of every occupier of an institution generating bio-medical waste, which includes a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank by whatever name called to take all steps to ensure that such waste is handled without any adverse effect to human health and the environment.

The Segregation, Packaging, Transportation and Storage shall be done as under:

1. Bio-medical waste shall not be mixed with other wastes.
2. Bio-medical waste shall be segregated into containers/bags at the points of generation prior to its storage transportation, treatment and disposal. The containers shall be labeled (Table 47.4).

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Table 47.4 Categories of biomedical waste management (According to Schedule I)

Waste Category No.	Waste Category [Type]	Treatment and Disposal [Option+]
Category No. 1	**Human Anatomical Waste** (tissue biopsy, extracted teeth)	incineration@@
Category No. 2	**Animal Waste** Not Applicable	incineration@@
Category No. 3	**Microbiology and biotechnology waste** (wastes from laboratory cultures, human cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)	local autoclaving/ microwaving/ incarnation@
Category No. 4	**Waste sharps** (needles, root canal instruments, glass, orthodontics wires and brackets, syringes, scalpels, blades, etc. that may cause puncture and cuts. This includes both used and unused sharps)	Disinfection at source by chemical treatment@ or autoclaving/microwaving followed by mutilation/Shredding##
Category No. 5	**Discarded medicines and cytotoxic drugs** (wastes comprising of outdated, contaminated dental material like GIC, ZnOE, sealants, composites, local anesthesia, hemostat etc.and discarded medicines)	incineration@@/disposal in secured landfills
Category No. 6	**Soiled waste** (Items contaminated with blood and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)	incineration@@ autoclaving/ microwaving
Category No. 7	**Solid waste** (Wastes generated from disposable items other than the waste sharps such as hand gloves, syringes, suction, LA bottles, saline bottles, glass, intravenous sets etc.)	Disinfection by chemical treatment@ autoclaving/ microwaving followed by multilation/shredding##
Category No. 8	**Liquid waste** (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities)	disinfection by chemical treatment@ and discharge
Category No. 9	**Incineration ash** Not Applicable	disposal in municipal landfill
Category No. 10	**Chemical waste** (Chemicals used in production of biologicals, chemicals used indisinfection, as insecticides, developer etc.)	Chemical treatment@ and discharge into drains for liquids and secured landfill for solids

@Chemicals treatment using at least 1% hypochlorite solution or any other equivalent chemical reagent. It must be ensured that chemical treatment ensures disinfection.
##Multilation/shredding must be such so as to prevent unauthorized reuse.
@@There will be no chemical pretreatment before incineration. Chlorinated plastics shall not be incinerated.

LEAD MANAGEMENT

Lead foil is used in intraoral films to protect the film from backscatter and secondary irradiation.

In absence of leachate collection system, the lead contained in the foil can leach from the landfills. Microorganisms break down organic material during the anaerobic acid subphase of the degradation process and produce organic acids such as acetic acid, which results in a drop in pH. This acidic pH can cause significant dissolution of lead from the radiographic foil in only 17 hours. Thus lead enters the ecosystem. It has been found out that there is no safe level of exposure to lead and it is toxic even at low exposures. Lead film in intraoral pack should be collected and recycled through licensed facility.

MERCURY SPILL MANAGEMENT (Table 47.5 and Fig. 47.6)

Community programs

- Regular protocol to be followed for infection control and waste management.
- Studies have showed as an alternative pressure cooker can be used at camps (when they are in remote areas where there is no electrical supply) for sterilization of equipment as explained earlier with prior validation for appropriate temperature and pressure using biological indicators.

DENTAL HEALTH CARE WASTE MANAGEMENT

The mercury spill management along with different types of biomedical waste have been described as follows (Figures 46.6 and 46.7).

*Waste from dental health care setting, which needs special attention are Lead, Mercury and Fixer. All these not be incinerated but to be stored in air tight containers and a licensed buyer to be identified.
**Dental institutions generate huge quantities of plaster of Paris (POP) as waste during undergraduate training and patient care (categorized as soiled and solid waste) POP if comes in contact with water, will release H_2S, so, guidelines for its treatment and disposal are to be framed.

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Table 47.5 Steps in management for spillage of mercury

In case of accidental spillage of mercury following are the task to be followed:	
Do's	**Don't's**
• Access to "mercury spill kit"- containing nitrile gloves, N-95 face mask, two pieces of cardboards, two plastic containers, cello tape and flashlight • Remove all jewelry, wear gloves, masks • Wear appropriate personal protective equipment • Use flashlight to locate and cardboards to bring mercury beads together • Eyedropper of a syringe should be used to collect and carefully place it or "contain" in a bottle containing water • Sticky tape should be used to pick any remaining beads of mercury and placed in the plastic bag, properly labeled • The bottle should be sealed with a tape, labeled as hazardous waste and securely stored inside another plastic container; awaiting final disposal to Govt. nominated or authorized mercury dealers • Reporting formats will be used to report and register any mercury spills/leakages	• Do not touch mercury. • Do not switch on the fan • Do not broom

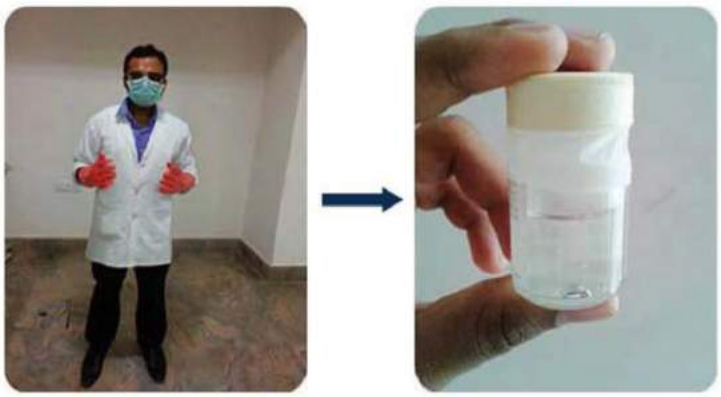


Figure 47.6 Mercury spill management.



Figure 47.7 Different types of biomedical waste.

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Biohazard symbol Cytotoxic harzard symbol

Figure 47.8 Schedule III: Biomedical waste containers.

CONCLUSION

Dental patients and dental health care personnel can be exposed and are being exposed to pathogenic microorganisms that colonize or infect the oral cavity and respiratory tract. These organisms can be transmitted in dental settings if proper and effective infection control measures are not taken. The recommended infection control practices are applicable in all settings in which dental treatment is provided. The goal of infection control for dentistry is to break the chain of infection through the use of standard or universal precautions.

With the earlier procedures described in detail about infection control, it is clear that the proper procedures be updated and followed both in the clinical set-up and the field work. Hence, the latest information should be obtained about the post exposure procedures and updated especially about the recent and most hazardous infectious diseases for both the health professionals and for the patients, thereby creating a healthy and infection-free environment in any dental health care set-up.

REVIEW QUESTIONS

1. Enumerate the various infection control procedures in dental care settings/dental clinic.
2. Write notes on:
   a. universal precautions
   b. biofilm
   c. sterilization monitoring procedures
   d. barrier techniques
   e. autoclave
   f. disinfection

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48 Evidence-Based Dentistry

Hiremath SS and Ramya R Iyer

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INTRODUCTION

Over the past few decades dental health care has transformed into a complex and refined science owing to advances in techniques and materials that have enhanced the scientific knowledge to this domain. Each new discovery and invention requires to be tested for scientific validity. Thus the branch of evidence based dentistry has evolved to ascertain the scientific soundness of the newer advances and provide concrete proof for incorporating those into dental practice.

Oral disease is widespread affecting all age groups and most people would require preventive or therapeutic oral health care at some point of time. With increased life span of people there is a greater possibility that more people will retain all or most of their teeth for longer duration than ever before. Furthermore, pattern of oral disease changes with changing lifestyle and dietary habits, which requires constant advances in treatments. The dentist has an obligation to provide most cost-effective treatment in the light of best available method of prevention, diagnosis and treatment procedure suitable for tailored patient according to present evidence.

Today, the clinical or community decision-making is patient-centered. Dentistry has advanced manifold in technologies, techniques, materials, concepts and strategies. While there is a plethora of treatment options available today, the challenge of choosing the best option for the particular patient has become tougher than ever before. There is a sea of information and an ocean of contradictions in literature. What that was learned in the past many a time may have to be unlearned. However, one cannot discard the successful science of the past owing to the claims and promotions of researchers and industries. Also, the overwhelming volume of new knowledge cannot be accepted by face-value and should be subject to analysis. At the end, there still lingers this dilemma of, "Does this work? Is it as good as the standard regimen? Will it suit my patients? Can my patients afford it?"

Evidence-based dentistry is a philosophy that optimizes dental health care provision through participatory and practical decision-making involving patient as a partner in treatment planning, taking into consideration the best scientific evidence available.

American Dental Association defines Evidence-Based Dentistry as "an approach to oral health care that requires the judicious integration of systematic assessments of clinically relevant scientific evidence, relating to the patient's oral and medical condition and history, with the dentist's clinical expertise and the patient's treatment needs and preferences (Fig. 48.1)."

STEPS IN EVIDENCE-BASED DENTISTRY

Evidence-based dentistry is a sequential, systematic process of addressing a clinical or community relevant



Figure 48.1 Components of evidence-based medicine/dentistry.

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Figure 48.2 Steps in evidence-based dentistry.

problem. The steps in evidence-based dentistry are depicted in the flowchart (Fig. 48-2).

STEP1: Identification of a Clinical Problem

It is important to frame a focused question to retrieve the best evidence in order to arrive at a clinical decision. A well-built question in the PICO format has the following components:

P-*Patient/Population/Problem (among _____)*
I-*Intervention/Exposure (does _____)*
C-*Comparison (versus _____)*
O-*Outcome (affect _____)*

To retrieve the answers to these questions, we need to understand two "Ts"- Type of questions and Type of research designs. Hence, PICO format is also called PICOTT format.

The most common types of questions are:

Therapy/Prevention Question: (Seeks evidence related to effectiveness of treatment or prevention), e.g. Is ischlorhexidine varnish more effective than sodium fluoride varnish in preventing root caries?

Diagnostic Question: (Seeks evidence related to diagnostic abilities of an assessment method or device)

E.g. Is the diagnostic validity of DIAGNODENT greater than that of bitewing radiographs in proximal caries detection in primary teeth?

Prognostic question: (Seeks evidence to estimate likely clinical course over time of the disease)

E.g Will chronic smokers experience delayed osteointegration after implant placement?

Etiology/Harm question: (Seeks evidence to ascertain causes/ risk factors of disease),

E.g. Are asthmatic patients at increased risk of dental caries?

For any type of question, systematic review is considered to be better than an individual study. A hierarchy of research designs based on the inherent quality of research design constitutes what is known as the "Evidence Pyramid".

Difference between hierarchy of evidence and level of evidence. There is a different between the hierarchy of evidence and level of evidence. Although the hierarchy of research designs in Figure 48-3 indicates increased quality of evidence up the pyramid, level of evidence depends not only on the inherent strength of the study design. Level of evidence also depends on study quality, consistency and directiveness. Hence the level of evidence refers to the quality of evidence from an individual study.

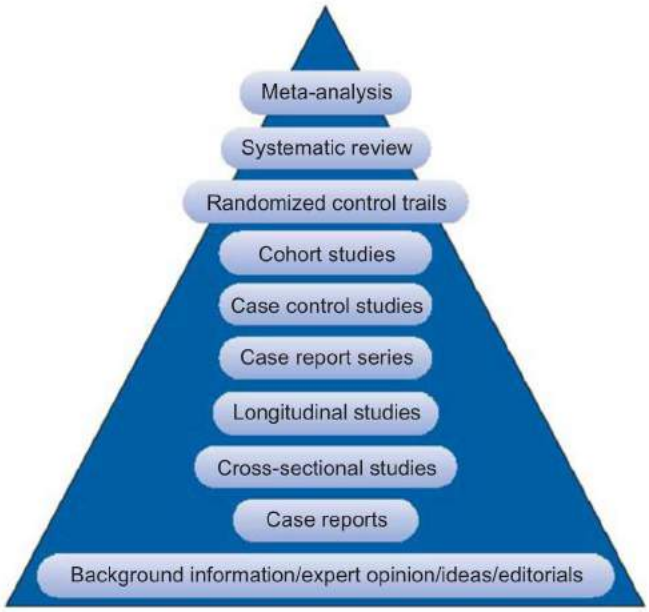


Figure 48.3 Evidence pyramid.

Step 2: Search for Evidence

What do we search for?
We search for the best evidence based on the type of question and research design as. Evidence can be classified as Primary Evidence or Secondary Evidence.

Primary Evidence: All original articles (research studies) retrieved through database search (MEDLINE, EMBASE etc.) are referred to as Primary Evidence Sources.

Secondary Evidence: Secondary Evidence sources are also known as "studies of studies" i. e if the authors have done what is known as *"synthesis"*, it is called secondary evidence source. In a synthesis, evidence extracted from different sources is juxtaposed to identify patterns & direction in the findings, or included to produce an overarching, new explanation/theory which attempts to account for the range of findings. A systematic method of synthesis, that identifies and reviews published materials, selects the permissible evidence, summarizes the relevant research, evaluates the quality of individual studies to give a conclusive answer, is called *systematic review.* If statistical pooling of results of the combined studies is done, it is referred to as *meta-analysis.*

Where do we search for evidence?

Search Engines: A software program that searches for information in the worldwide web is called a search engine. Google and Google scholar are the two most widely used search engines. The disadvantage of search engines is that the sources of retrieved information are rated based on popularity rather than quality or authenticity assessment.

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Meta-search engines: Meta-search engines are similar to search engines. However, while the search engines search the websites, the meta-search engines search the search engines and databases. Examples of some meta-search engines are SUM search and BIOME.

Databases: Electronic bibliographic database is an exhaustive resource of quality research, constantly updated on all aspects of a scientific field.

Important general medical databases are:

a) The Cochrane Library of Systematic Reviews
   It is a database of systematic reviews, which have been reviewed for high standard and quality by Cochrane approved reviewers.
b) MEDLINE
   MEDLINE indexes over 5000 journals based on quality review by US. National Library of Medicine.
c) PubMed
   PubMed is a freely available database, which contains all the journals indexed by MEDLINE. It was developed by the US National Library of Medicine and National Center for Biotechnology Information.
d) EMBASE
   EMBASE is of importance because of its broad scope and in-depth update on drugs and pharmacology. It was produced by Elsevier. Apart from including journal articles, it also includes conference abstracts (since 2009).

How to search for evidence?

Evidence search starts with entering search terms or key words in the search box. True keyword searching allows an individual to select their own words or phrases. A thesaurus search, on the other hand, uses a consistent list of vocabulary choices for standardization and searching efficiency. MeSH or the Medical Subject Headings system used with the Medline (PubMed) database an example of a thesaurus search.

Booleans viz AND, OR, NOT may be used depend on whether we want a broad or narrow search. **'AND'** is used to join words both (or all) of the search terms are to be included in results. **'OR'** is used to find the similar words. **'NOT'** is used to exclude a word or phrase from search results.

STEP 3: Making Sense of Evidence

Once the evidence is retrieved, it should be appraised. In the process of appraisal, we update new evidence and discard poor evidence. The most important components of making sense of evidence are:

a) Study quality (methodological quality including statistics)
b) Bias (systematic error)
c) Internal validity (validity)
d) External validity (generalizability, applicability)

To facilitate the systematic assessment of the aforementioned components, it is recommended to use critical appraisal check-lists or toolkits.

Step 4: Act On Evidence

Acting on evidence depends on the **quality of evidence** and **strength of recommendation.** However, strength of recommendation refers to the overall quality of evidence for the given problem/ clinical condition, which is the extent to which one can be confident that adherence to the evidence will do more good than harm.

Clinicians practicing evidence-based dentistry are at an advantage of having:

- better critical thinking capabilities
- equipped with lifelong learning skills
- knowledge regarding how to access and critically appraise the literature

However, it is important to remember that some evidence is more likely to be valid than the other. The practice of EBD demands that evidence upon which the treatment decisions are based have the lowest possible risk of bias.

EVIDENCE-BASED PUBLIC HEALTH

Evidence-based public health is an offshoot of evidence-based medicine. Evidence-based public health approach refers to the amalgamation of the best research evidence with public health expertise and society's values.

Evidence-based public health (EBPH) (Kohatsu et al., 2004) is defined as "the process of integrating science-based interventions with community preferences to improve the health of populations."

Ciliska D et al (2008) proposed a model of components of evidence-based public health.

Hence, evidence-based public health decision-making will include essentially all the steps in evidence-based dentistry with emphasis on the public health resources, the dynamics of the communities and diversities of the societies on whom the interventions will apply (Fig. 48.4).

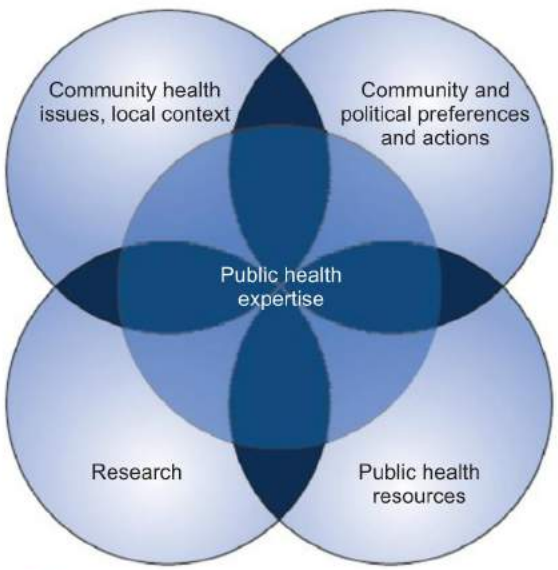


Figure 48.4 Components of evidence-based public health.

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CONCLUSION

Evidence-based dentistry practice demands the dentists to have ordered approach in eliciting the information gathered from the patients, the literature, colleagues and experts in the field so that the treatment decision makes use of present evidence in best possible ways.

The decision-making for particular treatment should be considerate towards clinician's expertise, individual patient needs and personal preferences. Hence, in EBD the final treatment rendered may vary from patient to patient within the constraints of recent valid evidence.

Evidence-based practice is driven by a practical, quality-rich, updated, ethical and patient-centred dental service approach. Clinical expertise, high-quality evidence and patient preferences are the promising combinations for a successful clinical and community dental practice.

REVIEW QUESTIONS

1. What are the components of evidence based dentistry?
2. Describe the steps in evidence based dentistry.
3. What are the differences between search engines, meta-search engines and databases?
4. What is level of evidence?
5. Describe the evidence pyramid.
6. What is strength of recommendation?
7. Write a short note on evidence-based public health.

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49 National Oral Health Programme: Overview

Vijay Prakash Mathur and Vartika Kathuria Monga

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BACKGROUND

Oral Health is fundamental to overall health, wellbeing and quality of life. Thus, oral health care is equitably essential and an integral part of general health care. The prevalence and distribution of dental caries and gingivitis in particular are a huge public health concern. Various epidemiological studies have stated that the prevalence of dental diseases is decreasing in the developed countries while reverse is true in the developing countries. Existence of the inequity in oral health service delivery, a huge burden is placed on the public health system to deliver adequate and appropriate oral health services.

Thus, to improve oral health and wellbeing across the Indian population by improving oral health status and reducing the burden of oral disease National oral health programme was incepted. This chapter will give a brief overview about the history of development of oral health programme and insight into the current status of the programme.

HISTORY

After establishment of Indian Dental Association (IDA) in 1945, sometimes the voice was being raised to have an Oral Health Policy but concrete steps were laid in the direction in 1980's only. At this time Dentistry in the country was growing very fast and many dental instiutions were opening in private sector. However, as regards to prevention and service provisions for masses, no policy was in place. There were large differences between provisions of dental health care between various states. Moreover, systematic preventive programmes by the state Govts. were almost negligible. The Indian Dental Association was actively pursuing with the Central Govt. about need of Oral Health Policy for the country. A focussed national level four day workshop was organized in Bombay in 1984 to establish a draft background guideline document on National Oral Health Policy (NOHP). The workshop represented probably the first collective efforts of leaders of the profession, dental experts, educationists, member of different speciality groups and others from all parts of the country. This workshop was an eye opener, an attempt to highlight some salient points as guidelines towards formulating a national dental programme for India. In this workshop the oral health goals for year 2000 were also envisioned (in line with Alma ata declaration).

In the year 1991-IDA Head office also initiated some public awareness and primary preventive programme with the help of its own branches in various parts of the country. In the same year, they did another advocacy workshop for the betterment of oral health of the population. The outcome of the meeting enlists the efforts required on part of Govt., Association and individual member dentists. Some of the state branches of IDA did work very enthusiastically for the programme and they launched several initiatives like school health programme, free denture program etc. they also published posters, pamphlets, health education books, etc.

NEED FOR ORAL HEALTH POLICY

Every country needs an appropriate National Oral Health Policy. Every country differs in their socio-cultural background, diet, financial conditions, manpower and oral health status. No single Oral Health policy can be considered as ideal policy. In order to develop a policy several initiatives are required at regional and national levels by the profession and the government. The Indian dental profession has also worked hard for the same.

The theme of World Health Day 1994 was 'oral health' and World Health Organisation decided to celebrate whole year as International Year of Oral Health. IDA also participated under this umbrella and extending its work towards NOHP. They organized several activities across the country for primary prevention of oral diseases. IDA hosted a three-day national brainstorming workshop in New Delhi to

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primarily make a draft on National Oral Health Policy. Moreover, collaboration was also made with the Commonwealth Dental Association and the outcome was "Oral Health Policy Guideline for Commonwealth countries." The workshop clearly delineated some goals for oral diseases prevention in line with Alma-Ata declaration. They also emphasized detailed roadmap to achieve these objectives.

DRAFT FOR ORAL HEALTH POLICY

After this, a core committee was appointed by the Hon'ble Minister for Health and Family Welfare to finalize agenda for the "Draft Oral Health Policy" to be placed before the Central Council of the Ministers of Health and Family Welfare. This council is the highest decision-making body in the Ministry of Health with Central Government Health Minister as Chairman and all state Govt. Health Ministers as members. This council deliberated on the agenda and then accepted the ten points of the "Draft for Oral Health policy" in principle to be included as an integral part of the National Health Policy.

