EPIDEMIOLOGY

An Introductory Text

MAUSNER / BAHN

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PREFACE

This text is designed to provide a background in epidemiology for an introductory course in community medicine, health administration, or public health. It is also intended as a review for students preparing for examinations in preventive medicine.

We consider it important that all physicians, not just those who serve as health officers or do research in epidemiology, be familiar with epidemiologic principles and methods. Epidemiology and biostatistics, no less than physiology and pathology, are basic disciplines essential to both clinical and community medicine. They provide a way of thinking about health and disease.

Further, in reading the medical literature, all physicians should be able to follow critically a chain of evidence and to avoid the major pitfalls of epidemiologic inference. Epidemiologic sophistication fosters a questioning attitude toward medical practices which may be introduced and accepted without adequate support from well-controlled studies.

Finally, physicians and other health workers have an increasing role in providing preventive services and in maintaining the health of a community. This makes it desirable for them to know the common indices of community health, the analytic methods of demography, and the theory behind screening programs, as well as the methods appropriate to the epidemiologic study of acute and chronic diseases.

The text is intended to be a general introduction to epidemiology. Certain diseases are cited for purposes of illustration, but no attempt is made to present a comprehensive survey. However, the basic principles presented should provide the background for understanding the epidemiology of specific diseases.

Several technical subjects are explained in appendices to the appropriate chapters; they may be omitted without loss of continuity. To aid in self-teaching, at the end of each chapter there are study questions, including key concepts to be defined. Detailed answers to most of these questions are provided at the end of the

book. For those readers unfamiliar with medical terminology, definitions have been provided when they seemed necessary.

We hope that our text will serve, at least for some, as a stepping stone to more advanced studies in epidemiology and preventive medicine. There is a great need for epidemiologists and other specialists in preventive medicine to participate actively in the prevention of disease and maintenance of health in population groups.

Many persons have helped, directly and indirectly, in the writing of this book. An early version of the entire manuscript was read by Drs. Frederic Bass, Jean D. Galkin, Nicholas Petrakis, Raymond Seltser, and Charlotte Silverman. Portions of the text were reviewed by Mr. Nathan Mantel; Drs. William H. Barker, Thomas C. Chalmers, Helen C. Chase, Ira W. Gabrielson, Frederick Hoesly, and Anders S. Lunde; and other colleagues at The Medical College of Pennsylvania, the Maryland State Department of Health and Mental Hygiene, the Washington (D.C.) Hospital Center, the Center for Disease Control, and the National Center for Health Statistics. Special thanks are due to Dr. Richard Morton, who reviewed a large portion of the manuscript. We benefited greatly from his keen pedagogic insights and judgment. We also profited from the comments and suggestions of several classes of medical students at The Medical College of Pennsylvania and of graduate students in public health nursing and health administration at the University of Pennsylvania. Of course, any errors in fact or interpretation in the book are entirely the responsibility of the authors.

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EPIDEMIOLOGIC ORIENTATION TO HEALTH AND DISEASE

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POPULATION MEDICINE AND EPIDEMIOLOGY

Knowledge about human health and disease is the sum of the contributions of a large number of disciplines—anatomy, microbiology, pathology, immunology, clinical medicine, pediatrics, radiology—the list is potentially very long. However, the various disciplines can be grouped according to their methods and underlying concepts. When this is done three major categories emerge: one consists of the basic sciences (e.g., biochemistry, physiology, pathology), another the clinical sciences (e.g., adult medicine, neonatology, obstetrics and gynecology, urology, and so on), and the third population medicine. In different settings, population medicine is also referred to as community medicine, preventive medicine, or social medicine. This is the field concerned with the study of health and disease in human populations. Its goal is to identify the totality of health problems and needs of defined populations and to consider mechanisms by which these needs are, or should be, met.

The concerns of population medicine are quite different from those of the clinical disciplines. **Clinical medicine** focuses largely on the medical care of individuals. Typically, these have been **sick** people who have presented themselves for help; in recent years examination of apparently well people has been encouraged in order

to detect disease in early stages. In **population medicine** the community replaces the individual patient as the primary focus of concern. The problem here is to evaluate the health of a defined community, including those members who would benefit from, but do not seek, medical care. This approach requires specific techniques and skills in addition to those needed for clinical practice. The principles and methods underlying population medicine form the subject matter of this book.

