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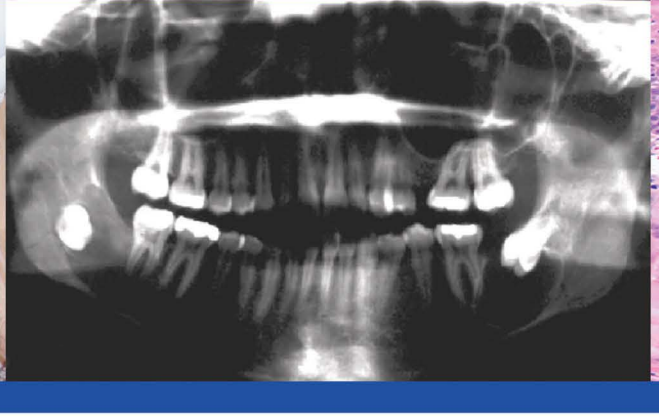
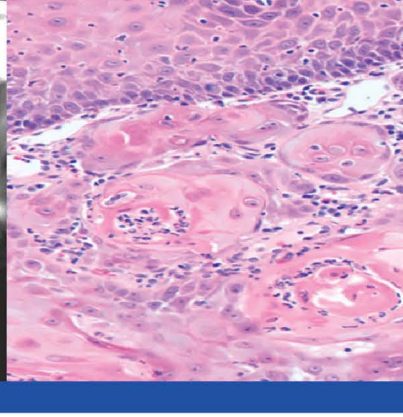
Oral Diseases in the Tropics







Foreword
Hiroshi Nakajima

JAYPEE

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SR Prabhu

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CHAPTER 3

The Science of Epidemiology

SR Prabhu, DM Roder, DF Wilson

INTRODUCTION

Tropical countries are faced with many health-related problems, partly as a result of substantial levels of poverty and a lack of fully developed health services. These factors can have complex political, social, cultural, and environmental determinants. Certainly there is often a great shortage of health personnel and a chronic shortage of health statistics for planning purposes.

A comprehensive account of the role of epidemiology in dentistry is beyond the scope of this chapter. The intent here is to introduce some of the more fundamental principles and methods so that the reader, especially the dental undergraduate, will be better placed to appreciate the contribution that this discipline can make to an understanding of disease causation and of the methods appropriate for disease control in tropical countries.

DEFINITION AND AIMS OF EPIDEMIOLOGY

Literally, the term epidemiology means the study of people (Greek: *epi*, upon or on; *demos*, people; *logos*, the source or study of). In a broad sense, epidemiology has been defined as 'the study of the factors determining the frequency and distribution of disease in human populations' (Lowe and Kostrzewski 1973. pp. 1-8). Initially, epidemiological practice was limited to the detection and control of communicable diseases, but epidemiology is now used to study a broader range of health issues, including motor vehicle accidents, maternal and child health, family planning, mental health, dental health, nutritional and other lifestyle disorders. Epidemiology is also a fundamental tool in the administration of medical and dental care delivery, in the health sciences, and in planning and evaluating health education programs.

Lowe and Kostrzewski (1973) have listed three main aims of epidemiology:

1. To describe the size and distribution of the disease problem in human populations.
2. To provide the data essential to the planning, implementation, and evaluation of services for the prevention, control, and treatment of disease and to the setting-up of priorities among those services.
3. To identify etiological factors in the pathogenesis of disease.

In order to fulfill its aims, epidemiology comprises several specific activities, which are according to Roht and colleagues (1982. pp. 1-10):

- The collection and analysis of vital records (births and deaths)
- The collection and analysis of morbidity data for hospitals, health agencies, clinics, physicians, and industry
- The surveillance of levels of disease or other community health problems
- The implementation of investigations leading to the control or prevention of epidemics or other community health problems
- The design and implementation of clinical research studies and health surveys
- The design and implementation of health registries for problems of special interest such as birth defects, cancer, or drug abuse
- The screening for diseases
- The evaluation of the effectiveness of existing or newly proposed treatment methods
- The description of the clinical course as well as of the natural history of specific diseases
- The identification of individuals or subgroups of the general population who appear to be at special risk of developing certain diseases
- The identification of links in the etiology of the disease
- The identification of public health problems and measurement of the extent of their distribution, frequency, or effect on the public's health
- The evaluation of health programs
- The provision of data necessary for health planning or decision making by health agency administrators or health policy makers.