The ten points were:

1. There is an urgent need for an Oral Health Policy for the nation as an integral part of the National Health Policy.
2. Special, well-coordinated, National Oral Health Programme be launched to provide Oral Health Care, both in the rural as well as in urban areas due to deteriorating oral health conditions in the country as revealed by various epidemiological studies. Dentist/population ratio in the rural areas is only 1:300,000. Whereas 80% of the children and 60% of the adults suffer from dental caries, more than 90% of adult community after the age of 30 years suffer from periodontal diseases which also have its inception in childhood. In addition, 35% of all body cancers are oral cancers. Large segment of the adult population is toothless due to the crippling nature of the dental diseases and about 35% of the children suffer from malaligned teeth and jaws affecting proper functioning. In view of these facts, it is important to launch preventive, curative and educational oral health care programme integrated into the existing system utilizing the existing health and educational infrastructure in the rural, urban and deprived areas.
3. A post of full time Dental Advisor at appropriate level in the Dte. G.H.S. should be created as a first step towards strengthening the technical wing of the Dte. G.H.S.
4. Studies have revealed that dental diseases have been increasing both in prevalence and severity over the past few decades. There is, therefore, an urgent need to prevent the rising trend of dental diseases in India. The method used for primary prevention of dental diseases aims at achieving primary prevention of periodontal diseases and oral cancers.
5. The council, therefore, resolves that preventive and promotive oral health services be introduced from the village level onwards and accordingly a pilot project on oral health care may be launched by the Ministry of Health and Family Welfare during 1995-96 in five districts, one each in five States.
6. The Council further resolves that legislative measures be adopted to ensure a statutory warning on the wrappers and advertisement of sweets, chocolates and other retentive sugar eatables 'TOO MUCH EATING SWEETS MAY LEAD TO DECAY OF TOOTH'. Similar measures are also called for tobacco and Pan Masala related products.
7. The council recommends that a national training centre be established or the existing centres be strengthened for training of various categories of oral health care personnel.
8. The council also resolves that all district hospitals and community health centres have dental clinics. All dental colleges should have courses on dental hygienists and dental technicians.
9. The council further resolves that the pilot project may be extended to all the states at the rate of one district in every state.
10. The council also resolves that there is an urgent need to have a national institute for dental research to guide oral health research appropriate to the needs of the country.

After exalt, Central Council of Health Ministry stressed to have a programme with oral health component. Central Health Education Bureau (CHEB) was invoked to draft a plan and pilot test the programme. For this adequate fund was allocated.

In the year 1996–1997, CHEB undertook to draft the outline for NOHP and pilot trained the health workers in Haryana, Punjab and Himachal Pradesh. In 1998, for the first time GOI earmarked Rs 30 lakhs for Oral Health Programme and invited eminent dental professionals to formulate a pilot project on National Oral Health Programme. After several rounds of discussions with various stake holders and long deliberations, it was decided to involve one of the institute to help in planning and implementation of the programme.

PILOT PROJECT ON NATIONAL ORAL HEALTH CARE PROGRAMME

In the year 1999, All India Institute of Medical Sciences, New Delhi (AIIMS) became the Nodal agency for implementing the pilot project on oral health. They were given the following terms of reference for the programme:

i. To determine the methodology of spreading the information and prevention of oral diseases.
ii. To develop IEC material for prevention of common oral diseases.
iii. To frame and develop the curriculum module for trainers.

Towards these objectives, they were asked to first determine the methodology with the help of various stakeholders and dental professionals across the country. They were asked to conduct various regional and national brainstorming workshops so that a consensus can be reached on implementation strategies for the programme.

Four regional and two national workshops were conducted in various parts of involving various dental institutions, Dental Council of India, Indian Dental

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Association, eminent professionals and public health experts from government and private sector.

The final outcome consensus document was compiled in the form of "National Oral health care programme: Implementation strategies" having details about objectives, strategies, manpower and infrastructure, etc. required for implementation of the programme. It also had draft chapters for inclusion in text books for schoolchildren, guidelines for setting up dental health care services at PHC, CHC and district hospital etc. The pilot project developed during this period was continued during the 10th Five Year Plan also (2002–2007).

Apart from this, AIIMS also conducted several activities during the implementation of pilot project. It included school children dental health education and Teachers Training Programme with the help of Indian Dental Association, training of health workers and advocacy with other organizations for primary prevention of oral diseases.

An educative video film entitled **"Kripaya Muskuraiye"** was produced with information about normal oro-dental structures, common dental problems and methods of prevention. This video film was made in Hindi and English language for easy understanding of most of the population. This video was also used for the training of health workers and teachers and also for public viewing. The educative video was sent to all the state health education Bureaus and who have been conducting various oral health-related activities using this film.

Apart from this, **training manual on oral health for health workers and school teachers** was published in both Hindi and English language. This manual covered information about common dental problems and simple methods of prevention. This manual was meant to be used by Health Workers as well as teachers and other social workers for awareness generation in the public. Moreover, a single-page **reference card** having brief information about oro-dental problems and their prevention was also printed and distributed in health workers and school teachers so that it can be easily carried and may act as ready reference during their day to day activities. As a part of mass media IEC development, nine different types of posters developed in Hindi as well as English on oral health covering simple instructions for all age groups.

All India Institute of Medical Sciences (AIIMS) also conducted ten training and re-orientation programmes for master trainers (dental surgeons) in Delhi, Chandigarh, Nagpur, Guwahati, Agartala, Shillong, Rohtak, Chandigarh and Itanagar and a total of 13 Training workshops for health workers were organized in these states.

AIIMS then submitted its final report on the three terms of reference to the Health Ministry and various IEC materials developed under the project. The project work was then externally reviewed by National Institute of Health and Family Welfare, New Delhi. They concluded that the work has been performed satisfactorily as per the terms of reference.

During 11th Five Year Plan (2007–2012), most of the national programmes was merged with the National Rural Health Mission (NRHM) and enough stress was not given to oral health component. However, a token allocation was made for oral health programme, out of which some training programmes and research was funded. One of the national projects was also undertaken on infection control and waste disposal practices in dental health care facilities in the country during this time.

NATIONAL ORAL HEALTH PROGRAMME

During 12th Five Year Plan (2012–2017) efforts were made to put emphasis on various non-communicable diseases (NCD) programmes and make implementation plans. Therefore, Oral Health Programme was planned in a way that some amount was kept for allocation to states for enhancing dental health care services and primary prevention and some allocation was made for central component to establish national oral health cell in the health ministry. The general objective of the programme is to achieve improvement of the determinants of oral health in the country by providing comprehensive oral health care through synergistic, equitably distributed general and oral health facilities and coordination with related sectors in public or private. In order to achieve the same three pronged strategies were identified as strengthening oral health services at health facilities located in the districts; integrate oral health promotion and preventive services with general health care system and other sectors that influence oral health and integrate promotion of public private partnerships (PPP) for achieving public health goals.

The programme envisages a holistic approach towards oral health care in the country with adequate emphasis on prevention and augmentation of service provisions. Under the Central component, there will be a national oral health cell in the Ministry wherein manpower is being recruited through the programme. This cell will be the primary coordinating pivot for the programme in the country. The cell will take primarily the responsibility for helping NRHM Mission directorate in examining the state PIPs, monitoring of the activities under the programme, development of IEC materials and some support for oral health research. Further, the Centre for Dental Education and Research, AIIMS, New Delhi has been identified as National Centre of Excellence for Implementation of National Oral Health Programme in the country. The main functions for the centre are to develop IEC material, training materials for various health workers and support government in research activities.

As peripheral component, in the first phase it is envisaged to augment the efforts of the state government to provide comprehensive oral health care in the community. A dental unit equipped with necessary trained manpower and equipment, including dental chair and support for consumables would be provided to the states through the NOHP. These units, according to the level of saturation of state's own dental units, may be established at district hospitals or in the health facilities below the level of district hospitals. Apart from this, the programme will also support an state oral health cell in each state.

The state oral health cell will be headed by an identified state nodal officer for oral health who would liaise with the other NCD program and central government on various aspects of the programme.

The programme will be expanding to cover more than 200 dental health care facilities in the country with central assistance during the 12th Plan period. It is expected that by the end of this Plan, there will be functional oral health cell in each state.

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CONCLUSION

The government is very keen on progress of National Oral Health Programme but since health is a state subject and success of implementation of any programme is dependent on the people, it is imperative that each one of us should be involved in the programme. We should actively participate in various activities, provide our suggestions and feedback to the government on programme implementation and finally work selflessly for the country.

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RESEARCH METHODOLOGY AND BIOSTATISTICS

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Scientific Research Methods in Public Health Dentistry

Amit Chattopadhyay

CHAPTER OUTLINE

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"All of the fruits of scientific work, in epidemiology or other disciplines, are at best only tentative formulations of a descriptive nature, even when the work itself is carried out without mistakes. The tentativeness of our knowledge does not prevent practical applications, but it should keep us skeptical and critical, not only of everyone else's work, but of our own as well". – Kenneth Rothman and Sander Greenland, 1998.

INTRODUCTION

Broadly speaking, research is a search for knowledge. Loosely speaking, research is an inquiry to explore the unknown to find truths about various phenomena. The term has been used in a variety of ways and carries an aura of science with it. However, all research is not scientific research. "Non-scientific research" or "unscientific research" may sound to be an oxymoron, but research devoid of scientific methods is that – unscientific! This issue is important to understand because the aura of science that goes with the term "research". A key factor that distinguishes scientific and unscientific research is the need for and nature of evidence. Most unscientific research is more of belief (i.e. not needing evidence), indemonstrable events or actions using questionable, unsubstantiated and non-confirmable events as evidence. Belief needs no demonstration, but science must demonstrate and be able to reproduce those observations in suitable settings as evidence. Science has to do with truth – it is about finding the truth about things, events, and various phenomena in the observable Universe.

Science works on the premise that the Universe is understandable; it works on logic which mostly uses mathematics as its core language to explain the workings of the Universe. Science aims to understand the world and improve life conditions of humans, requires industriousness, courage and strong commitment to fact-finding and truth. Technology is a very useful outcome of science, which provides tools for uplifting of life conditions as well as in advancing science. Scientific understanding advances piecemeal in small steps building on past understanding. This piecemeal growth of science mandates that each and every study be scientifically valid and their conclusions be drawn from within the framework of the study rather than indulge in hyperbole. This directly imparts the moral responsibility of good scientific work on the scientist conducting the study. A wisp of understanding of the nature of science can be obtained by reading some of the quotes attributed to Sir Isaac Newton (see the following), one of the greatest scientists the world has known.

- *If I have seen further than others, it is by standing on the shoulders of giants.*
- *A man may imagine things that are false, but he can only understand things that are true, for if the things be false, the apprehension of them does not understand*
- *I can calculate the motion of heavenly bodies, but not the madness of people.*
- *To myself I am only a child playing on the beach, while vast oceans of truth lie undiscovered before me.*
- *I keep the subject of my inquiry constantly before me, and wait till the first dawning opens gradually, by little and little, into a full and clear light.*

Though strong commitment to the scientific method came from the Western world, throughout history, "the East" made its own significant contributions. However, it was Sir Isaac Newton (1643-1727) who forever changed the way science worked in investigating nature. Prior to 1600, the nature was considered a manifestation of super-natural powers which was unobservable, opaque and to be feared. However, with establishment of a systematic method of inquiry with evidence being the pivot around which facts were now accepted based on theory, experiments and scientific paradigms. History of the scientific method is deep, enriching and an exposition of human nature, human

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fallibility and courage at the cost of extreme personal danger as exemplified by Johannes Kepler, Copernicus and several others. In this chapter, henceforth, the term research will imply only scientific research.

SCIENTIFIC RESEARCH PROCESS

Essentially, overall, the scientific method has four steps as follows.

1. Observation and description of phenomena of interest.
2. Setting up a hypothesis about the phenomenon. This might take the form of a causal association or a non-causal association or a mathematical relationship.
3. Using the hypothesis to describe causation, explain associations or predict outcomes associated with the hypothesis. Often, non-hypothesis driven studies are conducted to find potential associations, which might help in generating hypotheses about the phenomena one is interested in.
4. Conducting similar tests as aforementioned by other scientists to confirm or refute the associations seen/predicted earlier by other scientists in different populations and centers. This repeatability of experimental results provides importance evidence about truth of the findings.

The term "research cycle" has been used in the scientific literature to imply a variety of ideas. Without getting into semantic of these many descriptors of "research cycle", it is best to describe a series of steps for conducting research studies – the steps and descriptors of those steps vary with the type of research one is involved in. In general, in situations where one tests a hypothesis, the following steps are involved:

1. Identifying a problem and write a research question about it in plain language. This implies that one has reviewed the relevant literature about the question at hand extensively and is aware of the current state of science on that question. A substantive understanding of the subject matter is critical.
2. Stating the research question as a statistical hypothesis. This is a clear statement of what is being tested (i.e. write a null hypothesis and its corresponding alternative hypothesis).
3. Formulating the study to test the aforementioned hypothesis. This will imply figuring out the type of information that will be needed – variables and how to collect the information, how to assess those variables, strengths, weaknesses and threats to the study. This will involve though on how to minimize the weaknesses and add on the strengths while eliminating the threats. Another key element will be to understand the power of the study and what kind of sample and what sample size one would need to test the hypothesis with an associated effect size about the differences one wishes to demonstrate. Careful thought must be given to quality assurance of every aspect of the study. It is also important to state explicitly the inclusion and exclusion criteria within which the study will be conducted. Careful planning and quality assurance are critical to a study's success.
4. Deciding how to collect, store and handle the data; which statistical test to use; level of significance (depends on the type of study and the hypothesis); how to interpret data. Several a-priori decisions will need to be made on these aspects.
5. Conducting the study, obtain the data and analyze the data.
6. Interpreting the results and drawing logical conclusions within the framework of the study.

For a non-hypothesis testing situation, except for the steps to formulate the hypotheses, other steps remain the same. Just because a study does not necessarily have a hypothesis to start with does not mean that the scientific rigor could be compromised.

In the process of understanding a subject and assessing evidence about it, reviews are very handy. Reviews may be narrative reviews (traditional reviews) or systematic reviews (which are quite popular these days). Systematic reviews focus on single narrow topics and assess the published literature critically following prescribed methods using clear metrics to answer specific questions about the evidence related to the question at hand. Systematic reviews are being published very frequently. Meta-analysis is an important statistical tool used with systematic reviews. However, fallacious use of meta-analysis is fairly common in the published literature and one must critically assess systematic reviews when reading, and conduct systematic reviews with good scientific rigor.

STUDY TYPES AND DESIGNS

The design and conduct of research studies in dentistry need to bring together clinical experience, biological understanding, epidemiological-statistical expertise and community perspective among several other skills. Foremost among other skills are: logical thought, attention to details, careful record-keeping and astute observational ability.

Study Types

In general, there are three ways most studies have been categorized and taught (see below). Such categorizing exercises might have been useful in the distant past, but today they serve little purpose other than confusing people and generate needless controversy especially because in most situations, one does not have the capability to choose between the category alternatives for reasons beyond one's control.

Descriptive vs. analytical studies. The traditional understanding these studies as mutually exclusively different from each other has now been discarded. The general idea was that descriptive studies describe vs. analytical studies analyze. However, the truth is that analysis and description of questions, methods, data and results go hand in hand in all studies.

Cross-sectional vs. longitudinal studies. In cross-sectional studies, one measures the exposures and outcomes at

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about the same time without being able to attribute temporality between occurrences of the exposure and the outcome (i.e. which came first). Subjects are measured in one interaction with the study group and all information is collected about then. In longitudinal studies, there is an opportunity to observe the study participant several times over time starting from the first interaction where measurements are done (baseline). Cross-sectional studies and longitudinal studies address different types of questions and have different strengths and weaknesses.

Observational vs. experimental studies. The essential difference between these two broad categories of studies is that in an experimental study, the experimenter controls the intervention (i.e. who gets/ does not get the intervention exposure and how much dosage of the intervention is to be given). A key concept in most experimental studies is that the exposure is assigned to different groups in a random manner. If this random assignment is not possible, the study is then usually referred to as a "*quasi-experimental study*". In contrast, in observational studies, intervention/ exposures are not allocated by the experimenter, and these occur due to circumstances outside the control of the experimenter, therefore, they can only "observe" the results of those exposures.

A general thought that experimental studies are more rigorous than observational studies is perhaps not the whole truth because they have very different applicability and utility. What can be done in experimental studies cannot be done on observational studies and vice-versa. Whereas experimental studies may be very useful to prove causation and assess efficacy, observational studies are very good for assessing effectiveness, population impact, generating hypothesis and even providing evidence for causation. Whether one conducts an experimental study or an observational study, defining the population of interest is a very important activity.

Study Designs

Table 50.1 provides the general overview of common types of study designs used in dentistry. Selection of study design is usually a result of multiple forces. Important ones are: the scientific question tempered by practicality of conducting the study, available finances, logistics, available time, available skill level and several political factors. For example, if one wants to conduct a community trial of any kind, getting through the political barriers will be an uphill task. The investigator might in that case resort to a different study design with a slightly "re-oriented" study design. If one examines the various

Table 50.1 General characteristics of common study designs

Case Control Study	Cohort Study	Clinical Trial	Community Trial
• Study starts when cases are identified • Only one type of disease/case can be studied • Controls selected after cases • Mostly retrospective in design (prospective case-control study is possible) • Possible to study a variety of exposures • Strong possibility of recall bias and other biases • Causal inference is not possible as exposure time cannot be ascertained and temporal association with outcome is not possible • Relatively inexpensive compared to cohort study • Possible to complete in short span of time • Odds ratio measured as a rough estimate of the true relative risk • Incidence density not usually calculable unless a prospective design is used • Logistics are relatively simple compared to cohort studies • Efficient design to study rare diseases • Good design to collect preliminary data	• Study starts with exposure ascertainment • Longitudinal in nature with respect to assessment of outcome after exposure • Mostly prospective in design (retrospective cohort study possible) • Can study only one exposure • Possible to study multiple outcomes • Causal association inference possible because exposure can be proven to have come before outcome by study design • Useful design to study natural history of disease • Expensive study design • Time consuming study • Possible to measure relative risk • Better control of bias • Possible to obtain incidence density • Requires careful study monitoring logistics as dropouts may occur over time • Possible to incorporate small case-control studies within the cohort study. Such studies are called "nested case control studies"	• Experimental study type • Expensive studies • Good for studying efficacy of interventions • Random allocation of subjects to exposure groups is a key issue • Causality can be demonstrated • Complicated logistics. Multicenter studies require very careful oversight. • Requires expensive and extensive infrastructure • Drop outs can cause problems with study power • Several types of sub-designs possible such as: crossover design, split-plot design, randomized block design etc. • Double blind studies most common, but triple blind studies are becoming the norm slowly • Requires extremely meticulous record-keeping. These records are scrutinized minutely by several entities multiple times	• Experimental study type • Expensive studies • Good for studying effectiveness of interventions • Random allocation of communities to exposure is possible • Secular trends may impact study outcomes • Diffusion of exposures from outside communities may impact study outcomes • Only one type of exposure can be examined • Multiple outcomes may be examined that are linked to the exposure being studied

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aspects of HPV vaccination-related issues in India over the past several years, the complex interaction between science, politics and various other forces become explicitly clear. A brief, non-nuanced discussion of common study design follows.

Case control studies are the commonest type of studies found in the literature. In general, investigators select a disease to study as case. They select a number of cases and controls group free of the disease. Then the investigator inquiries into the study group asking about various exposures and examining a variety of bio-social-environmental parameters. The key point in case control study is that a case's exposure status and all other parameters are obtained after the disease has occurred. Therefore, one cannot demonstrate if the disease came before or after the exposure occurred. This precludes any inferences about a causal association between cases and exposures.

A major issue with case-control studies is the selection of the control group. Source population is the population from which cases and controls arise. Cases in case-control studies should represent all the cases in the source population. Ideally, controls should arise from the same population from which the cases arise. Controls should be selected randomly from the source population. If the source population cannot be defined or controls are not selected randomly, then usually the results of the study cannot be generalized to the population.

Matching is a process of balancing certain characteristics between cases and controls so that outcomes cannot be attributed to those characteristics. It is used when a characteristic is so important that an imbalance between cases and controls would affect the conclusions (match controls to cases on the characteristic). Matching ensures that cases and controls will be similar in regard to important characteristics that may otherwise confound conclusions. If matching is done, then analyses of data must adjust for this fact because this makes the data structure "correlated," which requires special handling. For example, if a simple chi-square test was planned and matching is done, then a special adjustment using McNemar's test will need to be conducted.

Cohort studies are relatively less common, but are being conducted with more frequency around the world as more countries invest in research related to the health status of their citizens. Essentially, the investigator inquires into study participants about their exposure status to an exposure of interest and establishes that status through demonstrable measures. Then they divide the participant group into two subgroups – exposed and unexposed. The investigator then follows these groups over time examining them periodically for development of diseases/ outcomes of interest. Because at the start of the study, exposure status was recorded and demonstrated, any disease outcomes that are more frequent in the exposure group can be then attributed to the exposure providing evidence towards potential causal link between the two.

Clinical trials are experimental studies that are conducted in controlled clinical environment used to determine effects of new interventions (medications, diagnostic devices, treatment modalities etc) in a prospective cohort design. Most commonly, clinical trials test the difference between a drug and a placebo to demonstrate that the drug has a property to treat a disease. The critical feature of clinical trials is random allocation of participants to drug/ placebo treatment. Therefore, the study participant does not have a choice of getting the drug or a placebo. By the same token, the investigator also does not have a choice about which participant gets an active drug or placebo. Randomization is done to make the two groups (drug and placebo) as comparable as possible, although randomization does not guarantee comparability of groups, but minimizes bias. With a large enough sample size, the random errors can be reduced substantially. Single blind trials hide the treatment allocation from participants. Double blind trials hide the allocation from participants as well as doctors and those who administer the treatment. Triple blind trials hide the allocation from participants, doctors as well as those analyzing study results. *Community trials* are trials that are conducted in communities involving large populations (usual entire communities) to study the effects of community-level exposures.

Errors and biases are major threats to studies. Errors can occur in every stage of a study. Design errors, instrument errors, measurement errors and random errors can invalidate studies and/or impact their precision and accuracy. Biases are systematic deviation of results or inferences from the truth, or processes leading to such systematic deviation. Any trend in the collection, analysis, interpretation, publication or review of data can lead to conclusions that are systematically different from the truth. Biases may be estimated, but cannot be corrected by mathematical treatment during analyses. In general, information biases are distortions in the estimate of association between risk factor and disease that is due to systematic measurement error or misclassification of subjects on one or more variables, either risk factor or disease status (e.g. recall bias). Selection biases are distortions in the estimate of association between risk factor and disease that results from how the subjects are selected for the study. Several types of information and selection biases are known and need to be guarded against. Confounding occurs when the risk factor being studied is so mixed up with other possible risk factors that its single effect is very difficult to distinguish. For example, smoking associated with oral cancer; but also smokers also drink more, and alcohol is associated with oral cancer. Confounding may be adjusted for using advanced mathematical methods. It is useful to keep in mind two errors linked with making scientific inferences from study results. Type I error (also called alpha error) occurs when one rejects a hypothesis when difference is actually the result of chance i.e. concluding that groups ARE different when in reality they are NOT different. Type II error (also called beta error) occurs when one accepts a null hypothesis when, in fact, the observed difference is real i.e. concluding that groups are NOT different when in reality they ARE different.

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A BRIEF NOTE ON SAMPLING

Samples are segments of the population about which research is being done. Because it is not possible to measure all individuals in the population (a census), a small proportion is selected. Samples are selected based on the assumption that they faithfully represent the entire population from which they are selected. Sampling methodology uses certain assumptions about disease and exposure distribution in the population to select samples. In brief, a *random sample* is one where every participant is selected from the population randomly. In a *simple random sample* (SRS), individuals in the population have a known and equal probability of being selected. A simple way to select a SRS is to have a list of all people in the population of interest (the sampling frame) and from it select a certain desired number of people randomly (using a computer generated random strategy). A common mistake is to select a group of people from a school or hospital or clinic as they come in and assume that the sampling was random. Perhaps, investigators involved in such sampling believe that because they did not select study participants based on some whim, the sample is random. This is an incorrect view. Such samples are convenient samples. Random sample has a precise statistical meaning that is based on well-proven scientific logic and mathematical proof of its properties. *Stratified sampling* is done when the population is divided into different groups (strata) based on some characteristic and sampling is done from within these strata. If random sampling is done from within the strata, the technique is called stratified random sampling. In some situations, people share a common characteristic (e.g. exposure to an environment) over a small area which clusters of those characteristics (e.g. clusters of exposures or diseases). Cluster sampling uses these clusters as sampling units and all people within the clusters are measured. Sampling designs that use stratification as well as clusters in their sampling technique are called *complex samples*. Sampling may be done in one stage as most SRSes are done (*single stage sampling*) or they may be done in multiple stages (*multi-stage sampling*).

When analyzing SRS, routine analysis can be done as all participants contribute the same weight to the observations. However, when sampling strategy is modified such as in some stratified sampling and cluster sampling, the weights contributed by different individuals may be different depending on the sampling strategy, number of stages etc. In such situations, some kind of weighted analysis needs to be conducted. Furthermore, complex samples must be analyzed keeping in mind the sampling design as there occurs a significant "design effect" I the data. If such weighted/ non-SRSes are analyzed assuming them to be SRSes, then even if the effect estimates may be correct or close to correct, the standard errors are always wrong leading to erroneous statistical testing result. Usually the sampling designer will supply the weights and design effect factors for the observations that should be used for the specific sample analysis. Before using a statistical program for analysis, one must ensure that the package has the capability to address the sampling design for which the analysis is being conducted.

RESPONSIBLE CONDUCT OF RESEARCH

A good research question must address an answerable question, be practically feasible to be addressed, be clear in its intent and presentation to the researcher and peers and must be ethically appropriate. Conducting health research is a serious responsibility and must be done in a way that all individuals associated with the research must be trained in human subject research and should be certified through appropriate agencies. Most institutional ethics committees or review boards impart training in ethical conduct of research.

Two major events have impacted human research in drastic ways to cause a paradigm shift in the way such research was to be conducted. First, the Nuremberg trial of Nazi war criminals exposed the reality of unethical research and human practices. The Nuremberg trial set forth a series of events that led to the Helsinki declaration in 1994. The Helsinki declaration is not a legally binding instrument, but carries its weight because of its adaptation by the World medical Association and all biomedical research entities around the world. The declaration has undergone several revisions and clearly states that "concern for the interests of the subject must always prevail over the interests of science and society."

The second event was on July 12, 1974 when the National Research Act (Pub. L. 93-348) was signed into law in the United States. This changed the conduct of human subject research for ever. The law created the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. The report of the commission, commonly known as the "Belmont Report," identified and set the basic ethical principles that should underlie the conduct of biomedical and behavioral research involving human subjects. It also developed the guidelines to be followed to assure that such research is conducted in accordance with those principles. The report provided clear guidelines for ethical conduct of biomedical research as follows.

Defining Boundaries Between Practice and Research

The report suggests that "for the most part, the term practice refers to interventions that are designed solely to enhance the well-being of an individual patient or client and that have a reasonable expectation of success." It defined research as "an activity designed to test a hypothesis, permit conclusions to be drawn, and thereby to develop or contribute to generalizable knowledge (expressed, for example, in theories, principles, and statements of relationships)".

Basic Ethical Principles to be Applied

1. Respect for Persons. This principle states that "individuals should be treated as autonomous agents, and that persons with diminished autonomy are entitled to protection."
2. Beneficence. Persons are treated in a way to secure their well-being.
3. Justice. Benefits of research should be distributed with a sense of "fairness in distribution" or "what is deserved."

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Application of the General Principles

Informed consent (information, comprehension, voluntariness for the participants). "The manner and context in which information is conveyed is as important as the information itself. Special provision may need to be made when comprehension is severely limited. An agreement to participate in research constitutes a valid consent only if voluntarily given".

Assessment of risks and benefits. This requires a careful appraisal "of relevant data, including, in some cases, alternative ways of obtaining the benefits sought in the research".

Selection of subjects. "Justice is relevant to the selection of subjects of research at two levels: the social and the individual. Individual justice in the selection of subjects would require that researchers exhibit fairness. Social justice requires that distinction be drawn between classes of subjects that ought, and ought not, to participate in any particular kind of research, based on the ability of members of that class to bear burdens and on the appropriateness of placing further burdens on already burdened persons".

The Belmont report explicitly states how to act to safeguard human well-being in biomedical research as follows.

"(i) Brutal or inhumane treatment of human subjects is never morally justified. (ii) Risks should be reduced to those necessary to achieve the research objective. It should be determined whether it is in fact necessary to use human subjects at all. Risk can perhaps never be entirely eliminated, but it can often be reduced by careful attention to alternative procedures. (iii) When research involves a significant risk of serious impairment, review committees should be extraordinarily insistent on the justification of the risk (looking usually to the likelihood of benefit to the subject — or, in some rare cases, to the manifest voluntariness of the participation). (iv) When vulnerable populations are involved in research, the appropriateness of involving them should itself be demonstrated. A number of variables go into such judgments, including the nature and degree of risk, the condition of the particular population involved and the nature and level of the anticipated benefits. (v) Relevant risks and benefits must be thoroughly arrayed in documents and procedures used in the informed consent."

The Belmont document continues to be a strong foundation for ethical principles in conduct of biomedical research. Much work has been done since and more updated guidelines are available at the websites of different national agencies dealing with the subject. For example, the Indian Council of Medical Research guidelines can be freely downloaded from http://icmr.nic.in/ethical_guidelines.pdf.

PUBLISHING RESEARCH RESULTS

After completion of the study, its results should be communicated to the scientific world. There exists a bias towards publishing only positive results. However, negative results from well conducted studies are equally important. Such studies reporting null results are increasingly being accepted for publication in various journals.

A research report must communicate its procedures briefly, but comprehensively in the methods section. Study sample selection, study power, important variables measured should be discussed. The sample size should be explicitly mentioned. Analytical methods including all statistical tests should be described in sufficient details. Presentation of data in tables and figures can help reporting much information in less space. The results section should provide the context for the data presented in tables and figures and present other data not presented elsewhere. Repetition of data in tables/figures and results section narrative is a practice that should be avoided as it will only result in rejection of the report during peer review – whatever may be the forum of presentation – meetings, dissertations or publication in journals.

General guidance for good scientific writing is available over the internet through several high-quality institutions. In brief, comprehension and brevity are the hall marks of good scientific writing. One should strive to stick to the guidelines to authors that different journals provide. Non-adherence to these guidelines will only result in delays and worse, rejection! The Committee on Publication Ethics maintains an active and comprehensive website discussing various aspects of biomedical publications including international guidelines for authors and a number of flow charts that help in decision-making related to different aspects of biomedical writing and publication. The website can be found at: http://publicationethics.org/.

CONCLUSION

Research methodology encompasses a wide range of activities to unearth the mysteries and puzzles in the biomedical world. When done systematically, they provide a wealth of useful information and add to the body of scientific knowledge apart from providing a great number of applications to improve human life conditions.

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51 Biostatistics

Shivaraj NS

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INTRODUCTION

The word 'Statistics' is derived from the Latin for 'state' indicating historical importance of governmental data gathering, which principally is demographic information. Statistics is the science, which deals with collection, compilation, summarisation and interpretation of numerical data. Inferences derived from these findings help in making valid decisions. Statistical methods and techniques applied to biological problems or data is simply called biostatistics.

In health sciences, one of the important aspects is to know, what is normal value? or How much biological variation can be considered as normal? This question arises in all our biological characteristic like blood pressure, body temperature, FBS, DMFT…Etc. By knowing the normal values the decision is made to intervene or not. Obtaining the normal values is done with the help of biostatistics.

PRESENTATION OF DATA

Data collected from various experiments do not lead to any information by itself. Hence, it should be complied, classified and presented in a purposive manner to bring out the important points clearly and strikingly, therefore, the manner in which statistical data is presented is of utmost importance.

Methods of Presentation of Data

Based on the data type, representation of data also differs. There are two different data types in statistics; they are: (i) discrete and (ii) continuous type of data.

Discrete data are distinct and separate and also invariably whole numbers, e.g. gender, blood group, disease status etc.

Continuous data are those, which takes the value between range of values, e.g. height, weight, age etc.

There are two methods of presenting the data: (i) tabulation and (ii) charts and diagrams.

Tabulation (frequency distribution table). The distribution of the total no. of observation among the various categories is termed as a frequency distribution:

1. Frequency distribution table—discrete data (Table 51.1)
2. Frequency distribution table—Continuous data (Table 51.2).

Charts and diagrams. Presenting data in these forms is useful in simplifying the presentation and enhancing comprehension.

Table 51.1 Sex-wise distribution of the study subjects

Sex	Frequency	%
Male	110	55
Female	90	45
Total	200	100

Table 51.2 Age-wise distribution of study subjects

Age	Frequency	%
0 – 15	30	15
16 – 30	40	20
31 – 45	35	17.5
46 – 60	45	22.5
>60	50	25
Total	200	100

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of the data. Representation of data in these forms provides the following:

- They simplify the complexity in understanding.
- They facilitate visual comparison of data.
- They create interest in readers.
- They draw some conclusion directly or indirectly.

Charts and Diagrams for Discrete Type of Data

1. *Bar charts:* These are merely a way of presenting a set of numbers by the length of a bar; the length of the bar is proportional to the magnitude to be represented (Fig. 51.1). Bar charts are easy to prepare, easy to understand and enables visual comparison. There are three types of bar charts; they are: (i) simple bar chart, (ii) multiple bar chart and (iii) component bar chart.
2. *Pie chart:* Here, instead of comparing the length of a bar, the areas of segments of a circle are compared. The area of each segment depends upon the percentage, which is converted to angle and drawn (Fig. 51.2).

Charts and Diagrams for Continuous Type of Data

1. *Histogram:* Histogram is a set of vertical bars whose areas are proportional to the frequencies represented. The class intervals are given along the horizontal axis and the frequencies along the vertical axis (Fig. 51.3).
2. *Line chart:* It shows trends or changes in data varying with a constant, at even intervals. Although similar to an area chart, a line chart emphasizes the flow of a constant and rate of change rather than the amount of change. When you need to show trends or changes in data at uneven or clustered intervals, an XY (scatter) chart is usually more appropriate than a line chart (Fig. 51.4).

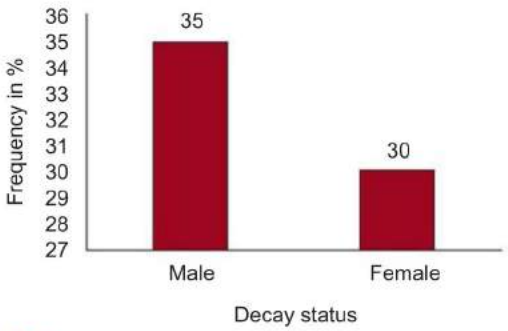


Figure 51.1 Bar chart depicting sex-wise comparison of decay status.

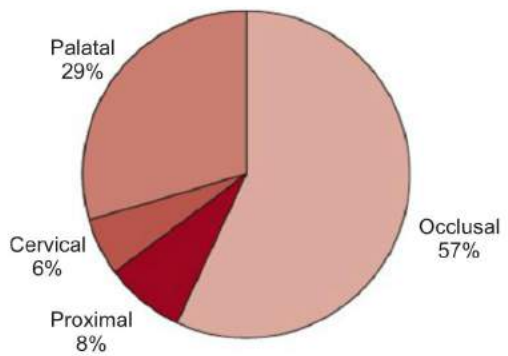


Figure 51.2 Pie chart depicting distribution according to surface affected by dental caries.

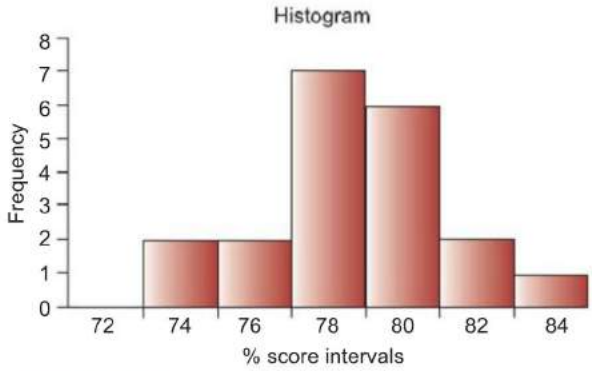


Figure 51.3 Histogram depicting class intervals.

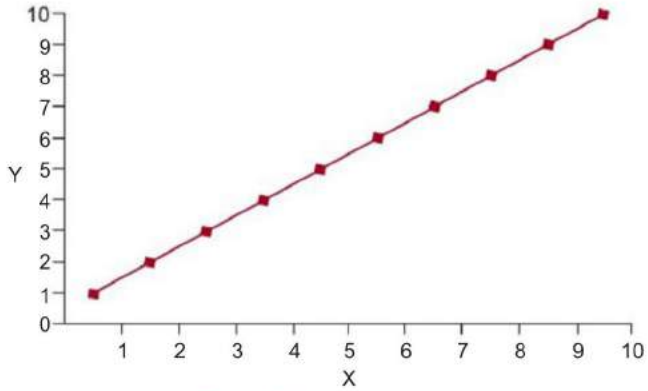


Figure 51.4 Line chart.

SAMPLING TECHNIQUES

Normally, the study population will be too large and it may be too expensive or too time consuming to attempt either a complete or a nearly complete coverage in a statistical study so we take a sample (Fig. 51.5) from the population, and investigation is carried out and result obtained from sample is generalised to the whole population. The results obtained will be valid if the sample is representative, unbiased and sufficiently large. To ensure that the sample is representative of study population we chose each unit of the sample technically. This process is called sampling technique.

Definition of Sampling : Procedure by which some members of the given population are selected as representatives of the population is called sampling. There are two methods in sampling technique, they are: (i) Random sampling technique (Probability sampling) and (ii) non-random sampling technique (non-probability sampling).

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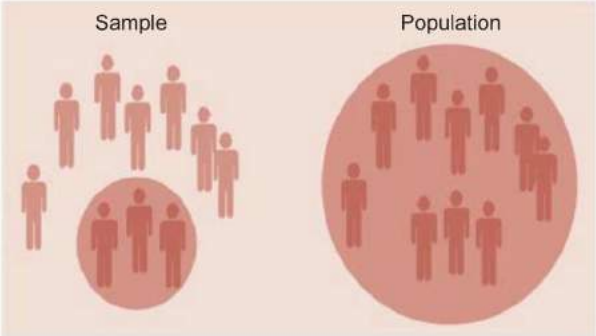


Figure 51.5 Sampling technique.

Steps in Sampling Procedure

The sampling procedure should be carried in the following steps:

a) Defining the population of concern: If the study is to find the prevalence of decay status among children 5–15 years in a specified region, then population of concern is only children in that age in that region.
b) Specify the sampling frame: Here, we list all the study subjects giving a number in order. Without this sampling frame the random sampling cannot be carried out.
c) Determine the sample size: The sample size when it is considered for study, it should be fixed before collecting the information. A scientific method needs to be used to estimate the sample size.
d) Specify a sampling method: There are various sampling methods available to collect the data, but the appropriate method need to adopted, based on the population distribution and the importance of precision required in the result.
e) Collect the data: Using the specified sampling method the required sample is collected from the population.

Random Sampling Technique (Probability sampling)

In random sampling technique, the sample is chosen randomly to remove personal bias in the selection of sample. Some of the commonly used techniques are: (i) simple random sampling, (ii) systematic sampling, (iii) stratified sampling, (iv) cluster sampling and (v) Multistage sampling.

Simple random sampling. Simple random sampling technique is applicable when: (i) the population is small, (ii) the population is readily available and (iii) the population is homogeneous. For example, patients lying on ward or study subject selected from a class. The principle used in selecting the sample is, using random table the required number of subjects is selected randomly. Here each and every subject of population will have equal chance of getting selected. This is done either by using random table or lottery method. Though it is easy, scientific and more representative, this technique cannot be used when the population is large and scattered (like field studies). This technique is usually used in clinical experiments.

Random number table

76	58	30	83	09	24	33	45	77	58
47	56	91	40	23	01	31	60	10	39
10	80	21	04	90	50	78	13	69	36
00	95	01	77	62	90	78	50	05	62
7	28	37	30	89	46	72	60	18	77
20	26	36	37	62	47	21	61	88	32
31	56	34	28	09	12	73	73	99	12
98	40	07	47	81	23	54	20	83	85

Example: Selecting a sample of 10 subjects from the population of 60 subjects. Blindly point at any number in the table and from that point continuously select 10 different numbers either row wise or column wise to meet your sample.

Systematic sampling. Systematic sampling technique is applicable when: (i) the population is large and scattered but the population list available (sampling frame), and (ii) the population is not homogeneous. The principle used is systematically after every certain number i.e. every 10^{th} or 20^{th} or 30^{th} the sample is selected from the population. The systematic number is called as sampling interval (k), which is calculated as:

Sample interval (κ) = Total population/sample size required

For example, if the total population is 1000 and sample size required is 100, then k will be 10, i.e. every 10th unit is selected as the sample. The first unit is selected randomly, which is less than k. This technique leads to more accurate result if the population is homogeneous and preparation of sampling frame is possible. When the population is too large, preparing sampling frame will be difficult, applying this technique is difficult. The result will not be true if the population is heterogeneous.

Stratified sampling. Stratified sampling technique is applicable when: (i) the population is large and (ii) the population is not homogeneous. In such a scenario, first the population is divided into homogeneous group called strata, and the sample is drawn from each stratum at random in proportion to its size. This gives greater accuracy result as proportionate representative sample from each strata is secured. The demerit of this technique is dividing the population into homogeneous group is not easy and requires statistical expertise and different strata population may overlap.

Cluster sampling. Cluster sampling is applicable when preparing the sampling frame is difficult. In it, geographical area is divided into small area called cluster. This technique allows only a small number of target population to be sampled. Normally 30 clusters are selected by systematic sampling method. Error will be more in the result but the cost and time will be reduced

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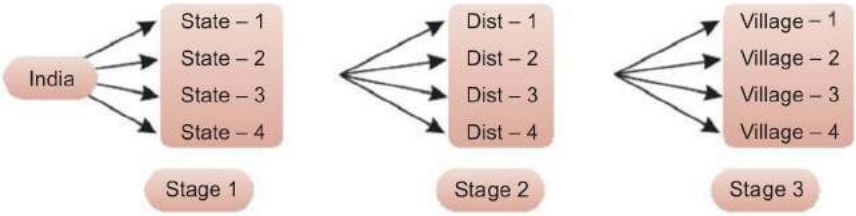


Figure 51.6 Multistage sampling.

remarkably. Usually this technique is used for evaluation of the immunisation programme.

Multistage sampling. This is applicable for large-scale survey like country survey. Here, the sampling procedures are carried out in several stages using random sampling techniques, e.g. to find the nutritional status of children of India, sampling can be carried as depicted in Figure 51.6.

Non-random Sampling Technique (Non-probability sampling)

Judgment. Choosing the sample items depends exclusively on the judgment of the investigator. Selection is based on a predetermined criterion. Samples are because the investigator believes that they are typical or representative of the population under his/her study.

Convenience sampling. The criterion adopted in this sampling is that of convenience to the investigator. Selection is made from an available source like that from a nearby college students to study the awareness regarding AIDS in college students, because getting sample is convenient.

Non-random sampling method gives less precise result compared to random sampling method, but time, cost and resource required will be considerably less.