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SOURCES OF EPIDEMIOLOGICAL INFORMATION

These can be summarized under the following headings:

- *Population statistics*: While many countries undertake a population census every 10 years, thereby providing a wide range of demographic, social, and economic data for epidemiological research, this is not always so in the tropical countries. Sometimes the population statistics are grossly incomplete or even unavailable.
- *Vital statistics*: These comprise mortality and natality data drawn from death records and birth records respectively. Analysis of these data provides an important perspective of the public health profile of a country.
- *Morbidity statistics*: These statistics are generally available from a variety of sources, including patient records from hospitals and general practices, statutory notifications of infectious diseases to health departments, and, sometimes, specialist disease registries for cancer, birth defects, and other medical conditions. These statistics can show differences in disease rates in time and place and according to a wide range of social and demographic characteristics. Also, they may be used to identify outbreaks of disease promptly so that disease control procedures can be expedited.
- *Surveys*: Surveys may be implemented periodically to obtain health-related data not available from routine record systems or registries. Generally, surveys produce a higher quality of data and a fuller ascertainment of disease cases than are available through hospital or medical record systems. They may be undertaken as part of descriptive, analytical, or experimental studies.

EPIDEMIOLOGICAL STUDY DESIGNS

Descriptive studies are normally directed at showing the prevalence of disease in a population and in its various subgroups. A cross-section of the community may be selected in the sample to be surveyed. Statistical correlations between disease rates and lifestyle or environmental characteristics may suggest causal hypotheses which can then be subjected to more rigorous analytical or experimental study. For example, Dean (1938) surveyed a sample of 12–14 year old children in 13 US cities and showed a negative correlation between the fluoride content of the public water supply and dental decay rates. The hypothesis of a causal link was then tested more rigorously in field experiments where selected towns were fluoridated and comparisons were drawn between childhood decay rates subsequently presenting in these and control low-fluoride towns.

Analytical studies can be divided into two types. The first are called case-control or retrospective studies. These entail the selection of a representative sample of cases and controls and may yield historical information on lifestyle and environmental exposures for the testing of causal hypotheses. Such studies may be particularly useful when the population of the community affected by the disease is very small and a long time is thought to elapse between initial exposure to causal factors and clinical manifestation of the disease. An investigation of the relationship between tobacco smoking or snuff 'dipping' and oral cancer could well employ a case-control or retrospective study design. The second type of analytical investigation may be termed a longitudinal, prospective, follow-up, or cohort study. Rather than seeking representative samples of cases and controls as the starting point, this study design begins with samples of individuals selected according to exposure or nonexposure to the putative causal factor. These individuals are then followed prospectively and their disease incidence rates compared. For example, children attending schools where sweets are removed from canteens may be followed and compared with control children at schools which continue to sell sweets. This would be an effective design in instances where the disease under study is relatively common and the time elapsing between exposure to the test factor and clinical manifestation of the disease outcome is short.

Experimental studies are longitudinal, prospective, follow-up, or cohort studies where the researcher has control over who is exposed to the putative causal factor and when. This control is normally exercised through a process of random allocation. An example of such studies would be a clinical trial where fluoride and placebo solutions are applied randomly to test subjects and controls respectively for comparative purposes. Experimental research designs are likely to yield more conclusive evidence of causal associations than are analytical designs, but they are not applicable to many research problems. One is not at liberty, for example, to randomly allocate tobacco smoking, dietary habits, and various other lifestyle practices to test subjects to determine the impact of those factors on the risk of oral cancer.