Sampling Error

Repeatedly if we take the sample from the same population, whatever the care has been taken to choose the sample the results will differ from sample to sample. The occurrence of this variation from one sample to another sample is called sampling error. The factors that influence the sampling error are: (i) size of the sample and (ii) natural variability of the individual readings. As the size of the sample increases, sampling error will decrease.

Non-sampling Error (systematic error)

Sampling error is not only error which arises in a sample survey, errors may also occur due to inadequately calibrated instruments, due to observer variation, as well as due to incomplete coverage achieved in examining the subjects selected and conceptual sampling errors.

DESCRIPTIVE STATISTICS

After collecting large biological data, it does not give any information unless it has been compiled and interpreted. The data need to be summarized to bring out some information. Descriptive statistics means summarising or describing the data set. There are various methods are there to describe the data example: Percentage, mean, median, mode and geometric mean. Based on the data distribution, the data should be appropriately summarized. Descriptive statistics has two parts 1) Measures of central tendency and 2) Measures of dispersion.

Measure of Central Tendency

In any data distribution, normally data are concentrated around a central value or data tend to congregate around a central value, this tendency is called central value or central tendency, and measuring this value is called measures of central tendency. This value represents the entire group of values and helps in drawing some conclusion, e.g. average bond strength of an agent.

There are several kinds of measures of central tendency, of which the commonly used are: (i) arithmetic mean, (ii) median and (iii) mode.

Arithmetic mean. Arithmetic mean is the most commonly used measure, and it is obtained by summing up the values of all the observations, divided by the total number of observation. If X is a variable and X_1, X_2, X_3. X_n are individual values of n observation, then the arithmetic mean is given by

$$X = X_1 + X_2 + X_3 + \ldots\ldots + Xn/n$$
$$\bar{X} = \Sigma X/n$$

Example: Values of pulse rate per min of a group are: 67, 72, 73, 68, 71, 74

$$\text{Mean}(\bar{X}) = 67 + 72 + 73 + 68 + 71 + 74/6 = 70.83/\text{min}$$

The advantage of mean is easy to calculate and understand but it may not be representative when there are extreme values. Mean will be unduly affected by extreme values.

Median. Median is another method of central tendency used whenever extreme values are there and mean does not give appropriate representative value. Median is the central value after arranging in ascending or descending order. Also, Median is the value which divides the distribution in such a way that equal number of observations lie on either side of it. To obtain the median, first the data is arranged in ascending or descending order of magnitude, and the value of middle observation gives median value. If the number of observation (n) is odd, then the middle value is median,

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if n is even, then average of middle two observation gives median.

For example, DMFT of five children are as follows:

4, 2, 4, 3, 1

Arranging the observation in ascending or descending order gives: 1, 2, 3, 4, 4 then the Median = 3

Mode. Mode is the value which most commonly occurs observation in the distribution, or occurs most frequently in a series. For example, values of pulse rate per min of a group are:

71, 72, 73, 68, 71, 71

Mode = 71/min

Though mode is more representative and easy to find, it is not unique, i.e. it may give two or more values sometimes. Also it is not frequently used.

Measures of Dispersion

Measures of central tendency alone do not summarize the data completely. To give a better picture of a distribution of the data, we need understand the variation in the data distribution within the sample. Measuring the variation between the observation is called as measure of dispersion. It gives the information about how individual observations are scattered or dispersed from the mean. Together with measure of central tendency and measures of dispersion will describe the data distribution completely. Also, measure of variation is important whenever the comparison of mean between the two or more is needed. In the following example, mere comparing two or more groups by the averages is inadequate. For example, two sleep producing drugs are administered for two groups of patients. Results are as follows:

Drug A: 6, 2, 4, 3, 5, 2	Mean = 3.7 hours
Drug B: 1, 6, 7, 1, 2, 6	Mean = 3.7 hours

In the earlier-mentioned data though averages are same in both the group, but variation within the group is large. So, it is important to look into the variation within the sample observation.

The four different measures of dispersion are: (i) range, (ii) mean deviation, (iii) standard deviation and (iv) co-efficient of variation.

Range. Range is the simplest measure of dispersion. It can be used by one who has little knowledge of statistics. It is the difference between the highest and lowest. This is not a satisfactory measure as it is based only on two extreme values. It does not consider all the observations to find range.

Mean deviation. Mean deviation is found by summing up the differences from the mean and divide by the number of observation.

$$\text{Mean deviation (MD)} = \sum \left| X - \bar{X} \right| / n$$

Though simple, easy to calculate and better measure of variation, mean deviation is not used in statistical analysis as it cannot be used in further mathematical expressions.

Standard deviation. Standard deviation is an improvement over mean deviation as a measure of dispersion, and is used most commonly in statistical analysis. It is defined as square root of mean squared deviations.

$$SD = \sqrt{\sum \frac{(X-\bar{X})^2}{n}} \qquad \text{if } n \geq 30$$

$$SD = \sqrt{\sum \frac{(X-\bar{X})^2}{n-1}} \qquad \text{if } n < 30$$

Uses of Standard Deviation

- Standard deviation shows that how the data are scattered from mean.
- It summarises the deviation of a large distribution from mean in one figure used as a unit of variation.
- It helps to indicate whether variation of difference of an individual from the mean is by chance.
- It helps in finding the suitable size of sample in sampling technique.

Co-efficient of variation. It is a measure used to compare relative variability, i.e. to compare the variability between two characteristics or group. Quite often variation of the same character in two or more different series has to be compared and also whenever the unit of measurement is different between the characteristics is compared, co-efficient of variation is used, e.g. whether weight varies more in spleen or in heart. Growth varies more in girls or in boys and variation of pulse rate is more in young or old. Co-efficient of variation is expressed in terms of percentage. It is calculated as follows:

Co-efficient of Variation (CV) = (SD/Mean) × 100

Normal Distribution (Gaussian)

It is very important in health science to understand how much variation can be considered as normal or due to biological variation. Mean and standard deviation just describes the data. Here, it has to be estimated that how much variation from mean is considered as normal. To estimate this, first we should understand the knowledge of normal distribution. This normal distribution concept provides the basis for all our conclusions drawn from the sample.

When we take large number of observations of any variable such as height, blood pressure, pulse rate, etc. and we draw a frequency distribution curve or graph with small class interval, we get normal distribution or normal curve with the following characteristics (Fig. 51.7):

- It is bell-shaped.
- It is symmetrical in distribution.
- Mean, median and mode coincide.
- The tails never touch the base line theoretically.

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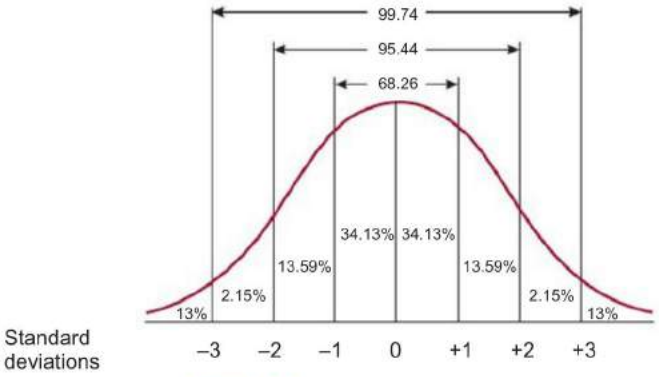


Figure 51.7 Normal curve.

It is easy to understand normal distribution with the following data:

Mean ± 1 SD = 68.26% of observation will be covered within this limit,
Mean ± 2 SD = 95.44% is covered.
Mean ± 3 SD = 99.74% is covered.

Normal distribution describes how normally data are distributed, but it does not say anything about the normal value of a character. Now the question is whether to consider 2SD or 3SD or 2.5SD on both sides of mean as normal. If we consider 2 SD on both the sides of mean (Mean ± 2SD) as normal then almost 95% observation fall within this range, which means we are sure with almost 95% and in 5% of the chances we would be wrong, since it falls above ± 2SD. Similarly, if ±3SD is considered as normal then we are almost 99% correct and 1% wrong. While estimating the normal value we cannot estimate with 100% confidently. Decisions are made with certain error, so with 5% error or with 95% confident level the normal range would be mean ± 2SD. Similarly with 99% confident level normal range is mean ± 3SD.
Example: From the sample of 100 normal babies the mean birth weight is 2.5 Kgs with SD of 0.25 Kgs. What would be the normal birth weight with 95% confidence level. The result would be the mean ± 2SD (2.5 ± 2 * 0.25) i.e. 2.00 to 3.00kgs.

Standard normal curve. Although the curve will differ for different characteristics and sample size but characteristics remain same. To estimate easily the area under the normal curve between any two ordinates, only one standardised normal curve has been devised, which is called standard normal curve. Here, the total area of the curve is considered as 1, its mean 0 and SD as 1. All other characteristics remain same as in normal distribution.

Supposing, we are considering the 95% confidence limits ($\bar{X}$ ± 2SD). When we say this, we mean that 95% of the area of normal curve (Fig. 50.8), and hence 95% of the values in the distribution will be included between the limits ($\bar{X}$ ± 2SD). Therefore, the probability of a reading falling outside the 95% confidence limits is 1 in 20 ($p = 0.05$).

The distance of a value (X) from the mean ($\bar{X}$) of the curve in units of standard deviation is called 'relative deviate or standard normal deviate' and usually denoted by Z. The standard normal deviate is given by the formula:

$$Z = (X - \bar{X}) / SD$$

Therefore, probability of reading falling outside the 95% confidence limits (i.e. Z above 2) is 1 in 20 ($p = 0.05$).

Estimation of probability (example). Let us suppose, pulse of a group of normal healthy males was 72, with a standard deviation of 2. What is the probability that a male chosen at random would be found to have a pulse of 78 or more? Here,

$$Z \text{ (standard normal deviate)} = (X - \bar{X}) / SD = 3$$

The area of normal curve corresponding to a deviate 3 = 0.4987. Since we are dealing with only half the total area (i.e. 0.5) the area beyond 0.4987 is equal to 0.5 – 0.4987 or 0.0013. Therefore, the probability is that only 13 out of 10,000 individuals would likely to have a pulse rate of 80 or higher.

STATISTICAL INFERENCE

The procedure followed in drawing conclusion from the sample values are known as statistical inference. The statistical inference consists of two aspects: (i) estimation of a population value and (ii) testing of hypothesis.

Estimation of population value

After obtaining the result from a sample value, we need to extrapolate the result to entire population. Here, we need to consider how much variation can be considered as normal from sample to sample. When we take many samples from the sample population, all the sample would not give same result. Occurrence of this variation is called as sampling variation. If we measure this variation it is called as standard error (SE). This is not an error , it is due to sampling variation.

Now to estimate the population value from the sample we use concept of normal distribution. If we draw the frequency curve for the large samples mean values, it has been observed that samples mean values will follow normal distribution. So, we need standard error, which is variation between sample means to estimate the population value. Practically, it is difficult to consider many samples and estimate standard error. So, based on the single sample mean value we estimate the standard error using the following formula. We can find the standard error for single or more sample mean value known

Standard error for single sample mean is known

$$(SE) = \frac{SD}{\sqrt{n}}$$

Where SD is standard deviation and n is the number of observation in sample

Standard error for two sample mean is known

$$(SE) = \sqrt{\frac{SD_1^2}{n_1} + \frac{SD_2^2}{n_2}}$$

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Where SD1 and SD2 are standard deviations of the first and second sample, n1 and n2 are number of samples of two samples

Standard error for single proportion is known

$$(SE) = \sqrt{\frac{PQ}{n}}$$

Where P is percentage of occurrence and Q is 100 – p and n is the number of observation in sample.

Standard error for two proportion is known

$$(SE) = \sqrt{\frac{P_1Q_1}{n_1} + \frac{P_2Q_2}{n_2}}$$

Where, P_1 and P_2 is percentage of occurrence of the two samples and Q_1 and Q_2 is $100 - P_1$ or P_2 and n1 and n2 are number of observations in two samples.

Example: From the sample of 100 normal babies the mean birth weight is 2.5 Kgs with SD of 0.25 Kgs. What would be the birth weight in the population with 95% confidence level.

Standard Error for the given data is

$$(SE) = \frac{SD}{\sqrt{n}} = 0.25/10 = 0.025$$

So, with 95% confidence level the population mean birth weight is mean ± 2SE (2.5 ± 2* 0.025) i.e. (2.45 to 2.55). We interpret this as with 95% confidence interval, the population means birth weight may lie between (2.45 to 2.55).

TESTING OF HYPOTHESIS

Hypothesis. It is an assumption that is made before investigation regarding the outcome under study. Hypothesis is made because it can be tested scientifically using statistical procedure.

A test procedure used to decide whether a hypothesis is to reject or not is called testing of hypothesis. Steps are as follows:

Step 1. Set the hypothesis

Null hypothesis (Ho): It is the hypothesis which assumes that there is no significant difference between the two values.

Alternate hypothesis (H_1): It is the hypothesis, which assumes there is significant difference.

Step 2. Choose level of significance (α)

While testing hypothesis you would make two types of errors Type one error (α) and type II error (β). Type one error is when null hypothesis is actually true we reject it and type II error is when null hypothesis not true we accept null hypothesis (Table 51.3). The experimenter does not like to commit these types of error or will see to it that both are committed with least chance. When we try to minimise one type of error, other type of error will increase and vice versa. So, we fix the probability of committing type I error (α) also called level of significance (l.o.s.) and minimise the chances of committing the second type of error by increasing the samples. Here 5% l.o.s. means experimenter runs a risk of making wrong decision only in 5 out of 100 cases. In other words, correct null hypothesis would be rejected in 5 out of 100 cases, i.e. we are about 95% confident that we have made the correct decision, and we could be wrong only with probability of 0.05.

Table 51.3 Errors in testing hypothesis

Result Based on Population Null Hypothesis	Result Based on Sample Null Hypothesis	
	Accepted	Rejected
True	Correct decision	Type I Error (α)
False	Type II Error (β)	Correct decision

Step 3. Compute the value of test statistic: critical ratio

Test statistic (critical ratio) = Observed difference / SE

Here, we find the difference observed between two groups in their means, proportion or parameter under study so that to know whether the difference falls within the confidence interval or not to decide whether the difference is significant or not.

Step 4. Obtain the table value at given l.o.s. and for the number of degrees of freedom

Here, we obtain the maximum allowable difference in terms of standard error, which can be considered as acceptable for null hypothesis. This is obtained from the standard tables in the book. Table value depends on the α error and degrees of freedom.

Step 5. Compare critical ratio value with that of table value

Step 6. Draw the conclusion

Reject Ho if calculated value is > table value.

Accept Ho if calculate value is < table value.

Example : Comparison of anxiety scores between hypertensive and normal subjects to know whether they differ in anxiety scores

Hypertensive : Mean $\bar{X}_1 = 5.91$, $SD_1 = 1.2$, $n_1 = 100$

Normal : Mean $\bar{X}_2 = 3.90$, $SD_2 = 1.3$, $n_2 = 100$

Test the difference in mean anxiety scores between the two groups at 5% level of significance.

Testing of hypothesis procedure

1. **State the hypothesis**
   Null Hypothesis H_0: No significant difference in mean anxiety scores b/w Hypertensive's and normal's
   Alternate Hypothesis H_1: There is significant difference in mean anxiety scores b/w Hypertensive's and normal's
2. **Level of significance** (α)

   α error = 5%

3. **Critical ratio**
   Since we have considered large number of samples in both the group, we assume data follow normal

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distribution, so Z test static is being used for comparison. Z – test statistic is given by

$$Z = \frac{X_1 - X_2}{\sqrt{\frac{SD_1^2}{n_1} + \frac{SD_2^2}{n_2}}}$$

$$= 5.91 - 3.90/\sqrt{1.2*1.2/100 + 1.3*1.3/100} = 11.36$$

4. **Table value : For 5% level of significance**

   Z table value is = 1.96

5. **Draw conclusion**

   Since Critical value (11.36) is > Table value (1.96), we reject the null hypothesis.

   We infer that there is statistically significant difference in mean anxiety scores between Hypertensive's and normal's.

Tests of Significance

There are various tests used for testing the hypothesis like t –test, chi-square test and ANOVA. Using these tests depends on the data distribution type. Appropriate test should applied to get less error in the result.

There are two types of tests of significance a) Parametric test and b) Non-Parametric test (Table 51.4).

Parametric tests

Parametric uses parameter like mean, SD or proportion for comparison, which is called as parameter. These test has certain assumption. If one of the assumption fails to satisfy then parametric test cannot be used then we need to use non-parametric test which is equivalent to that parametric test. The assumptions are a) data should have been drawn from normally distributed population, b) standard deviation of comparable group should be not significant and c) data should have been measured in interval or ratio scale.

Nonparametric tests

These tests have no assumption. The advantages of these tests are a) Can deal with nominal and ordinal data b) Can be used where mean and SD can be found and c) very few assumptions.

CORRELATION AND REGRESSION

Correlation

Sometimes we may be interested to study whether there is any mutual relationship between two variables under consideration. Relationship or association between two quantitatively measured variables is called correlation. The extent or degree of relationship is measured in terms of correlation co-efficient and it is denoted by 'r'. It varies between $-1 \leq r < 1$. This value shows how close the relationship exists between the two variables.

Based on the extent of correlation or relationship, it has been classified into five different types, they are:

1. Perfect positive correlation — Here r = 1
2. Perfect negative correlation — Here r = −1
3. Moderate positive correlation — Here $0 < r < 1$
4. Moderate negative correlation — Here $-1 < r < 0$
5. Absolutely no correlation — Here r = 0

Suppose, we have two variables X and Y, and we have 'n' individual values of both the variables, then correlation co-efficient is calculated as:

$$'r' = \Sigma\left(X - \overline{X}\right)\left(Y - \overline{Y}\right) / \sqrt{\Sigma\left(X - \overline{X}\right)^2 \Sigma\left(Y - \overline{Y}\right)^2}$$

Regression

Regression analysis enables to predict the value of one character from the knowledge of the other character value provided if they are linearly correlated. Regress means falling back. Regression analysis helps find the risk factor, which is associated with the outcome variable. For example, the linear correlation and prediction analysis based on the graph are given in the following (Fig. 51.8),

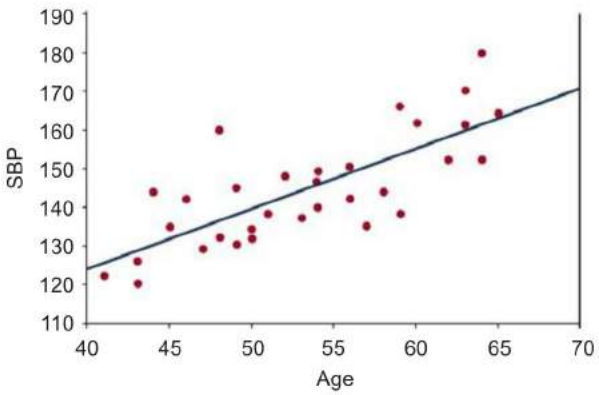


Figure 51.8 Correlation between age and systolic blood pressure.

Table 51.4 Table of parametric and non-parametric test

Comparison Between	Parametric Test	Non-parmetric Test	Bi-nomial Outcome
Two different groups	Independent t test	Mann-whitney U test	Chi-square test
Two Repeated values from same group	Paired t test	Wilcoxson signed rank test	Mc-Nemar's test
More than two groups	ANOVA test	Kruskal Wallis test	Chi-square test
More than two repeated values from the same group	Repeated ANOVA test	Friedman test	-

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Here, graphically we can predict that the SBP for the age above 70 since it is increasing linearly. Extend the line till the age for which the SBP need to drawn and look at the SBP value until which the line has extended. The earlier graph depicts the age and SBP are linearly correlated. To predict the SBP based on age, a co-efficient is required which gives, how much change exist by one unit change in age. This change is called as regression co-efficient. This can be estimated by the formula given in the following, which is called as Regression co-efficient and it is denoted by (β).

$$\beta = \frac{\sum (X-\bar{X})(Y-\bar{Y})}{\sum (X-\bar{X})}$$

The equation to estimate the dependent variable outcome based on independent variable is given by

$Y = \beta(X) + \alpha$ where X is independent variable and Y is dependent variable.

CONCLUSION

Biostatistics is an inevitable part of epidemiological tool that most people make use of it and consists more of mathematical calculations to which the statisticians are more adapted. Health information is an integral part of the national health system and it is a basic tool of management for the progress of any society. The primary objective of a health information system is to provide reliable, relevant, up-to-date, adequate and reasonably complete information for health managers at all levels and selling of technical and scientific information by all health personnel participating in the health services. However, most of the today's medical and dental students are not making use of this type of health information adequately. But all of them will become consumers of research and will need to understand the inferential statistical principles behind the reports that they read. That is why all of them should have some knowledge regarding biostatistics.

REVIEW QUESTIONS

1. Write notes on:
   a. presentation of data
   b. measures of central tendency
   c. measures of dispersion
   d. normal curve
   e. tests of significance
   f. probability sampling
   g. non-probability sampling

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Definitions and Glossary

APPENDIX A

AGENT
A substance living or non-living, or a force tangible or intangible, the excessive presence or relatively lack of which initiate or perpetuate a disease process.

ALLERGY
An abnormally high sensitivity to certain substances, such as pollens, foods, or microorganisms.

AMPHIXENOSES
Infections maintained in both man and lower vertebrate animals that *may* be transmitted in either direction.

ANTHROPOLOGY
Anthropology is the science of studying man/woman in terms of their physical, social, cultural characteristics.

ANTHROPOZOONOSES
Infections transmitted from vertebrate animals to man.

ARRESTED CARIES
Carious lesion which becomes arrested at any stage of caries process, due to changes in the causal factors, or increased protective factors, leading to open, self-cleansing, discolored, hard dentine lesion.

ATTACK RATE
The number of new cases of a specified disease, occurring in a specified population during a specified time interval.

ATTRIBUTABLE RISK (AR)
Attributable risk is defined as "the difference in the incidence rates of disease (or death) between an exposed group and non-exposed group."

AUXILIARY
A dental auxiliary is a person who is given responsibility by the dentist, so that he or she can help dentist in rendering dental care, but who is not himself or herself qualified with a dental degree.

BALANCED DIET
Balance diet is defined as one, which contains varieties of food in such quantities and proportion that need for energy, amino acids, vitamins, minerals, fats, carbohydrates, and other nutrients is adequately met for maintaining health, vitality and general wellbeing and also makes small provisions for extra nutrients to withstand short duration of leanness.

BASIC HEALTH SERVICE: WHO/UNICEF 1965
A basic health service is understood to be a network of co-ordinated peripheral and intermediate health units capable of performing effectively a related group of functions essential to the health of an area, and assuring the availability of competent professional and auxiliary personnel to perform these functions.

BIAS
Any systematic error in the determination of the association between exposure and disease.

BIOLOGICAL ENVIRONMENT
It is the universe of living things, which surrounds man including man himself.

BIOMEDICAL WASTE
Any waste which is generated during the diagnosis, treatment or immunization of human beings or animals, or in research activities pertaining thereto or in the production or testing of biologicals.

BIOSTATISTICS
It is the method of collection, organizing, analyzing, tabulating and interpretation of data related to living organisms and human beings.

CALCULUS [Greene 1967]
Calculus is defined as a deposit of inorganic salts composed primarily of calcium carbonate and phosphate mixed with food debris, bacteria and desquamated epithelial cells.

CALIBRATION
It is a procedure or an exercise carried out before conducting an epidemiological survey to get valid, reliable data by ensuring uniform interpretation through standardization of the procedures, measurements and instruments by proper training of all examiners, and minimizing inter and intra examiner variations.

CARRIER
Defined as an infected person or animal that harbours a specific infectious agent in the absence of discernible clinical disease, and serves as a potential source of infection for others.

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CASE
Is defined as "a person in the population or study group identified as having the particular disease, health disorder or condition under investigation".

CASE FATALITY RATE
Is defined as the ratio of number of deaths due to a disease to the total number of cases due to the same disease.

CENSUS
Is the total process of collecting, compiling, and publishing demographic, economic and social data pertaining at a specified time or times to all persons in a country or delimited territory.

CHILD MORTALITY RATE
Is defined as "the number of deaths at ages 1–4 years in a given year per 1000 children in that age group at the midpoint of the year concerned".

COHORT
Is defined as a group of people who share common characteristics or experience within a defined time period.

COLD CHAIN
It is a system of storage and transport of vaccines at low temperature from the manufacturer to the actual vaccination site.

COMMUNITY [Osborn & Neumayer]
A group of people living in a contiguous geographic area, having centres of interest and functioning together in the chief concerns of life.

It is a social group of individuals living in a given area and having a degree of "we" feeling.

COMMUNITY DENTISTRY
It is that branch of dentistry, which is practised in relation to population, and group, which derives from epidemiology an awareness of service required to organize the application of these services for the benefit of the population.

COMMUNITY DIAGNOSIS
Generally refers to the identification and quantification of health problems in a community in terms of mortality and morbidity rates and ratio, and the identification of these correlates for the purpose of defining those individuals or groups at risk or those in need of health care.

COMMUNITY HEALTH
Defined as including all the personal health and environmental services in any human community irrespective of whether such services are public or private ones.

COMMUNITY MEDICINE
Is that specialty which deals with populations, and comprises those doctors who *try* to measure the needs of the people both sick and well, who plan and administer services to meet those needs and those who are engaged in research and teaching in the field.

COMMUNICABLE DISEASE
An illness due to a specific infectious agent or its toxic products capable of being directly or indirectly transmitted from man to man, animal to animal, or from the environment (through air, dust, soil, water, food etc.) to man or animal.

COMMUNICABLE PERIOD
Is defined as the time during which an infectious agent *may* be transferred directly or indirectly from an infected person to another person, from infected animal to man, or from an infected person to an animal including arthropods.

COMPREHENSIVE DENTAL CARE
Defined as "a process of providing preventive, therapeutic and maintenance care necessary for function, aesthetics and integrity of oral tissues with balanced consideration to patient's physical, social, economic and psychosomatic status."

CONCEPT OF DISEASE [Webster]
A condition in which *body* health is impaired, a departure from a state of health and alteration of human *body,* interrupting the performance of vital functions.

CONFOUNDING FACTOR
It is defined as one, which is associated both with exposure and disease and is distributed unequally in study and control groups.

CONTAMINATION
Is defined as the presence of an infectious agent on a body surface, also on or in clothes, bedding, toys, surgical instruments, or substances including water, milk and food.

CONTAGIOUS
A disease that is transmitted through contact.

CROSS-SECTIONAL STUDY
It is based on a single examination of a cross-section of population at one point in time, the result of which can be projected on the whole population.

CRUDE DEATH RATE
Is defined as "the number of deaths per 1000 population per *year* in a given community."

CULTURE
May be defined as a shared and organized body of customs, skills, ideas and values, which are transmitted socially from one generation to another.

DENTAL CARIES
It is defined as sucrose-dependent microbial disease of multifactorial nature affecting the calcified tissues of the teeth, characterized by demineralization of the inorganic portion and destruction of the organic portion of the tooth.

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DENTAL FLUOROSIS
Is a hypoplasia or hypomineralisation of tooth enamel or dentine produced by the chronic ingestion of excessive amounts of *fluoride* during the period when teeth are developing.

DENTAL HEALTH [WHO 1970]
Is the state of complete normality and functional efficiency of the teeth and the supporting structures and also surrounding parts of the oral cavity and of the various structures related to mastication and maxillo-facial complex.

DENTAL HEALTH EDUCATION
It is defined as the provision of oral health information to people in such a way that people adopt and maintain healthy practices and lifestyle and apply in everyday living.

DENTAL PRACTICE MANAGEMENT
Is defined as the process of obtaining and allocating inputs (human and economic resources) by planning, organizing, staffing, directing and controlling for the purpose of outputs (dental services) desired by patients, so that practice objectives are achieved.

DENTAL PUBLIC HEALTH (AMERICAN BOARD OF DENTAL PUBLIC HEALTH)
The science and art of preventing and controlling dental disease and promoting dental health through organized community efforts.

It is that branch of dentistry or that form of dental practice which serves the community as a patient, rather that the individual. It is concerned with the dental health education of the public with research and application of the findings of research. With the administration of programmes of dental care for groups and with the prevention and control of dental diseases through a community approach.

DENTAL ASSISTANT
Is a non-operating auxiliary who assists the dentist or dental hygienist in treating patients but who is not legally permitted to treat independently.

DENTAL HYGIENIST
Is an operating auxiliary, licensed and registered to practice dental hygiene under the laws of the appropriate state, province, territory or nation.

DENTAL LABORATORY TECHNICIAN
Is a non-operating auxiliary who fulfils the prescriptions provided by dentists regarding the extraoral construction and repair of oral appliances.

DENTIFRICE
It is mixture used to clean the tooth surface in conjunction with toothbrush.

DENTIST
A dentist is a person licensed to practise dentistry under the laws of the appropriate state, province, territory or nation.

DENTURIST
Is a term applied to those dental laboratory technicians who are permitted in some states in the United States, some provinces of Canada, and in some other countries to fabricate dentures directly for patients without a dentist's prescription.

DIET
Defined as total oral intake of substances that provide nutrition and energy.

DISABILITY (WHO 1982)
Is any restriction or lack of ability (resulting from an impairment) to perform an activity in the manner or within the range considered normal for a human being.

DISASTER
Any occurrence that causes damage, ecological disruption, loss of human life or deterioration of health and health services on scale sufficient to warrant an extraordinary response from outside the affected community or area.

DISCLOSING AGENT
A dye used in dentistry as a diagnostic aid, applied to the teeth to reveal the presence of dental plaque.

DOUBLE BLIND STUDY
The study, which is so planned that neither the doctor nor the participant is aware of the group allocation and the treatment received.

EARLY DIAGNOSIS
WHO Expert Committee defined early detection of health impairment as "the detection of disturbances of homeostatic and compensatory mechanism while biochemical, morphological, and functional changes are still reversible."

ECOLOGY
Is the science of mutual relationship between living organisms and their environment.

ECOLOGY OF HEALTH
Is the study of the relationship between variations in man's environment and his state of health.

ENVIRONMENT
Can be defined as the sum total of all conditions and influences that affect the development and life of an organism.

ENVIRONMENTAL SANITATION (WHO)
It deals with control for all those factors in man's physical environment, which exercise or may exercise a deleterious effect on his/her physical development, health and survival.

ENDEMIC
It refers to the constant presence of a disease or infectious agent, within a given geographic area or population

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groups without importation from outside, may also refer to the usual or expected frequency of the disease within such area or population group.

ENZOOTIC
An endemic occurring in animals.

EPIDEMIC
The unusual occurrence in a community or region, of disease, specific health related behaviour or other health related events clearly in excess of normal expected occurrence.

EPIDEMIOLOGY (EG CLARK, 1965)
"A science concerned with the study of factors that influence the occurrence and the distribution of health, disease, disability or death among groups of individuals."

ERADICATION
It is the termination of all transmission of infection by extermination of infectious agent through surveillance and containment.

ETHICS
The science of ideal human character and behaviour in situations where distinction should be made between right and wrong, duty must be followed, and good interpersonal relations maintained.

EVALUATION
Evaluation is the process by which results are compared with the intended objectives, or more simply the assessment of how well a programme is performing.

EXPECTANCY OF LIFE
The average number of years that will be lived by those born alive into a population if the current age-specific mortality rate persists.

EXOTIC
Diseases, which are imported into a country in which they do not otherwise occur.

FAMILY PLANNING (WHO expert committee, 1971)
A way of thinking and living that is adopted voluntarily upon the basis of knowledge, attitudes and responsible decisions by individuals and couples in order to promote the health and welfare of the family group, and thus contribute effectively to the social development of a country.

FOOD ADDITIVES
Non-nutritious substances, which are added intentionally to food, generally in small quantity, to improve its appearance, flavour, texture or storage properties.

FOOD FORTIFICATION
Process where by the nutrients are added to foods in relatively small quantities to maintain or improve the quality of the diet of a group, a community or a population.

HABIT
A recurrent, often unconscious pattern of behaviour that is acquired through frequent repetition.

HANDICAP [WHO 1980]
Is a disadvantage for a given individual resulting from impairment or disability that limits or prevents the fulfillment of a role that is normal (depending on age, sex and social and cultural factors) for that individual.

HEALTH [WHO 1948]
A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

HEALTH EDUCATION (NATIONAL CONFERENCE ON PREVENTIVE MEDICINE, USA)
Is defined as the process which informs, motivates and helps people to adopt and maintain healthy practices and lifestyles, advocates environmental changes as needed to facilitate this goal, and conducts professional training and research to the same end.

HEALTH FOR ALL
Defined as the organized application of local, national and international resources to achieve health for all, i.e. Attainment by all people of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life."

HEALTH CARE
It is defined as "a multitude of services rendered to individuals, families or communities by the agents of the health services or professions, for the purposes of promoting, maintaining, monitoring or restoring health".

HEALTH PROTECTION
Health protection is defined as "the provision of conditions for normal mental and physical functioning of the human being individually and in the group. It includes the promotion of health, the prevention of sickness and curative and restorative medicine in all its aspects."

HEALTH PROMOTION [WHO]
Health promotion is a process of enabling individuals to improve their health through personal choice and social responsibility.

HERD IMMUNITY
It is a level of resistance of the community or group of people to a particular disease.

HOLOENDEMIC
A high level of infection beginning early in life and affecting most of the child population, leading to a state of equilibrium such that the adult population shows evidence of the disease much less commonly than do the children.

HOMEOSTASIS
The state of physiological/dynamic equilibrium between internal and external environment.

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HOST
A person or other animal including birds and arthropods, that affords subsistence or lodgment to an infectious agent under natural conditions.

HYGIENE
Is defined as the science of health and embraces all factors, which contribute to healthful living.

HYPERENDEMIC
It expresses that the disease is constantly present at a high incidence and/or low prevalence rate, and affects all age groups equally.

HYPOTHESIS
It is a supposition arrived at from observing or reflection.

IATROGENIC
Any untoward or adverse consequences of a preventive, diagnostic or therapeutic regimen or procedure, that causes impairment, handicap, disability or death resulting from a physician's professional activity or from other health professionals.

IMPAIRMENT [WHO 1980]
Any loss of or abnormality of psychological, physiological or anatomical structure or function.

INCIDENCE
Incidence rate is defined as "the number of new cases occurring in a defined population during a specified period of time."

INCIPIENT CARIES
It is an early carious lesion manifesting at the subsurface of the enamel, leading to appearance as white opaque region.

INCREMENTAL CARE
Periodic care so spread that increments of dental diseases are treated at the earliest time consistent with proper diagnosis and operating efficiency, in such a way that there is no accumulation of dental needs beyond the minimum.

INCUBATION PERIOD
The time interval between invasion by an infectious agent and appearance of first sign or symptom of the disease in question.

INDEX (RUSSEL, 1969)
An index has been defined as a numerical value describing the relative status of a population on a graduated scale with definite upper and lower limits, which is designed to permit and facilitate comparison with other populations classified by the same criteria and methods.

INFANT MORTALITY RATE
It is the ratio of deaths under one year of age in a given year to the total number of live births in the same year; usually expressed as a rate per 1000 live births.

INFECTION
The entry and development or multiplication of an infectious agent in the body of man or animals, causing infection.

INFECTIOUS DISEASE
A clinically manifested disease of men or animals resulting from an infection.

INFESTATION
In persons or animals, the lodgment, development and reproduction of arthropods on the surface of the body or in the clothing.

INFECTIVITY
It is defined as the ability of an infectious agent to invade and multiply, produce infection in a host.

IMMUNITY
It is possessing specific protective antibodies or cellular immunity as a result of previous infection or immunization.

INTERVENTION
Can be defined as any attempt to intervene or interrupt the usual sequence in the development of disease in man.

INTERCEPTIVE ORTHODONTICS
Is that phase of the science and art of orthodontics employed to recognize and eliminate potential irregularities and malpositions in the developing dentofacial complex.

ISOLATION
Separation for the period of communicability of infected person or animals from others, in such places and under such conditions, as to prevent or limit the direct or indirect transmission of the infectious agents from those infected to those who are susceptible or who *may* spread the agent to others.

JURISPRUDENCE
Is the philosophy of law or the science that treats the principles of law and legal relations.

LATENT PERIOD
It is the period from disease initiation to disease detection.

LEVEL OF LIVING
As per United Nations documents "level of living" consists of nine components: health, food consumption, education, occupation and working conditions, housing, social security, clothing, recreation and leisure, and human rights.

LICENSURE
It is the process by which an agency of government grants permission to those meeting predetermined qualifications to engage in a given occupation and use a particular title or by which it grants permission to institutions to perform specified functions.

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LONGITUDINAL STUDY
It is defined as a study in which the same individuals are examined on repeated occasions and changes within a group are recorded in lapse of time.

MACRO-ENVIRONMENT
It is defined as all that which is external to the individual human host, living and non-living and with which he/she is in constant interaction.

MALNUTRITION (WHO)
Is a pathological state resulting from a relative or absolute deficiency or excess of one or more essential nutrients.

MANPOWER
Is defined as individuals with the kind of knowledge, skills and attitudes needed to achieve predetermined health targets and ultimately health status objectives.

MATCHING
Matching is defined as the process by which controls are selected in such a *way* that they are similar to cases with regard to certain pertinent selected variables (e.g. age) which are known to influence the outcome of disease, and which if not adequately matched for comparability could distort or confound the results.

MATERIA ALBA
Materia alba is a deposit composed of aggregate of microorganisms, leucocytes and dead exfoliated epithelial cells, randomly organized and loosely adherent to the surfaces of the teeth, plaque and gingiva.

MATERNAL DEATH
Deaths associated with complication of pregnancy, childbirth and puerperium.

MENTAL HEALTH
A state of balance between the individual and the surrounding world, a state of harmony between oneself and other and co-existence between the realities of the self and that of other people, and that of the environment.

MODES OF INTERVENTION
Is defined as any attempt to intervene or interrupt the usual sequence in the development of disease in man.

MONITORING
It is defined as the performance and analysis of routine measurements aimed at detecting changes in the environment or health status of populations.

MORBIDITY
Is defined as any departure, subjective or objective, from a state of physiological wellbeing.

MORTALITY RATE
The total number of deaths due to a disease or condition in a general population or in a community that is not just among cases.

MOTIVES
Emotional emerging forces, which bring certain features of belief to the forefront of consciousness, make personal and immediate changes, and push the person towards acting upon them.

MOTIVATION
There is a fundamental desire of learning new things in every human being; awakening this desire of learning is called motivation.

NATIONAL HEALTH POLICY
A national health policy is an expression of goals for improving the health situation of the people and to attain the goal of health for all. Health policy is often defined at national level.

NATIONAL PATH FINDER SURVEY
It is a collection of data incorporating sufficient examination sites to cover all important subgroups of the population that may have differing disease level or treatment needs, and at least three of the age groups are index ages, for the planning and monitoring of the services.

NEONATAL DEATH
Deaths occurring under 28 days of age.

NOSOCOMIAL INFECTION
Nosocomial infection (hospital acquired) is an infection originating in a patient while in a hospital or other health care facility.

NUTRITION
The science of nourishing the body properly or adequately for its growth, development, maintenance and repair.

ODDS RATIO (OR)
It is a measure of the strength of association between risk factor and outcome.

OPPORTUNISTIC INFECTION
This is infection by an organism that takes the opportunity provided by a defect in host defence to infect the host and hence cause disease.

ORAL HEALTH SURVEY [WHO]
Basic oral health surveys are defined as surveys to collect the basic information about oral disease status and treatment needs that is needed for planning or monitoring oral health.

ORAL HYGIENE
The practice of keeping the mouth, teeth, and gums clean and healthy, to prevent occurrence of disease, by regular toothbrushing, flossing and rinsing.

ORAL HYGIENE AIDS
Oral hygiene aids are the tools or materials used in the mouth to remove food residue, stain and plaque, a

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bacterial film that causes tooth decay (dental caries), periodontal disease, and halitosis (bad breath).

OUTBREAK
"The sudden, unexpected pronounced increase in the occurrence of disease, usually focal or confined to a limited segment of the population."

PANDEMIC
An epidemic usually affecting a large proportion of the population occurring over a wide geographic area such as a section of a nation, the entire nation, a continent, or the world.

PATHFINDER SURVEY
It is a survey, a sampling methodology to collect relevant information about factors associated with the most common oral diseases in the most important population subgroups.

PERINATAL DEATH
Deaths occurring after 28 weeks of fetal life, in labour or in first week after birth.

PERIOD PREVALENCE
Is defined as the frequency of all current cases (old and new) existing during a defined period of time, expressed in relation to a population.

PHYSICAL ENVIRONMENT
It is applied to non-living things and physical factors (e.g. air, water, soil, housing, climate etc.) with which man is in constant interaction.

PILOT SURVEY
It is one, which provides minimum amount of data, which includes only the most important subgroups in the population and only one or two index ages, usually 12 years and one other age group.

PIT AND FISSURE SEALANT (GORDON)
Defined as materials, which are designed to prevent pit and fissure caries when they are applied to the occlusal fissures, and remove the sheltered environment in which caries may thrive, forming a mechanical, physical protective layer against the action of caries bacteria and substrates.

PLAQUE
It is a specific, but highly variable structural entity resulting from colonization of microorganisms on tooth surfaces, restorations and other parts of oral cavity which consists of salivary components like mucin, desquamated epithelial cells, debris and microorganisms, all embedded in a gelatinous extra-cellular matrix.

POINT PREVALENCE
Is defined as the number of all current cases (old and new) of a disease at one point in time in relation to a defined population.

POPULATION MEDICINE
It is referred to the activities in the fields of hygiene, public health, preventive medicine, social medicine or community medicine. These share common ground in their concern for promotion of health and prevention of disease.

POSITIVE HEALTH [WHO]
Implies that a person should be able to express as complete as possible, the potentialities of his/her genetic heritage.

PREVALENCE
All current cases (old and new) existing at a given point in time or over a period of time in a given population.

PREVENTIVE DENTISTRY
Procedure employed in practice of dentistry and community dental health programmes, which prevent occurrence of oral disease and oral abnormalities.

PREVENTIVE MEDICINE
Has been defined as meaning "not only the organized activities of the community to prevent occurrence as well as progression of disease and mental and physical disability, but also the timely application of all means to promote the health of individuals and of the community as a whole, including prophylaxis, health education and similar work done by a good doctor in looking after individuals and families."

PRIMARY HEALTH CARE [WHO]
It is defined as "Essential health care based on practical, scientifically sound and socially acceptable methods and technology, made universally accessible to individuals and families in the community through their full participation and at a cost that the community and the country can afford to maintain at every stage of their development in the spirit of self-determination."

PRIMARY PREVENTION
Actions taken prior to the onset of disease, which removes the possibility that a disease will ever occur.

PRIMORDIAL PREVENTION
Primordial prevention is prevention of emergence or development of risk factors in countries or population groups in which they have not yet appeared.

PROPORTION
It is a ratio, which indicates the relation in magnitude of a part of the whole.

PROSODEMIC
Pertaining to infections that maintain themselves in human populations by a variety of mechanisms of transmission.

PROSPECTIVE COHORT STUDY
It is one in which the outcome (e.g. disease) has not yet occurred at the time the investigation begins.

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PSYCHOSOCIAL ENVIRONMENT
It includes a complex of psychosocial factors, which are defined as "those factors affecting personal health, health care and community wellbeing, that stem from the psychosocial make-up of individuals and the structure and functions of social groups."

PUBLIC HEALTH (WHO Expert Committee)
Defined as "the science and art of preventing disease, prolonging life and promoting health and efficiency through organized community efforts, for the sanitation of the environment, the control of communicable infections, the education of the individual in personal hygiene, the organization of medical and nursing services for early diagnosis and preventive treatment of disease, and the development of social machinery to ensure for every individual, a standard of living adequate for the maintenance of health, so organizing these benefits as to enable every citizen to realize his birthright of health and longevity."

QUALITY OF LIFE [WHO]
Defined as the condition of life resulting from the combination of the effects of the complete range of factors such as those determining health, happiness (including comfort in the physical environment and a satisfying occupation) education, social and intellectual attainments, freedom of action, justice and freedom of expression.