TERMINOLOGY

As a background to the information provided in various chapters of this book, an introduction to epidemiological terms will now be provided. It is beyond the scope of this chapter, however, to deal with epidemiological terminology in detail. Definitions of some commonly used terms follow (Mosley 1977):

- *Epidemic*: A level of disease that is substantially above the usual for the population or community.
- *Outbreak*: The sudden, unexpected, pronounced increase in the occurrence of disease, usually focally or in a limited segment of the population.
- *Endemic*: Pertaining to the persistence of a disease or disability within a human population at a more or less constant level.
- *Hyperendemic*: Pertaining to the persistence of a disease or disability in a human population at a very high level.
- *Prosodemic*: Pertaining to infections that maintain themselves in human populations by a variety of mechanisms of transmission.
- *Sporadic*: Widely scattered cases of a disease which appear not to have experienced a common exposure.
- *Epizootic*: A level of infection or disease above the usual for a nonhuman population of vertebrates.
- *Prevalence*: The number of cases of a disease in a specific population at a given point in time.
- *Incidence*: The number of new cases of a disease occurring in a specific population during a specified interval of time.

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- *Attack rate*: The number of cases of a disease occurring in a specified population during a specified interval.
- *Case fatality rate*: The number of deaths due to a disease in a well identified group of cases.
- *Mortality rate*: The number of deaths due to a disease in a general population or in a community (i.e. not just among cases).
- *Vector*: Although it can be defined more broadly, the term vector is commonly used to describe arthropods which transmit infectious agents from human to human or from animal to human.
- *Source*: The milieu from which the agent was derived immediately prior to producing infection.
- *Vehicle*: A medium through which an infectious agent is conveyed to man, most commonly used with reference to drinking-water or food. A source of infection is capable of sustaining replication of the agent; a vehicle is not.
- *Fomes (plural, fomites)*: An inanimate object in the environment of a patient, or one that has been in contact with a patient (such as clothes and bed linen), capable of sustaining the viability of an infectious agent.
- *Carrier*: The individual who continues to harbor an infectious agent either following recovery from the illness it induced, or for a period more prolonged than expected in an asymptomatic infection. The term carrier implies that the individual is, or may become, a source of infection for others.
- *Reservoir*: The host or hosts upon which the infectious agent depends for survival or perpetuation. It may be human (as for measles virus), nonhuman (as for *Francisella tularensis*), or environmental (as for *Clostridium tetani*).

CLASSIFICATION OF DISEASES

Classification is an important prerequisite for the quantitative study of any phenomenon. The purpose of a classification is to summarize information and facilitate studies of the quantitative relationships between different items. Classifications of diseases may be based on any of the following items (Roht et al. 1982. pp. 193-200):

- Etiological aspects
- The disease process
- The body organ systems affected
- Methods of treatment
- Methods of transmission
- Methods of entry to and exit from the body
- Factors influencing exposure and/or susceptibility of the host
- Degree of incapacity resulting from the disease.

Uniform definitions and systems of classifications are prerequisites in the advancement of scientific knowledge about illness and death. Thus standard classifications of disease and injury are essential. Several classifications may be used with advantage in an epidemiological investigation. International uniformity in their use, however, should be one of the main objectives. In this context, the World Health Organization has published a standardized coding system for causes of death and morbidity. This is known as the International Classification of Diseases (ICD). Code numbers designating the diseases in each category are:

1. Infective and parasitic disease: 001–139.
2. Neoplasms: 140–239.
3. Endocrine, nutritional, and metabolic diseases and immunity disorders: 240–279.
4. Diseases of the blood and blood-forming organs: 280–289.
5. Mental disorders: 290–319.
6. Diseases of the nervous system and sense organs: 320–389.
7. Diseases of the circulatory system: 390–459.
8. Diseases of the respiratory system: 460–519.
9. Diseases of the digestive system: 520–579.
10. Diseases of the genitourinary system: 580–629.
11. Complications of pregnancy, childbirth, and the puerperium: 630–679.
12. Diseases of the skin and subcutaneous tissue: 680-709.
13. Diseases of the musculoskeletal system and connective tissue: 710–739.
14. Congenital anomalies: 740–759.
15. Certain conditions originating in the perinatal period: 760–779.
16. Symptoms, signs, and ill-defined conditions: 780–799.
17. Injury and poisoning: 800–999.

- *V code*: Supplementary classifications of factors influencing health status and contact with health service: V01–V82.
- *E code*: Supplementary classification of external causes of injury and poisoning: E800–E998.

CONTRIBUTION OF EPIDEMIOLOGY TO HEALTH SERVICES AND EDUCATION

The contribution made by epidemiology to health services, research, and education is enormous. In the field of communicable, nutritional, and occupational diseases, epidemiology has often provided the vital clues necessary to take preventive action well before the specific disease causes have become evident. Epidemiology has highlighted differences in disease trends between nations and within communities. For example, it is well-known that in many technically advanced countries, cardiovascular diseases, chronic respiratory diseases, rheumatism, and malignant diseases are the principal causes of invalidity and death. This is not so for many so-called Third World countries where infections and malnutrition are the overriding causes of morbidity and death. Information on the distribution and health effects of environmental pollution is a further example of the products of epidemiological studies. Studies of trends in traffic accidents have led administrators to introduce and evaluate primary or secondary preventive measures (e.g. introduction of helmets for motor cyclists and seat belts for motorists). For those concerned with national or community health services, epidemiological methods are fundamental for: (1) the diagnosis and measurement of the present health needs of a population; (2) the estimation of the future needs of the population; (3) the determination of health priorities; and (4) the evaluation of health service activities.

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Health administrators need to know which subgroups of the general population are at special risk of particular diseases or hazards so that effective measures can be taken to reduce the risk. It is also important that health personnel are alerted promptly to the onset of major communicable disease epidemics. The threat of such epidemics is usually predicted or revealed by epidemiologists.

Epidemiology is regarded as the basic science of social and preventive medicine. Epidemiological data provide essential information on needs and demands for service. Undergraduate and postgraduate medical and dental curricula should reflect the pattern of disease in the host country so that health needs can be met effectively.

Contribution of Epidemiology to Dental Health, Dental Services, and Education

The contribution made by epidemiology to our understanding of dental diseases, to dental health services, and to dental education is becoming increasingly evident. Specific areas to which epidemiology has made a major contribution include the control and management of dental caries, periodontal disease, disorders of occlusion, malformations of the craniofacial skeleton, and oral cancer. Our understanding of the relation of dental caries to diet is based on epidemiological studies. The role of fluoridation in the prevention of dental caries is a well-known example of a dental public health measure arising from epidemiological research.

Over the years, several indices have been formulated which quantify the presence of disease for dental epidemiological studies. These have contributed substantially to our understanding of the oral disease experience of various population groups. The development of indices largely depends upon an accurate definition of terms. Standardization of terminology on a world-wide basis is very important in this context. It is also important that the indices used are simple and that their practical implementation in the field is inexpensive.

For several reasons, the indices used in dental studies are sometimes regarded as less than perfect. Nevertheless, they have proved to be immensely valuable. The traditionally used indices for caries experience in a population are summations of the number of decayed (D), missing (M), and filled (F) teeth (DMFT index) and tooth surfaces (DMFS index). These indices are easy to use and, because they are internationally accepted, they provide a means of comparing the caries experience of population groups around the world. Also, at a local level, these indices can provide health personnel with valuable data on the dental health status of a population. In turn, this information can be a basis for national dental health service planning and provision. The same information can be used to plan and evaluate a public health education program.

Periodontal indices are used to measure the prevalence and severity of periodontal disease. Russell's Periodontal Index (PI) (Russell 1956) and the Ramfjord Periodontal Disease Index (Ramfjord 1967) are examples of well-established indices used in this field. However, they have serious limitations and can no longer be recommended (see Chapter 51). The problems are fully discussed in Johnson (1991). Green and Vermillion (1964) have devised an index for oral hygiene status known as the Oral Hygiene Index (OHI). This index has two components, namely, a Debris Index (DI) and a Calculus Index (CI). The Oral Hygiene Index is simple to use and can be employed in dental practice to monitor the oral hygiene status of individual patients. This can serve as a useful source of information for follow-up studies and patient evaluation at periodic recalls.

The 'Community Periodontal Index of Treatment Needs' (CPITN) (Ainamo et al. 1982) is a useful screening tool for community-wide studies and much epidemiology using this has been published in the past decade. It cannot, however, be translated into a realistic treatment need for population groups, even less so for an individual (see Chapter 51). For assessing malocclusion, the 'Orthodontic Treatment Priority Index' (OTPI) can be used.