QUARANTINE
The limitation of freedom of movement of such well persons or domestic animals exposed to communicable diseases for a period of time, not longer than the usual incubation period for the disease in such a manner as to prevent effective contact with those not so exposed.

RAMPANT CARIES
Defined as caries process, which occurs as a sudden, rapidly progressing and almost uncontrollable destruction of teeth, involving surfaces of the teeth that are ordinarily relatively caries resistant.

RANGE
It is the simple measure of dispersion—the difference between smallest and largest values in data.

RANDOM SAMPLING
It is a sampling procedure in which every element in the population has an equal and independent chance of being selected.

RANDOMISATION
It is a statistical procedure by which the participants are allocated into groups usually called "study" and "control groups", to receive or not to receive an experimental preventive or therapeutic procedure or intervention.

RATE
Rate is a proportion with a defined denominator, termed as population, during a given time period.

RATIO
It expresses a relation in the size between two random quantities.

REHABILITATION [WHO]
Is defined as "the combined and co-ordinated use of medical, social, educational and vocational measures for training and retraining the individual to the highest possible level of functional ability."

RETROSPECTIVE COHORT STUDY
It is one in which the outcome has occurred before the start of the investigation.

RISK FACTOR
It is defined as an attribute or exposure that is significantly associated with the development of a disease.

RISK ASSESSMENT
A professional judgment on an individual's susceptibility or resistance to disease, based on evidence based information.

RISK RATIO (RR)
It is defined as the ratio between the incidence of disease among exposed persons and incidence among non-exposed.

RELATIVE RISK (RR)
It is the ratio of incidence of the disease (or death) among exposed and incidence among non-exposed.

RESERVOIR
Is defined as "any person, animal, arthropod, plant, soil or substance (or combination of these) in which an infectious agent lives and multiplies, on which it depends primarily for survival, and where it reproduces itself in such manner that it can be transmitted to a susceptible host.

SAMPLE
It is the representative part of a whole group of people or population to be studied.

SCREENING
The search for unrecognized disease or defect by means of rapidly applied tests, examinations or other procedures in apparently healthy individuals.

SECONDARY ATTACK RATE (SAR)
Is defined as "the number of exposed persons developing the disease within the range of the incubation period, following exposure to the primary cause."

SECONDARY CARIES
Occurrence of carious lesion, which develops at the interface of any restoration and cavosurface of the enamel.

SECONDARY PREVENTION
It can be defined as "action which halts the progress of a disease at its incipient stage and prevents complications."

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SEGREGATION
The separation for special consideration, control of observation of some part of group of persons from the others, to facilitate control for communicable disease.

SENSITIVITY
Ability of a test to identify correctly all those who have the disease, that is "true positive."

SENTINEL SURVEILLANCE
It is a method for identifying the missing cases and thereby supplementing the notified cases required.

SINGLE BLIND STUDY
The study is so planned that the participant is not aware whether he/she belongs to study or control group.

SOCIAL DIMENSION
Quantity and quality of an individual interpersonal ties and the extent of involvement with the community.

SOCIAL MEDICINE
Social medicine is "the study of man as a social being in his/her total environment." It is concerned with all the factors affecting the distribution of health and ill health in population, including the use of health services.

SOCIETY
A group of individuals who have organized themselves and follow a given way of life.

SOURCE
The person, animal, object or substance from which an infectious agent passes or is disseminated to the host.

SPORADIC
The word sporadic means scattered about. The cases occur irregularly, haphazardly from time to time and generally infrequent.

SPECIFICITY
Ability of a test to identify correctly those who do not have the disease that is "true negative."

STANDARD OF LIVING (WHO)
Defined as income and occupation, standards of housing, sanitation and nutrition, the level of provision of health, educational, recreational and other services, *may* all be used individually as measures of socioeconomic status and collectively as an index of the "standard of living."

STATISTICS
It is the method of collecting, organizing, analyzing and interpreting of data.

STANDARD DEVIATION
It is the square root of the square deviation from the mean and dividing by the number of observations.

STERILIZATION
It is a process by which an article, surface or medium is freed of all microorganisms either in vegetative or spore state.

STILLBIRTH
It is defined as synonymous with late fetal death, i.e. one of 28 completed weeks of gestation or over.

SURVEILLANCE [WHO, 1981]
It is defined as "the continuous scrutiny of the factors that determine the occurrence and distribution of disease and other conditions of ill health."

TERTIARY PREVENTION
It is defined as "all measures available to reduce or limit impairments and disabilities, minimize suffering caused or by existing departures from good health and to promote the patients' adjustments to irremediable conditions."

TOOTH MORTALITY
Number of lost teeth divided by total number of teeth possible in the group.

TOOTH FATALITY
Number of missing teeth divided by decayed, missing, filled teeth.

TOXICITY
It is as a result of excessive or adverse action of drugs and other chemicals due to overdose or prolonged use resulting in functional alteration, changes in appearance and induced tissue damage.

TRANSPORT HOST
Is defined as a carrier in which the organism remains alive but does not undergo development.

TRIPLE BLIND STUDY
The study is so planned that the participant, the investigator and the person analyzing the data are all blind.

UTILIZATION OF SERVICES
It is expressed as the proportion of people in need of a service who actually receive it in a given period, usually in one year.

VECTOR
The term vector is commonly used to describe arthropods, which transmit infectious agents from human to human or from animal to human.

VEHICLE
A medium through which an infectious agent is conveyed to man, most commonly used with reference to drinking water or food.

VIRULENCE
It is defined as the proportion of clinical cases resulting in severe clinical manifestations (including sequelae).

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VITAL STATISTICS
Defined as the facts related to vital events systematically collected and numerically compiled.

WATER DEFLUORIDATION
Defined as "a downward adjustment of fluoride ion concentration in a public drinking water supply so that the level of fluoride is maintained at the normal physiological limit of 1 ppm to prevent dental caries with minimum possibility of causing dental fluorosis."

WATER FLUORIDATION
Defined as "an upward adjustment of fluoride ion concentration in a public drinking water supply so that the level of fluoride is maintained at the normal physiological level of 1 ppm to prevent dental caries with minimum possibility of causing dental fluorosis."

ZOONOSIS
An infection or infectious disease transmissible under natural conditions from vertebrate animals to man.

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APPENDIX B

WHO Oral Health Assessment Proforma (1997)

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WHO Oral Health Assessment Form (1997)

Country.....

Leave blank (1) ☐☐☐☐ (4) | Year Month (5) ☐☐☐☐ (8) | Day (9) ☐☐ (10) | Identification number (11) ☐☐☐☐ (14) | Examiner ☐ (15) | Original/duplicate ☐ (16)

GENERAL INFORMATION

Name.....

Date of birth (17) Year Month ☐☐☐☐ (20)

Age in years (21) ☐☐ (22)

Sex (M =1, F =2) ☐ (23)

Ethnic group ☐ (24)

Occupation ☐ (25)

Geographical location (26) ☐☐ (27)

Location type ☐ (28)
1 = Urban
2 = Periurban
3 = Rural

OTHER DATA (specify and provide codes)

..... ☐ (29)

CONTRAINDICATION TO EXAMINATION

Reason..... ☐ (31)

0 = No
..... 1 = Yes

CLINICAL ASSESSMENT

EXTRAORAL EXAMINATION

0 = Normal extra-oral appreance
1 = Ulceration, sores, erosions, fissures (head, neck, limbs)
2 = Ulceration, sores, erosions, fissures (nose, cheeks, chin)
3 = Ulceration, sores, erosions, fissures (commissures)
4 = Ulceration, sores, erosions, fissures (vermilion border)
5 = Abnormalities of upper and lower lips
6 = Enlarged lymph nodes (head, neck)
7 = Other swellings of face and jaws
8 = Not recorded

☐ (33)

TEMPOROMANDIBULAR JOINT ASSESSMENT

SYMPTOMS	SIGNS		
0 = No	0 = No	Clicking	☐ (34)
1 = Yes	1 = Yes	Tenderness (on palpation)	☐ (35)
9 = Not recorded	9 = Not recorded	Reduced jaw mobility (< 30 mm opening)	☐ (36)

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ORAL MUCOSA

CONDITION

0 = No abnormal condition
1 = Malignant tumour (oralcancer)
2 = Leucoplakia
3 = Lichen planus
4 = Ulceration (aphthous, herpetic, traumatic)
5 = Acute necrotizing gingivitis
6 = Candidiasis
7 = Abscess
8 = Other swellings of face and jaws

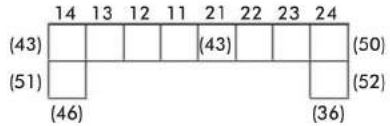
LOCATION

(37) ☐ ☐ (40)
(38) ☐ ☐ (41)
(39) ☐ ☐ (42)

0 = Vermillion border
1 = Commissures
2 = Lips
3 = Sulci
4 = Buccal mucosa
5 = Floor of mouth
6 = Tongue
7 = Hard and/or soft palate
8 = Alveolar ridges/gingiva
9 = Not recorded

ENAMEL OPACITIES/HYPOPLASIA

Permanent teeth
0 = Normal
1 = Demarcated opacity
2 = Diffuse opacity
3 = Hypoplasia
4 = Other defects
5 = Demarcated and diffuse opacities
6 = Demarcated opacity and hypoplasia
7 = Diffuse opacity and hypoplasia
8 = All three conditions
9 = Not recorded



FLUOROSIS

0 = Normal
1 = Questionable
2 = Very mild
3 = Mild
4 = Moderate
5 = Severe
8 = Excluded
9 = Not recorded

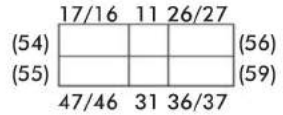
☐ (53)

COMMUNITY PERIODONTAL INDEX

PERIODONTAL STATUS (CPITN)

0 = Healthy
1 = Bleeding
2 = Calculus
3 = Pocket 4–5 mm (black band of the p partially visible)
4 = Pocket 6 mm or more (black band of probe not visible)
X = Excluded sextant
9 = Not recorded

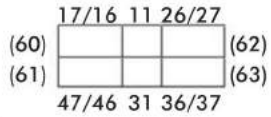
*Not recorded under 15 years of age



LOSS OF ATTACHMENT

0 = Healthy
1 = 4–5 mm (cemento enamel junction (CEJ) within black
2 = 6–8 mm (CEJ) within upper limit of black band & 8.5 m ring
3 = 9–11 mm (CEJ between 8.5 mm &11.5 mm rings)
4 = 12 mm or more (CEJ beyond 11.5 mm ring)
X = Excluded
9 = Not recorded ☐

*Not recorded under 15 years of age



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DENTITION STATUS AND TREATMENT NEEDS

		18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
		55	54	53	52	51	61	62	63	64	65							
Crown	(66)																	(61)
Root	(82)																	(97)
Treatment	(98)																	(113)

		48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38	
		85	84	83	82	81	71	72	73	74	75							
Crown	(114)																	(129)
Root	(130)																	(145)
Treatment	(146)																	(161)

Primary teeth Crown	Permanent teeth Crown/Root		STATUS	TREATMENT
A	0	0	Sound	0 = None
B	1	1	Decayed caries	P = Preventive and arresting care
C	2	2	Filled, with decay	
D	3	3	Filled, no decay	F = Fissure sealant
E	4	—	Missing, as a result of caries	1 = One surface filling
—	5	—	Missing, any other reason	2 = Two or more surface filling
F	6	—	Fissure sealant	3 = Crown for any reason
G	7	7	Bridge abutment Special crown or Veneer/implant	5 = Pulp care and restoration 6 = Extraction
—	8	8	Unerupted tooth, Crown/unexposed Root	7 = Need for other care (specify) 8 = for other care (specify)
T	T	—	Trauma (fracture)	
—	9	9	Not recorded	9 = Not recorded

PROSTHETIC STATUS

0 = No prosthesis
2 = More than one bridge
3 = Partilal denture
4 = Both bridge(s) and partial denture(s)
5 = Full removable denture
9 = Not recorded

Upper Lower
(162) [ ] [ ] (163)

PROSTHETIC NEED

0 = No prosthesis needed
1 = Need for one unit prosthesis
2 = Need for multi unit prosthesis
3 = Need for combination of one – and/or multi unit prosthesis
4 = Need for full prosthesis (replacement of all teeth)
9 = Not recorded

Upper Lower
(164) [ ] [ ] (165)

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DENTOFACIAL ANOMALIES

DENTITION

(162) ☐ (162)

Missing incisor, canine and premolar teeth-maxillary and mandibular–enter number of teeth

SPACE

☐ (168)

Crowding in the incisal segments

0 = No crowding

1 = One segment crowding

2 = Two segments crowding

☐ (169)

Spacing in the incisal segments

0 = No spacing

1 = One segment spaced

2 = Two segments spaced

☐ (170)

Diastema in mm

☐ (171)

Largest anterior maxillary irregularity in mm

☐ (172)

Largest anterior mandibular irregularity in mm

☐ (173)

Anterior maxillary overjet in mm

☐ (174)

Anterior maxillary overjet in mm

☐ (175)

Vertical anterior open bite in mm

☐ (176)

Anteroposterior molar relation

0 = Normal

1 = Half cusp

2 = Full cusp

NEED FOR IMMEDIATE CARE AND REFERRAL

Life threatening condition ☐ (177)

Pain or infection ☐ (178)

Other condition (specify)..... ☐ (179)

0 = Absent

1 = Present

2 = Not recorded

Referral

0 = No

1 = Yes

9 = Not recorded

☐ (180)

NOTES

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APPENDIX C

WHO Oral Health Assessment Form (2013)

World Health Organization

World Health Organization

Oral Health Assessment Form for Adults, 2013

Leave blank (1) (4) (5) Year Month Day (10) (11) Identification No. (14) Orig/Dupl (15) (16) Examiner (17)

General information: Sex 1=M, 2=F (18) (19) Date of birth (24) (25) Age in years (26)

(Name)

Ethnic group (27) (28) **Other group** (29) (30) **Years in school** (31) (32) **Occupation** (33)

Community (geographical location) (34) (35) **Location** Urban (1) Periurban (2) Rural (3) (36)

Other data (37) (38) **Other data** (39) (40)

Other data (41) (42) **Extra-oral examination** (43) (44)

Dentition status

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
Crown (45)																	(60)
Root (61)																	(76)
Crown (77)																	(92)
Root (93)																	(108)
	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38	

Permanent teeth

Status

0 = Sound
1 = Caries
2 = Filled w/caries
3 = Filled, no caries
4 = Missing due to caries
5 = Missing for any another reason
6 = Fissure sealant
7 = Fixed dental prosthesis/crown abutment, veneer, implant
8 = Unerupted
9 = Not recorded

Periodontal status (CPI Modified)

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
Bleeding (109)																	(124)
Pocket (125)																	(140)
Bleeding (141)																	(156)
Pocket (157)																	(172)
	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38	

Gingival bleeding

Score

0 = Absence of condition
1 = Presence of condition
9 = Tooth excluded
X = Tooth not present

Pocket

Score

0 = Absence of condition
1 = Pocket 4–5 mm
2 = Pocket 6 mm or more
9 = Tooth excluded
X = Tooth not present

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Oral Health Surveys Basic Methods

World Health Organization

World Health Organization
Oral Health Assessment Form for Adults, 2013

Loss of attachment

Severity
0 = 0–3 mm
1 = 4–5 mm Cemento-enamel junction (CEJ) within black band
2 = 6–8 mm CEJ between upper limit of black band and 8.5 mm ring
3 = 9–11 mm CEJ between 8.5 mm and 11.5 mm ring
4 = 12 mm or more CEJ beyond 11.5 mm ring
X = Excluded sextant
9 = Not recorded

* Not recorded under 15 years of age

Index teeth

17/16 11 26/27
(173) [ ][ ][ ] (175)
(176) [ ][ ][ ] (178)
47/46 31 36/37

Enamel fluorosis [ ] (179)

Severity
0 = Normal
1 = Questionable
2 = Very mild
3 = Mild
4 = Moderate
5 = Severe
8 = Excluded (crown, restoration, "bracket")
9 = Not recorded (unerupted tooth)

Dental erosion

Severity [ ] (180)

0 = No sign of erosion
1 = Enamel lesion
2 = Dentinal lesion
3 = Pulp involvement

Number of teeth affected

(181) [ ][ ] (182)

Dental trauma

Status [ ] (183)

0 = No sign of injury
1 = Treated injury
2 = Enamel fracture only
3 = Enamel and dentine fracture
4 = Pulp involvement
5 = Missing tooth due to trauma
6 = Other damage
9 = Excluded tooth

Number of teeth affected

(184) [ ][ ] (185)

Oral mucosal lesions

[ ] (186)
[ ] (187)
[ ] (188)

[ ] (189)
[ ] (190)
[ ] (191)

Condition

0 = No abnormal condition
1 = Malignant tumour (oral cancer)
2 = Leukoplakia
3 = Lichen planus
4 = Ulceration (aphthous, herpetic, traumatic)
5 = Acute necrotizing ulcerative gingivitis (ANUG)
6 = Candidiasis
7 = Abscess
8 = Other condition (specify if possible)
9 = Not recorded

Location

0 = Vermillion border
1 = Commissures
2 = Lips
3 = Sulci
4 = Buccal mucosa
5 = Floor of the mouth
6 = Tongue
7 = Hard and/or soft palate
8 = Alveolar ridges/gingiva
9 = Not recorded

Denture(s)

Upper [ ] (192) **Lower** [ ] (193)

Status

0 = No denture
1 = Partial denture
2 = Complete denture
9 = Not recorded

Intervention urgency [ ] (194)

0 = No treatment needed
1 = Preventive or routine treatment needed
2 = Prompt treatment (including scaling) needed
3 = Immediate (urgent) treatment needed due to pain or infection of dental and/or oral origin
4 = Referred for comprehensive evaluation or medical/dental treatment (systemic condition)

f0020

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World Health Organization

World Health Organization

Oral Health Assessment Form for Children, 2013

Leave blank (1) (4) (5) Year Month Day (10) (11) Identification No. (14) Orig/Dupl (15) (16) Examiner (17)

General information: Sex 1=M, 2=F (18) (19) Date of birth (24) (25) Age in years (26)

(Name)

Ethnic group (27) (28) **Other group** (29) (30) **Years in school** (31) (32) **Occupation** (33)

Community (geographical location) (34) (35) **Location** Urban (1) Periurban (2) Rural (3) (36)

Other data (37) (38) **Other data** (39) (40)

Other data (41) (42) **Extra-oral examination** (43) (44)

Dentition status

		17	16	55 15	54 14	53 13	52 12	51 11	61 21	62 22	63 23	64 24	65 25	26	27	
Crown	(45)															(58)
Crown	(59)															(72)
		47	46	85 45	84 44	83 43	82 42	81 41	71 31	72 32	73 33	74 34	75 35	36	37	

Periodontal status

		17	16	55 15	54 14	53 13	52 12	51 11	61 21	62 22	63 23	64 24	65 25	26	27	
	(73)															(86)
	(87)															(100)
		47	46	85 45	84 44	83 43	82 42	81 41	71 31	72 32	73 33	74 34	75 35	36	37	

Gingival bleeding

Scores

0 = Absence of condition
1 = Presence of condition
9 = Tooth excluded
X = Tooth not present

Primary teeth **Permanent teeth**

Status

A 0 = Sound
B 1 = Caries
C 2 = Filled w/caries
D 3 = Filled, no caries
E 4 = Missing due to caries
— 5 = Missing for any another reason
F 6 = Fissure sealant
G 7 = Fixed dental prosthesis/crown, abutment, veneer
— 8 = Unerupted
— 9 = Not recorded

Enamel fluorosis (101)

Status

0 = Normal
1 = Questionable
2 = Very mild
3 = Mild
4 = Moderate
5 = Severe
8 = Excluded (crown, restoration, "bracket")
9 = Not recorded (unerupted tooth)

Dental erosion

Severity (102)

0 = No sign of erosion
1= Enamel lesion
2 = Dentinal lesion
3 = Pulp involvement

No. of teeth (103) (104)

Dental trauma

Status (105)

0 = No sign of injury
1 = Treated injury
2 = Enamel fracture only
3 = Enamel and dentine fracture
4 = Pulp involvement
5 = Missing tooth due to trauma
6 = Other damage
9 = Excluded tooth

No. of teeth (106) (107)

Oral mucosal lesions

Condition (108) (109) (110)

0 = No abnormal condition
1 = Ulceration (aphthous, herpetic, traumatic)
2 = Acute necrotizing ulcerative gingivitis (ANUG)
3 = Candidiasis
4 = Abscess
8 = Other condition
9 = Not recorded

Location (111) (112) (113)

0 = Vermilion border
1 = Commissures
2 = Lips
3 = Sulci
4 = Buccal mucosa
5 = Floor of mouth
6 = Tongue
7 = Hard and/or soft palate
8 = Alveolar ridges/gingiva
9 = Not recorded

Intervention urgency (114)

0 = No treatment needed
1 = Preventive or routine treatment needed
2 = Prompt treatment (including scaling) needed
3 = Immediate (urgent) treatment needed due to pain or infection of dental and/or oral origin
4 = Referred for comprehensive evaluation or medical/dental treatment (systemic condition)

f0030

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World Health Organization

World Health Organization

Oral Health Assessment Form for Adults (by tooth surface), 2013

Leave blank (1) (4) (5) Year Month Day (10) (11) Identification No. (14) Orig/Dupl (15) (16) Examiner (17)

General information: Sex 1=M, 2=F (18) (19) Date of birth (24) (25) Age in years (26)

(Name)

Ethnic group (27) (28) **Other group** (29) (30) **Years in school** (31) (32) **Occupation** (33)

Community (geographical location) (34) (35) **Location** Urban (1) Periurban (2) Rural (3) (36)

Other data (37) (38) **Other data** (39) (40)

Other data (41) (42) **Extra-oral examination** (43) (44)

Dentition status by tooth surface

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
Occ						X	X	X	X	X	X						(45–54)
Mes																	(55–70)
Buc																	(71–86)
Dis																	(87–102)
Oral																	(103–118)