A further example of the value of epidemiology is in the study of oral cancer. Surveys around the world, and in particular in the Indian subcontinent, show the seriousness of this problem and offer useful clues to the associated etiological and 'risk' factors.

A very useful publication which makes a distinction between the prevalence of various dental diseases and their severity, is Oral health surveys, published by the World Health Organization (WHO 1977). This booklet is recommended to the reader. To those intending to carry out epidemiological investigations, assistance is offered by the WHO (Oral Health Division: WHO, 1211 Geneva 27, Switzerland). In addition to supplying survey forms free of cost, the WHO also will assist in the interpretation of results. For mucosal pathology, the WHO (1980) has published a freely available booklet entitled *Guide to Epidemiology and Diagnosis of Oral Mucosal Diseases and Conditions*. As a guide to dental epidemiological studies a WHO publication called *A Guide to Oral Health Epidemiological Investigations* (1979) is also available.

ROLE OF DENTAL EPIDEMIOLOGY IN THE DEVELOPING TROPICS

It is crucial that the provision of health services is tailored to community needs. In tropical societies, these needs can be quite different from those in industrial, Western societies. Epidemiology has a special contribution to make to dental health planning in these circumstances. For example, where epidemiological data show a virtual absence of carious lesions on the smooth surfaces of teeth, health authorities may choose not to devote scarce resources to fluoride mouth-rinsing and other surface applications of fluoride which are known to have only a limited effect on fissure lesions. Where the data show an abundance of dental plaque, calculus, and advanced periodontal disease, a considerable emphasis may be placed on oral hygiene practices. If economic resources are scarce, a work-force may be developed to tackle this problem and a high priority may be placed on the use of dental auxiliaries and village cadres, thus avoiding the expense of employing only fully trained dental professionals.

In some societies, epidemiological data may show a high rate of oral cancer. Such data may be used to define the age groups most at risk, the geographic areas and ethnic groups most affected, and other risk factors. Screening programs for the early detection

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of oral cancer can then be planned accordingly. By comparing the lifestyle practices of affected cases and controls clues may be gained as to the causal factors. Preventive educational programs can then be framed accordingly.

Through a periodic review of epidemiological data, judgments can be made as to whether the trends in disease rates are favorable and whether the health services provided are having an effect. For example, are levels of oral hygiene improving and is there evidence of a reduced prevalence of gingivitis and advanced periodontal disease? Are fewer cases of oral cancer presenting and is there evidence of earlier detection and improved case survival?

Dental record systems established within health services can be used to show trends in the patients' needs for care. They can show: (1) the extent of utilization of these services by different community groups, including those considered most at risk; (2) the types of services provided and whether they reflect a compliance with policy decisions on the types of services which should be provided to be most cost-effective; (3) the volume of services provided by type, and whether this denotes a satisfactory level of productivity for the size of work-force involved; and (4) the quality of services, as indicated by the need for replacement of restorations, for extraction of teeth previously restored, and so forth.

Periodic surveys and analyses of epidemiological data can indicate whether the services provided by dental staff and village cadres are of an adequate standard. They can show the sensitivity and specificity of diagnoses, the difference in dental status before and after dental treatment, the quality of restorations, and various other key parameters.

By monitoring disease trends, reassessments can be made of the appropriate future size and composition of the dental work-force. Are future needs likely to relate mostly to caries or oral soft tissue disease? How should these be tackled and what type and size of dental work-force would be appropriate?

Epidemiology can be used in clinical studies to indicate the relative effectiveness of alternative clinical practices and to answer a range of clinical questions. For example, which fissure sealants are the most retentive? Which fluoride measures are the most preventive? Which amalgam materials provide the most durable restorations? Which of the treatment modalities for oral cancer are associated with the best survival rates? Are primary healthcare workers capable of screening patients for oral cancer (Warnakulasuriya et al. 1985)?

In summary, the practice of epidemiology can allow countries to tailor their dental services to their own needs and adjust these services in the light of practical experience. The approach is empirical and contrasts with the practice of simply transferring Western modes of care to non-Western situations.

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