	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38	
Occ						X	X	X	X	X	X						(119–128)
Mes																	(129–144)
Buc																	(145–160)
Dis																	(161–176)
Oral																	(177–192)

Permanent teeth

Status

0 = Healthy
1 = Caries
2 = Filled w/caries
3 = Filled no/caries
4 = Missing due to caries
5 = Missing for another reason
6 = Fissure sealant
7 = Fixed partial denture,/crown, abutment, veneer, implant
8 = Unerupted
9 = Not recorded

Periodontal status (CPI Modified)

	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28	
Bleeding (193)																	(208)
Pocket (209)																	(224)
Bleeding (225)																	(240)
Pocket (241)																	(256)

48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38

Gingival bleeding

Score

0 = Absence of condition
1 = Presence of condition
9 = Tooth excluded
X = Tooth not present

Pocket

Score

0 = Absence of condition
1 = Pocket 4–5 mm
2 = Pocket 6 mm or more
9 = Tooth excluded
X = Tooth not present

f0040

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World Health Organization

World Health Organization
Oral Health Assessment Form for Adults, 2013

Loss of attachment

Severity
0 = 0–3 mm
1 = 4–5 mm Cemento-enamel junction (CEJ) within black band
2 = 6–8 mm CEJ between upper limit of black band and 8.5 mm ring
3 = 9–11 mm CEJ between 8.5 mm and 11.5 mm ring
4 = 12 mm or more CEJ beyond 11.5 mm ring
X = Excluded sextant
9 = Not recorded

* Not recorded under 15 years of age

Index teeth

17/16 11 26/27
(257) (259)
(260) (262)
47/46 31 36/37

Enamel fluorosis (263)

Severity
0 = Normal
1 = Questionable
2 = Very mild
3 = Mild
4 = Moderate
5 = Severe
8 = Excluded (crown, restoration, "bracket")
9 = Not recorded (unerupted tooth)

Dental erosion

Severity (264)

0 = No sign of erosion
1 = Enamel lesion
2 = Dentinal lesion
3 = Pulp involvement

Number of teeth affected

(265) (266)

Dental trauma

Status (267)

0 = No sign of injury
1 = Treated injury
2 = Enamel fracture only
3 = Enamel and dentine fracture
4 = Pulp involvement
5 = Missing tooth due to trauma
6 = Other damage
9 = Excluded tooth

Number of teeth affected

(268) (269)

Oral mucosal lesions

(270)
(271)
(272)
(273)
(274)
(275)

Condition

0 = No abnormal condition
1 = Malignant tumour (oral cancer)
2 = Leukoplakia
3 = Lichen planus
4 = Ulceration (aphthous, herpetic, traumatic)
5 = Acute necrotizing ulcerative gingivitis (ANUG)
6 = Candidiasis
7 = Abscess
8 = Other condition (specify if possible)
9 = Not recorded

Location

0 = Vermillion border
1 = Commissures
2 = Lips
3 = Sulci
4 = Buccal mucosa
5 = Floor of the mouth
6 = Tongue
7 = Hard and/or soft palate
8 = Alveolar ridges/gingiva
9 = Not recorded

Denture(s)

Upper (276) Lower (277)

Status

0 = No denture
1 = Partial denture
2 = Complete denture
9 = Not recorded

Intervention urgency (278)

0 = No treatment needed
1 = Preventive or routine treatment needed
2 = Prompt treatment (including scaling) needed
3 = Immediate (urgent) treatment needed due to pain or infection of dental and/or oral origin
4 = Referred for comprehensive evaluation or medical treatment (systemic condition)

f0050

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World Health Organization

World Health Organization

Oral Health Assessment Form for Children (by tooth surface), 2013

Leave blank (1) (4) (5) Year Month Day (10) (11) Identification No. (14) Orig/Dupl (15) (16) Examiner (17)

General information: Sex 1=M, 2=F (18) (19) Date of birth (24) (25) Age in years (26)

(Name)

Ethnic group (27) (28) **Other group** (29) (30) **Years in school** (31) (32) **Occupation** (33)

Community (geographical location) (34) (35) **Location** Urban (1) Periurban (2) Rural (3) (36)

Other data (37) (38) **Other data** (39) (40)

Other data (41) (42) **Extra-oral examination** (43) (44)

Dentition status by tooth surface

	17	16	55 15	54 14	53 13	52 12	51 11	61 21	62 22	63 23	64 24	65 25	26	27	
Occ					X	X	X	X	X	X					(45–52)
Mes															(53–66)
Buc															(67–80)
Dis															(81–94)
Oral															(95–108)

	47	46	85 45	84 44	83 43	82 42	81 41	71 31	72 32	73 33	74 34	75 35	36	37	
Occ					X	X	X	X	X	X					(109–116)
Mes															(117–130)
Buc															(131–144)
Dis															(145–158)
Oral															(159–172)

Primary teeth	Permanent teeth
	Status
A	0 = Sound
B	1 = Caries
C	2 = Filled w/caries
D	3 = Filled, no caries
E	4 = Missing due to caries
—	5 = Missing for another reason
F	6 = Fissure sealant
G	7 = Fix dental prosthesis/crown, abutment, veneer
—	8 = Unerupted
—	9 = Not recorded

f0060

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World Health Organization

Oral Health Assessment Form for Children, 2013

Periodontal status

	17	16	55 15	54 14	53 13	52 12	51 11	61 21	62 22	63 23	64 24	65 25	26	27	
(173)															(186)
(187)															(200)
	47	46	85 45	84 44	83 43	82 42	81 41	71 31	72 32	73 33	74 34	75 35	36	37	

Gingival bleeding

Score

(0) = Absence of condition
(1) = Presence of condition
(9) = Tooth excluded
(X) = Tooth not present

Enamel fluorosis ☐ (201)

Severity

0 = Normal
1 = Questionable
2 = Very mild
3 = Mild
4 = Moderate
5 = Severe

8 = Excluded (crown, restoration, "bracket")

9 = Not recorded (unerupted tooth)

Dental erosion

Severity

(202) ☐

0 = No sign of erosion
1 = Enamel lesion
2 = Dentinal lesion
3 = Pulp involvement

No. of teeth

(203) ☐☐ (204)

Dental trauma

Status

(205) ☐

0 = No sign of injury
1 = Treated injury
2 = Enamel fracture only
3 = Enamel and dentine fracture
4 = Pulp involvement
5 = Missing tooth due to trauma
6 = Other damage
9 = Excluded tooth

No. of teeth

(206) ☐☐ (207)

Oral mucosal lesions

Condition

(208) ☐
(209) ☐
(210) ☐

0= No abnormal condition
1= Ulceration (aphthous herpetic, traumatic)
2= Acute necrotizing ulcerative gingivitis (ANUG)
3= Candidiasis
4= Abscess
8= Other condition
9= Not recorded

Location

(211) ☐
(212) ☐
(213) ☐

0 = Vermillion border
1 = Commissures
2 = Lips
3 = Sulci
4 = Buccal mucosa
5 = Floor of mouth
6 = Tongue
7 = Hard/soft palate
8 = Alveolar ridges/gingiva
9= Not recorded

Intervention URGENCY ☐ (214)

0 = No curative treatment needed

1 = Preventive or routine treatment needed

2 = Prompt treatment (including scaling) needed

3 = Immediate (urgent) treatment due to pain or infection of dental and/or oral origin

4 = Referred for comprehensive evaluation or medical treatment (systemic condition)

f0070

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World Health Organization

World Health Organization

Record Form for Oral Manifestations in HIV/AIDS, 2013

Country: _____

Leave blank (1) (4) (5) Year Month Day (10) (11) Identification No. (14) Orig/Dupl (15) (16) Examiner (17)

General information: Sex 1=M, 2=F (18) (19) Date of birth (24) (25) Age in years (26)

(Name)

Ethnic group (27) (28) **Other group** (29) (30) **Years in school** (31) (32) **Occupation** (33)

Community (geographical location) (34) (35) **Location** Urban (1) Periurban (2) Rural (3) (36)

Other data _____ (37) (38) **Other data** _____ (39) (40)

Other data _____ (41) (42) **Other data** _____ (43) (44)

Extra-oral examination _____ (45) (46) **Extra-oral examination** _____ (47) (48)

Weight in kg (49–50)

Height in cm (51–53)

Fever (54)

1 = Present 2 = Absent

Candidiasis

1 = Present 2 = Absent

Erythematous	Hyperplastic	Pseudomembranous
(55)	(56)	(57)

Location of lesion

1 = Present 2 = Absent

Tongue	Gingiva	Lip/buccal mucosa	Palate	Pharynx
(58)	(59)	(60)	(61)	(62)

f0080

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World Health Organization

World Health Organization

Record Form for Oral Manifestations in HIV/AIDS, 2013

	1 = Present ✓ tick	2 = Absent ✓ tick	
Angular cheilitis	☐	☐	(63)
Oral hairy leukoplakia	☐	☐	(64)
Necrotizing ulcerative gingivitis (NUG)	☐	☐	(65)
Necrotizing ulcerative periodontitis (NUP)	☐	☐	(66)
Necrotizing stomatitis	☐	☐	(67)
Herpetic stomatitis/gingivitis and/or labial	☐	☐	(68)
Herpes zoster	☐	☐	(69)
Molluscum contagiosum	☐	☐	(70)
Cytomegalovirus	☐	☐	(71)
Warty-like lesions/human papillomavirus	☐	☐	(72)
Kaposi sarcoma	☐	☐	(73)
Aphthous ulcers	☐	☐	(74)
Other ulcerations	☐	☐	(75)
Dry mouth due to decreased salivary flow	☐	☐	(76)
Unilateral or bilateral swelling of major salivary glands	☐	☐	(77)
Other(s)	☐	☐	(78)

f0090

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Case History Proforma

APPENDIX D

DEPARTMENT OF PREVENTIVE AND COMMUNITY DENTISTRY

Student's name: _____

Date: _____ OP. No. _____

Patient's name: _____ Age: _____ Sex: _____ No. of family members: _____

Date and place of birth: _____

Education: _____ Occupation: _____

Total Income of family per month: _____ Per capita income: _____

Address: _____

_____

_____

Contact no. _____

I. Chief complaint:

II. History of present illness:

III. Medical History:

IV. Dental History:

V. Family History:

a) Siblings: ☐ Number ☐ Age

- Has any family member suffered from a similar problem? ☐
- Do you know of any illnesses that run in your family? ☐

b) Marital status Married ☐ Unmarried ☐

c) Children (if any) Number ☐ Age

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VI. Personal History:

a) Personal habits:

	Number	Frequency	Duration
1. Smoking			
2. Smokeless tobacco (With/without pan chewing)			
3. Pan chewing			
4. Alcoholism			

b) Habits related to oral cavity:

Mouth breathing	Thumb sucking	Tongue thrusting	Bruxism	Lip/nail/pencil biting
☐	☐	☐	☐	☐

Frequency:

Duration:

c) Oral Hygiene Practices:

1. Type of cleaning: (Specify if any other)	Toothbrush ☐	Finger ☐	Stick ☐	others ☐
2. Method of cleaning:	Vertical ☐	Horizontal ☐	Circular ☐	
3. Materials used:	Toothpaste ☐	Tooth powder ☐	Charcoal ☐	
	Sand ☐	Brick powder ☐	Any other ☐	
4. Frequency of cleaning:	Once ☐	Twice ☐	Thrice ☐	

5. Time of brushing:

Before meals ☐

After meals ☐

6. Frequency of changing the toothbrush:

7. Use of other oral hygiene aids: Flossing ☐ Interdental aids ☐ Oral mouth rinse ☐

d) Dietary habits:

1. Vegetarian ☐ Mixed ☐

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2. Dietary chart:
Staple Diet:

Time	Item		Sugar exposure
_____	_____	____	_____
_____	_____	____	_____
_____	_____	____	_____
_____	_____	____	_____
_____	_____	____	_____

3. Sugar consumption (per day):

- **Type:** Fermentable Less fermentable
- **Frequency:** Once ☐ Twice ☐ Thrice ☐ Four times ☐
  Please specify if more:
- **Time of intake:** With meals ☐ In-between meals ☐
- **Form and consistency:** Solid ☐ Liquid ☐
  Sticky ☐ Non-sticky ☐

VII. General Examination:

a) Gait: _____
b) Posture: _____
c) Built: _____
d) Height: _____
e) Weight: _____
f) BMI: _____

VIII. Local examination:

a) Extra oral

1. Symmetry: _____
2. Profile: _____
3. T.M.J: _____
4. Lymph nodes: _____

b) Intra oral

1. Soft tissue:

- **Tongue** _____
- Buccal mucosa _____
- **Labial mucosa** _____
  Gingiva _____
  _____
- Palate
- **Floor of mouth**
- Alveolar mucosa

2. Hard tissue:

- Type of dentition: **Deciduous** ☐ **Mixed** ☐ **Permanent** ☐
- Number of teeth present:
- Teeth absent and reason for loss:
- Root stumps:

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- **Dental caries:**

  Non-cavitated:

  Cavitated:

  Cavitated (with pulp exposure):

- **Filled teeth:**
- **Any prosthesis:** Crown (mention tooth)

  Bridge

  RPD/Implant
- **Wasting disease:** Generalized Localized (mention tooth)

  Attrition ☐

  Abrasion ☐

  Erosion ☐
- **Enamel hypoplasia:** Generalized ☐ Localized (mention tooth)
- **Fluorosis:** Generalized ☐ Localized (mention tooth)
- **Supernumerary teeth:**
- **Any other anomaly please specify:**
- **Malocclusion:**
- **Trauma from occlusion:** ☐
- **Fractured/non-vital tooth:**
- **Stains:** **Extrinsic** ☐ **Intrinsic** ☐

3. **Periodontal status:**

	Generalized	**Localized (mention tooth)**
	☐	

- **Gingivitis:**
- **Periodontal pocket:** ☐
- **Mobility of teeth:** ☐

4. **Oral hygiene status:**

- **Dental deposits:**

Plaque ☐	Stains ☐	Calculus ☐
f0040 Good ☐	Fair ☐	Poor ☐

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IX. Provisional diagnosis:

X. Investigation:

XI. Diagnosis:

XII. Treatment plan:

XIII. Work done

Date	Work done	Remarks

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APPENDIX **E**

Levels of Prevention

I. DENTAL CARIES

Levels	Primary	Secondary prevention		Tertiary prevention	
Preventive services	**Health promotion**	**Specific protection**	**Early diagnosis and prompt treatment**	**Disability limitation**	**Rehabilitation**
Services provided by the individual	Diet planning, Demand for preventive services, Periodic visits to the dental office, Good nutrition, Good oral hygiene measures	Appropriate use of fluoride, Ingestion of fluoridated water, Use of fluoridated dentifrice, Oral hygiene practices	Self-examination and referral, Utilization of dental services, Chemical plaque control agents	Utilization of dental services	Utilization of dental services
Services provided by the community	Dental health education programmes, Research in delivery of oral health care	Community or school water fluoridation, School fluoride mouth rinse programme, School fluoride tablet programme, School sealant programme	Periodic screening and referral, Making provision for dental services	Provision of dental services	Provision of dental services
Services provided by the dental professional	Patient education, Plaque control programme, Diet counselling, Recall reinforcement, Caries activity tests, Diet counselling and advice	Topical application of fluoride, Fluoride supplements, Rinse preparation, Pit and fissure sealants	Complete examination, Prior treatment of incipient lesions, Preventive resin restorations, Simple restorative dentistry	Complex restorative dentistry, Pulp capping Pulpotomy, RCT, Extraction	Removable and fixed prosthodontics, Orthodontic treatment, Implants

II. PERIODONTAL DISEASE

Levels	Primary prevention		Secondary prevention	Tertiary prevention	
Preventive services	**Health promotion**	**Specific protection**	**Early diagnosis and prompt treatment**	**Disability limitation**	**Rehabilitation**
Services provided by the individual	Periodic dental visit, Demand for preventive services, Good nutrition, Good oral hygiene measures	Oral hygiene practices	Self-examination and referral, Utilization of dental services, Chemical plaque control agents, Professional prophylaxis	Utilization of dental services	Utilization of dental services
Services provided by the community	Dental health education, Dental health programmes, Research in delivery of oral health care	Supervised school brushing programme	Periodic screening and referral, Making provision for dental services	Provision of dental services	Provision of dental services
Services provided by the dental professional	Patient education, Plaque control programme, Recall reinforcement, Diet counselling and advice	Correction of malaligned teeth	Complete examination, Scaling and curettage, Corrective restorative and occlusal services	Deep curettage, Root planning, Splinting, Periodontal surgery, Selective extractions	Removable and fixed prosthodontics, Orthodontic treatment

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III. ORAL CANCER

Levels	Primary prevention		Secondary prevention	Tertiary prevention	
Preventive services	**Health promotion**	**Specific protection**	**Early diagnosis and prompt treatment**	**Disability limitation**	**Rehabilitation**
Services provided by the individual	Promotion of good nutrition, Demand for preventive services, Periodic visits to the dental office	Maintenance of good dietary practices, Avoidance of any deleterious habit leading to encouragement of alcohol and tobacco use	Self-examination, Utilization of dental services whatever is available	Utilization of dental services whatever is available	Utilization of dental services whatever is available
Services provided by the community	Dental health education programmes, Lobbying of efforts to promote healthy living	Avoidance of sale of tobacco near school's premises, Avoidance of smoking at public places, Incorporation of healthy lifestyle and habits in children through health promoting school network, Development of the personal skills	Periodic screening and referral, Provision of dental services, Creating supportive environments (establishment of de- addiction centres in the community)	Strengthening community action, Provision of dental services whatever is available	Strengthening community action, Provision of dental services whatever is available
Services provided by the dental professional	Patient education, Patient counselling (regarding discontinuation of habit), Recall reinforcement	Encouragement of good dietary practices and advice on taking foods containing antioxidants e.g. Vit A, E, beta-carotene, Maintenance of good oral hygiene	Detailed and thorough examination, Prior treatment of premalignant lesions, Use of nicotine replacement therapy (nicotine patches, gums and sprays)	Surgical intervention and reconstruction of the tissue destroyed	Removable and fixed prosthodontics, Maxillofacial prosthesis

IV. DENTOFACIAL ANOMALIES

Orofacial defects, malocclusion, and accidents: individual, community, and dental professional preventive dentistry services

Levels of prevention	Primary		Secondary	Tertiary	
Preventive services	**Health promotion**	**Specific protection**	**Early diagnosis and prompt treatment**	**Disability limitation**	**Rehabilitation**
Services provided by the individual		Use of protective devices; habit control	Use of dental services	Use of dental services	Use of dental services
Services provided by the community	Dental health education programmes; promotion of protective grab; lobby efforts	Mouthguard programme; safety of children's toys; safety of school buildings and playgrounds	Provision of dental services	Provision of dental services	Provision of dental services
Services provided by the dental professional	Patient education	Caries control; space maintainers; genetic counselling; prenatal care; parental counselling	Minor orthodontics	Major orthodontics; surgery	Maxillofacial fixed/removable prosthodontics; plastic surgery; speech therapy; counselling

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APPENDIX F

Tobacco Use, Effects on Health and Management

I. FACTS AND FIGURES ABOUT TOBACCO

Tobacco is the leading preventable cause of death in the world.

- Tobacco is the only consumer product that kills when used as intended by its manufacturers.
- Tobacco causes 1 in 10 adult deaths worldwide.
- Tobacco causes nearly 5 million deaths a year, or one death every 6.5 second.
- The current death toll will nearly double by 2020 if current trends continue.
- Total global smoking prevalence is 29%. By gender, 47.5% of men and 10.3% of women smoke.
- Tobacco kills 50% of its regular users. Of the 1.3 billion smokers alive today, 650 million will eventually be killed by tobacco. Of them, 325 million between the ages of 35 and 69.
- 900 million smokers, or 84% of the world total, live in developing and transitional economy countries.
- By 2030, 70% of deaths attributable to tobacco will occur in the developing world.
- 100 million deaths were caused by tobacco in the 20th century. If current trends continue, there will be one billion deaths in the 21st century.
- Tobacco is a known or probable cause of about 25 diseases.
- Smokeless tobacco causes oral cancer, especially in the lip, tongue, mouth, and throat area.
- The annual mortality from tobacco chewing in South Asia alone may well be about 50000 deaths a year.
- Breathing Environmental Tobacco Smoke (ETS) (i.e. Side stream and exhaled smoke from cigarettes, cigars, and pipes) causes serious health problems and also aggravates allergies and increase the severity of symptoms in children and adolescents, with asthma and heart disease.
- Tobacco advertising plays a key role in encouraging young people to smoke—portraying tobacco use as "fun", "glamourous", "mature", "modern" and "western".
- Even trying cigarette is dangerous. One third to one half of adolescents, who experiment with cigarettes, go on to become regular smokers.
- People who start using tobacco early have more difficulty in quitting, are more likely to become heavy smokers.
- If young people do not begin to use tobacco before the age of 20, they are unlikely to start smoking as adults.
- One year after quitting, the risk of coronary heart disease decreases by 50% and within 15 years, the risk approaches that of a long-time non-smoker.
- 10–14 years after smoking cessation, the risk of death from cancer decreases to nearly that of those who have never smoked.
- A World Bank study estimated that the use of tobacco results in the global net loss of US 200 billion $ per year—with half of these losses occurring in developing countries.
- The World Bank also estimated that smoking prevention is among the most cost effective of all health interventions.

Key Learning Points

- There is a huge burden of tobacco use in the SEA Region.
- There is a large variety of both smoking and smokeless forms of tobacco in the Region.
- Smoking is still predominantly a male habit but use of smokeless forms of tobacco, particularly through chewing, is common among both men and women.
- Tobacco use among youth indicates early initiation and narrowing gender ratios.
- Tobacco use among health professionals is an important barrier to their providing cessation services.
- Tobacco is probably more addictive than alcohol, caffeine and illicit drugs such as heroin and cocaine.
- Nicotine is the addictive substance found in all forms of tobacco.
- Addiction occurs due to a combination of the effects of nicotine on the reward pathways in the brain, and its withdrawl effects.
- There is a genetic predisposition to addictions, including nicotine addiction.
- Addiction is not just a habit, it is a disease that involves biological changes in the brain.
- Smoking, chewing and other forms of tobacco cause serious health problems.
- Practically every system in the body is adversely affected by the use of tobacco and the mechanism of many of these effects have now been understood.
- Educating people about the general risks from tobacco use and personalizing this risk to individuals is at the core of tobacco cessation intervention, particularly in developing countries.
- There are both short-term and long-term benefits from tobacco cessation.
- Risks for various diseases continue to reduce over the years with complete cessation.

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Adult tobacco surveys in south-east Asia

Country	Source	Year and Type of Survey	Age Group	Tobacco Type	Overall Prevalence %	Male Prevalence %	Female Prevalence %
Bangladesh	Global Adult Tobacco Survey Bangladesh	2009 National	≥15	Current tobacco user Smoked only Smokeless only	43.3 23.0 27.2	50.0 44.7 26.4	28.7 1.5 27.9
Bhutan	–	–	–	–	–	–	–
Democratic People's Republic of Korea	Smoking survey among male population in DPRK	2002 Subnational	16+			59.9	
India	National Family Household Survey-3	2005–2006 National	15–54	Current any tobacco use		57.0	10.0
				Current smoking bidis or cigarettes		32.7	1.4
				Current smokeless		36.5	0.4
Indonesia	Indonesia Household Survey	2004 National	15+	Current Tobacco smoking	34.5	63.2	4.5
				Daily tobacco smoking	20.4	52.4	3.3
Maldives	Smoking Survey	2001 National	16+	Current any tobacco use		37.4	15.6
				Current cigarette use	12.6	27.3	2.2
Myanmar	World Health Survey	2003 National	18+	Current tobacco smoking	30.9	48.9	13.7
				Daily tobacco smoking	22.7	35.6	10.4
Nepal	Nepal Demographic and Health Survey	2006 National	15–49	Current cigarette use		30.2	15.2
Sri Lanka	World Survey	2003 National	18+	Current tobacco smoking	21.6	39.0	2.6
				Daily tobacco smoking	13.6	24.5	1.6
Thailand	Global Adult Tobacco Survey	2009 National	≥15	Current tobacco users	27.2	46.4	9.1
				Smoked only	85.7	97.1 (of users)	30.8 (of users)
				Smokeless only	12.9	1.8 (of users)	66.0 (of users)
Timor-Leste	Global School personnel study	2005 Subnational	Adults	Current any tobacco use	29.9	37.0	6.1
				Current cigarette use	23.4	30.5	1.3

Compiled from WHO Report on the Global Tobacco Epidemic and the Global Adult Tobacco Survey for Thailand and Bangladesh.

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- Even when there is established disease, there are advantages of quitting.
- Obviously, not starting at all or quitting early are the best strategies to prevent tobacco-related harm.

Bidis

A *bidi* contains one fifth to two thirds of the amount of tobacco contained in a cigarette.

However, weight for weight, *bidis* contain higher nicotine concentration [(21.2 mg/g) compared with commercial filtered cigarettes (16.3 mg/g) and unfiltered cigarettes (13.5 mg/g)].

Tar levels delivered by *bidis* are high, at 45–50 mg/bidi.

One study found that *bidis* produced approximately three times the amount of carbon monoxide and nicotine and five times the amount of tar as cigarettes.

As with cigarettes, tobacco from *bidis* contains many carcinogenic chemicals such as tobacco-specific nitrosamines (TSNAs). Very high TSNAs are present in snuff and chutts tobacco.

The amount of TSNAs contained in cigarettes, *bidis*, and smokeless tobacco are similar at 1–10 mg/g.

Bidis and *chuttas* have higher uranium content compared to cigarettes and snuff.

Bidis have high levels of volatile organic compounds.

Bidis contain more than one and a half times higher levels of carbon monoxide, ammonia, hydrogen cyanide, phenols, cresols and benzopyrene compared with cigarettes.

Bidis and cancers

Studies from India have shown that *bidi* smokers have a two-fold higher risk of developing oral cancer and five times higher risk of developing cancer of the base of the tongue and oropharynx than non-smoker. Specifically, they have a:

- three-fold higher risk for cancer of the hypopharynx;
- two-fold higher risk for laryngeal cancer;
- two to four times higher risk for oesophageal cancer;
- five-to-six-fold increase in risk for lung cancer; and
- greater risk for cancers of the buccal and labial mucosa, and of gingiva.

II. PRIMARY PHYSIOLOGIC EFFECTS OF NICOTINE

- Electroencephalographic desynchronisation
- Increased circulating levels of catecholamine, vasopressin, growth hormone, adenocorticotropic hormone, cortisol, prolactin, and beta-endorphin.
- Increased metabolic rate.
- Lipolysis, increased free fatty acids.
- Heart rate acceleration, nicotine can increase the heart rate by 10–15 beats/min.
- Cutaneous and coronary vasoconstriction.
- Increased cardiac output.
- Increased blood pressure. It increases blood pressure by 5–10 mmHg.
- Skeletal muscle relaxation.
- Nicotine can induce pathogenic changes to the endothelium that are associated with the atherosclerotic process.
- Although smoking is implicated in the development of cancer, nicotine itself is not carcinogenic, unless it undergoes nitrosation to form nitrosamines (a process known to occur during tobacco curing and combustion).

Tobacco is implicated in the development of cancer, nicotine itself is not carcinogenic.

III. ASSESSMENT OF HEALTH CONSEQUENCES

A. Health consequences of tobacco use

Mortality and morbidity	• result in premature death • cause significant disease and disability
Cardiovascular effects	• a cause of coronary heart disease • a cause of cerebrovascular disease (stroke) • a cause of atherosclerotic peripheral vascular disease
Cancer	• a cause of lung cancer • a contributing factor for pancreatic cancer • a cause of laryngeal cancer • a contributing factor for renal cancer • a cause of cancer of lip, tongue, mouth and pharynx • associated with gastric cancer • a cause of oesophageal cancer • a cause of bladder cancer
Lung disease	• a cause of chronic bronchitis • a cause of emphysema
Women's health effects	• a cause of (intrauterine) growth retardation, leading to low birth weight babies • a contributory factor for cervical cancer • a probable cause of unsuccessful pregnancies
Other health effects	• addiction to nicotine • adverse interactions with occupational hazards that increase the risk of cancer • alteration of the actions and effects of prescription and non-prescription medications • a probable cause of peptic ulcer disease

B. Health consequences of breathing environment tobacco smoke (ETS)

- A cause of lung cancer in non-smokers
- Associated with higher death rates from cardiovascular disease in non-smokers
- In children, associated with respiratory tract infections, increased severity of symptoms in children with asthma,

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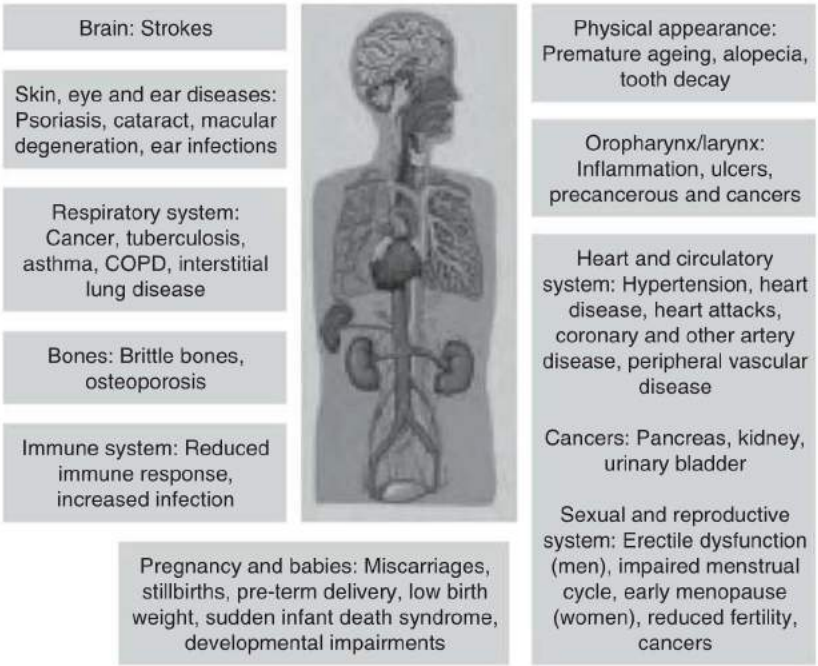


Figure A5-1 Adverse effects associated with tobacco use.

and a risk factor for new onset of asthma in children who have not previously displayed symptoms
- Associated with increased risk of sudden infant death syndrome (SIDS)
- Associated with increased irritant effects, particularly eye irritation, among allergic persons.

Tobacco use and oral disease—Mechanism

- Tobacco is thought to impair the body's immune response, making the person more vulnerable to bacterial infection.
- It impairs regeneration and repair of periodontal tissues.
- Smoking and chewing damage the soft and hard tissue that support the teeth known as periodontium (gingiva: tissues covering the root surfaces of the teeth and ligaments attaching the tooth root to the jaw).
- This leads to gingivitis, causing reddening of gums, swelling and bleeding.
- Untreated gingivitis can lead to chronic periodontitis.
- Plaque formed on the teeth spreads below the gum line, behind the gingiva, causing an inflammatory response.
- Gum recession, gingival separation from the tooth and further infection are common.
- This can lead to bone loss, loosening of teeth, development of abscesses in soft tissue and bone, root surface caries and tooth loss.

IV. ASSESSMENT OF TOBACCO DEPENDENCE

Question	Answer	Score
How soon after you wake do you smoke your first cigarette?	Within 5 minutes 5–30 minutes 31–60 minutes Over 60 minutes	3 2 1 0
Do you find it difficult to refrain from smoking in places where it is forbidden/	Yes No	1 0
Which cigarette would you most hate to give up?	The first one in the morning Any other	1 0
How many cigarettes per day do you smoke?	10 or less 11-20 21-30 over 30	0 1 2 3
Do you smoke more frequently during the first hours after waking than during the rest of the day?	Yes No	1 0
Do you smoke if you are so ill that you are in bed most of the day?	Yes No	1 0

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Score	Rating
0 to 2	Very low dependence
3 to 4	Low dependence
5	Medium dependence
6 to 7	High dependence
8 to 10	Very high dependence

V. INTERPRETATION: THE 5A's USED TO PROMOTE TOBACCO CESSATION

Ask: The health care professional should ask the patient about his or her tobacco intake habits at every opportunity that is during every visit to the dental surgeon. This may include questions about tobacco use in the patient's home and working environment.

Advice: The health care professional should continually advice patients to quit thereby creating a consistent message and emphasizing the importance of this issue.

Assess: The patient's readiness and motivation to quit should be assessed. Stopping tobacco entails a major lifestyle change, requiring preparation, readiness and usually several failed attempts.

Assist: The health care professional should assist those individuals who are motivated to quit attempt by informing, suggesting and/or prescribing a pharmacological cessation aid and by providing or referring the patient to counselling and support services where available.

Arrange: Follow-up services are often critical. The dentist or other health care provider can help the quitter to remain tobacco free by providing back-up services, e.g. advising on the availability of national hotlines, support from non-smoking friends or colleagues, or community based support groups.

Simple community-based interventions: Evidence for effectiveness in the region

Even simple health education can bring about change. In a 10-year prospective intervention study in India. Over 36,000 tobacco users were examined in a baseline survey for oral cancer and pre-cancer, and subsequently every year for 10 years. At each examination, they were given health education about their tobacco habits.

At the end of 10 years, 11% of men and 37% of women had quit tobacco use compared with 2% and 10% respectively of the control cohort. In addition, a substantial number of tobacco users had reduced their smoking significantly; higher percentage of leucoplakia at baseline regressed in those who had quit or reduced smoking substantially.

A study in Bihar, India, showed that community based mass approaches, with minimal sustained interventions, were more effective than clinic-centred individual interventions.

An NGO in Bangladesh, Ekhlaspur Centre of Health (ECH), started a tobacco cessation programme among women through community- and clinic-based activities in 2001 with WHO support. It carried out an evaluation of a tobacco cessation intervention by community health workers in 2006. A follow-up of tobacco use status was carried out every six months and further counselling provided.

A further follow-up was carried out after 18 months. Of the 184 tobacco users, 25% had quit tobacco after 18 months. This project demonstrated that a tobacco cessation programme can be delivered by trained health workers at the grassroots level.

In India tobacco cessation services were formally initiated in 2002 by the World Health Organization's Country Office and the Ministry of Health and Family Welfare, Government of India, through tobacco cessation clinics. Thirteen clinics were initially started in cancer, cardiology, respiratory, surgical, psychiatry and NGO settings and subsequently expanded.

The experience with treating more than 34,000 tobacco users, primarily chewers (65%) showed that behavioural forms of intervention, which included health education, simple tips for quitting and counselling to improve motivation and prevent relapse produced good results. Of those who maintained follow-up, nearly one third had been abstinent at the six-week follow-up and nearly half had reduced tobacco consumption by 50% or more. Less than one third of treatment seekers had received pharmacotherapy and those who received combined pharmacotherapy and counselling did significantly better than those receiving only counselling.

VI. TYPICAL WITHDRAWAL SYMPTOMS

- Restlessness
- Eating more than usual
- Anxiety/tension
- Impatience
- Irritability/anger
- Difficulty in concentrating
- Excessive hunger
- Loss of energy/fatigue
- Dizziness
- Depression
- Stomach or bowel problems
- Headaches
- Sweating
- Insomnia
- Heart palpitations
- Tremors
- Craving for tobacco

Key Learning Points

- Lapses and relapses are common when attempting to quit smoking, and the failed quit attempt should not evoke guilt in the tobacco user or blame from family members and the health professional.
- Every lapse need not end in a relapse.
- There are various strategies to anticipate, prevent and deal effectively with relapse.

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VII. NICOTINE REPLACEMENT THERAPY PRESCRIBING DETAILS FOR NRT

Formulation	Dose	Use
Gum*	2 mg of piece	Chew gum until taste is strong, then rest gum between gum and cheek; chew again when the taste has faded
Patch	16 h patch: 15, 10 or 5 mg 24 h patch; 21, 14 or 7 mg	One daily on clean unbroken skin; remove before bed (16 h new) patch or next morning (24 h; fresh) site
Inhalator	10 mg per cartridge	Inhale as required
Sublingual tablet	2 mg per piece 4 mg per piece	Rest under tongue until dissolved
Lozenge	1 mg per piece 2 mg per piece 4 mg per piece	Place between gum and cheek and allow to dissolve
Nasal spray	10 mg/ml per spray 0.5 mg per spray	One spray each nostril as required

*Only availabe NRT in Indian (NULIFE).

VIII. NICOTINE REPLACEMENT THERAPY (NRT)

Key Points

- Nicotine replacement therapy is an effective aid to tobacco cessation.
- Tobacco intakers who are motivated to quit and are dependent on nicotine should be offered NRT (Nicotine Replacement Therapy).
- NRT should be prescribed for six to eight weeks, in blocks of up to two weeks, contingent on continued abstinence.
- Obtaining nicotine from NRT is considerably safer than smoking and smokeless tobacco.
- NRT is safe in stable cardiac disease, but caution is needed in unstable, acute cardiovascular disease, pregnancy, or breastfeeding or in those aged under 18 years.

Dosage and Administration

If patient has heavy nicotine dependence, 4 mg nicotine gum should be used. Not exceeding 24 gums per day.

If patient has moderate nicotine dependence, 2 mg nicotine gum should be used. Not exceeding 30 gums per day, 2 mg and 1 mg gums are ideal while tapering down.

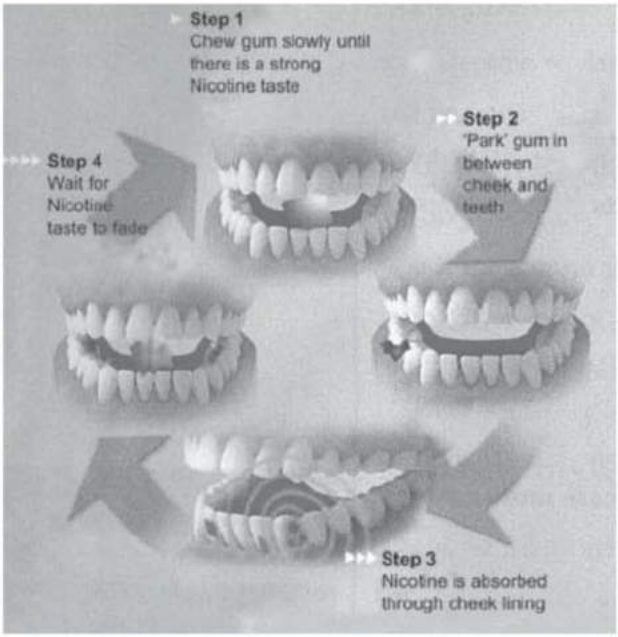


Figure A5-2 Steps in nicotine replacement therapy.

Step 1	1 to 6 weeks	One gum every one to two hours
Step 2	7 to 9 weeks	One gum every two to four hours
Step 3	10 to 12 weeks	One gum every four to eight hours

Summary of all interventions currently available for tobacco cessation

Intervention	Odds Ratio for Successful Quitting
Doctor's brief advice	1.3–1.74
Non-doctor health professional's advice	1.47–1.7
Individual counselling by non-doctor health professional	1.56–1.7
Self-help,with or without, provided material	1.1–1.24
Group interventions	2.17
Telephone interventions	1.56
Multiple interventions	1.9
Nicotine replacement therapy (NRT) (any type)	1.5–1.77
Bupropion	2.06–2.1
Nortriptyline	2.1–2.79
Varenicline	2.33–3

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APPENDIX G

Fluoride Fact

FLUORIDATING COMMUNITY DRINKING WATER TO PREVENT DENTAL DECAY IS ONE OF 10 GREAT PUBLIC HEALTH ACHIEVEMENTS OF THE 20TH CENTURY

Fluoride Facts

- Fluorine, from which fluoride is derived, is the 13th most abundant element and is released into the environment naturally in both water and air.
- Fluoride protects over 300 million people in more than 40 countries worldwide, with over 10,000 communities.
- Fluoride is not a medicine. Fluoride is a naturally occurring element and a nutrient.
- Fluoride is a community health measure that benefits people of all ages, all income groups, and ethnicity.
- Fluoride is naturally present in water. Community water fluoridation is the addition of fluoride to adjust the natural fluoride concentration of a community's water supply to the level recommended for optimal dental health, approximately 1.0 ppm (parts per million). One ppm is the equivalent of 1 mg/L, or 1 inch in 16 miles.
- Community water fluoridation is an effective, safe, and inexpensive way to prevent tooth decay.
- Children and adults who are at low risk of dental decay can stay cavity-free through frequent exposure to small amounts of fluoride. This is best gained by drinking fluoridated water and using a fluoride toothpaste twice daily.
- Children and adults at high risk of dental decay may benefit from using additional fluoride products, including dietary supplements (for children who do not have adequate levels of fluoride in their drinking water), mouth rinses, and professionally applied gels and varnishes.
- Daily use of fluoride containing dentifrice from the beginning of tooth eruption is probably the most efficient measure to control caries in individuals, since this procedure combines control of cariogenic plaque with daily delivery of post eruptive fluoride. (Thystrup 1985)
- The appropriate dose of fluoride supplement for children in communities with fluoride deficient water supply provides caries protection similar to that of community water fluoridation with minimal risk of enamel fluorosis.
- Fluoride was first used purposefully to prevent tooth decay in Grand Rapids, Michigan, in 1945 by adjusting the level of fluoride in drinking water. Fluoridation of drinking water has been used successfully in the United States for more than 50 years.
- Fluoridation of community water has been credited with reducing tooth decay by 50–60% in the United States since World War II. More recent estimates of this effect show decay reduction at 18–40%, which reflects that even in communities that are not optimally fluoridated, people are receiving some benefits from other sources (e.g. bottled beverages, toothpaste).
- Fluoride's main effect occurs posteruptively. This topical effect happens when small amounts of fluoride are maintained in the mouth in saliva and dental plaque.
- Before the widespread availability of topical fluorides, optimal levels of fluoride in the drinking water were designed to maximize its anti caries effect and minimize the levels of enamel fluorosis.
- Children aged 6 years or less may develop enamel fluorosis if they ingest more fluoride than needed. Enamel fluorosis is a chalk-like discolouration (white spots) of tooth enamel. A common source of extra fluoride is unsupervised use of toothpaste in very young children.
- Excessive amount of fluoride intake as occurs in some communities with high natural fluorides causes enamel fluorosis.
- Early use of toothpaste, associated with presumed unintentional swallowing of fluoride containing dentifrice by youngsters increases the prevalence of enamel fluorosis.
- Fluoride also benefits adults, decreasing the risk of cavities at the root surface. Use of fluoridated water and fluoride dental products will help people maintain oral health and keep more permanent teeth.
- The difference in caries rates between fluoridated and non-fluoridated communities is less because of the widespread use of fluorides through dentifrice, food and beverages (diffusion effect).
- Yet optimally fluoridated communities consistently have lower caries rates.
- Fluoride should be injected systemically (water, salt, milk or as a supplement) and used topically on daily basis for maximal caries prevention.

A *milligram* is one part per million of a *kilogram* thus, one part per million (ppm) by *mass* is the same as one *milligram* per *kilogram*. one *milligram* in a *kilogram* is 1 ppm by mass.

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Fluoride conversion chart

APF (10)(%)(1000)	ppm
1.1%	10,000
1.23%	12,300
NaF (4.5)(%)(1000)	**ppm**
0.05%	225
0.20%	900
0.44%	1,980
1.0%	4,500
1.1%	4,950
2.0%	9,000
5.0%	22,500
SnF_2 (2.4)(%)(1000)	**ppm**
0.40%	960
0.63%	1,512
8% and 10%	19,000

Worldwide prevalence of dental fluorosis

Very mild fluorosis	17%
Mild	4%
Moderate	1%
Severe	0.3%
Total	22.3%

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