It is readily apparent that clinical and population approaches to health and disease are highly interrelated and, together with the basic sciences, complement each other. A physician is guided toward a correct diagnosis in an individual patient by his knowledge of the distribution of diseases according to such factors as age, sex, and ethnicity. He is also aided by information about the illnesses prevalent in a given community. For a patient with fever and respiratory disease, for example, he will want to know if an influenza epidemic is in progress or if there has been a recent upsurge in streptococcal isolations. The answers to such questions will assist him in decisions about the avenues he should explore to reach a diagnosis.

Conversely, community diagnosis is dependent on the accuracy of the diagnoses made on individual patients and on the completeness with which reportable diseases are, in fact, made known to those responsible for the public's health. In addition, the accuracy of both individual diagnoses and epidemiologic assessments is dependent on adequate laboratory support.

Tuberculosis provides a good illustration of the three different approaches to a specific disease. The basic sciences are concerned with various aspects of the tubercle bacillus, its structure and antigenic composition, growth in different media, resistance to specified antibiotics, and with host responses, such as the extent to which tubercles become walled off by fibrous tissue. Clinical study of a case entails diagnosis, estimation of the extent and activity of disease, choice of therapy, appraisal of the patient's response, and adequate follow-up.

The questions pertinent to tuberculosis as a community problem concern the frequency of the disease, the relative contributions of different programs to identification of cases, and the environmental and cultural factors which serve to maintain or reduce its frequency of occurrence. How many new cases are diagnosed each year? What age groups and segments of the community are primarily affected and why? Who has been exposed to a newly discovered active case? What proportion of known active cases and their

contacts are under adequate medical supervision? How many deaths a year are due to tuberculosis? What proportion of cases become known to health agencies only after the death certificate is filed? Other community problems concern medical care needs, such as the number of hospital beds and clinic visits required.

Each of the three approaches outlined here has its characteristic locus of activity. The basic sciences are primarily based in the laboratory; clinical activities are carried out in hospital wards, emergency rooms, ambulatory care clinics, and private physicians' offices; and the locus of population medicine is the community. For a comprehensive picture of disease in a community, information is needed about the health problems and needs of all its segments. In part this is derived from the records of clinical facilities. However, since the entire population generally does not utilize the available clinical services, diagnosis of community health problems may require surveys of samples of the population to gather information about people not under medical supervision. On the basis of such information, health services needed to supplement those already in existence may be developed in health departments and other neighborhood health centers and through associated outreach activities.

Thus we see that for population medicine we need a systematic way of studying both the diseases present in a community and the patterns of delivery of medical care, since these influence the amount and nature of disease. Epidemiology is the discipline which provides this systematic approach.

Epidemiologists have traditionally concerned themselves with the elucidation of disease entities and with the practical aspects of containment of disease. Epidemiology, often under the label of "disease control" or "communicable disease control," has been one of the traditional services of local and state health departments. Recently there has been a move to apply epidemiologic methods in hospitals, mainly for the control of infections, but also for monitoring adverse drug reactions. Epidemiologists are now also applying epidemiologic principles and methods to studies of medical care systems and of the anticipated effects of new approaches to health care.

EPIDEMIOLOGY DEFINED

Epidemiology may be defined as **the study of the distribution and determinants of diseases and injuries in human populations.**

That is, epidemiology is concerned with the *extent* and types of illnesses and injuries in *groups* of people and with the *factors* which influence their distribution. This implies that disease is not randomly distributed throughout a population, but rather that subgroups differ in the frequency of different diseases. Further, knowledge of this uneven distribution can be used to investigate etiologic factors and to lay the groundwork for programs of prevention and control. The contribution of epidemiology to the advance of medical science was expressed well by Frost (1936) some 40 years ago.

> Epidemiology at any given time is something more than the total of its established facts. It includes their orderly arrangement into chains of inference which extend more or less beyond the bounds of direct observation. Such of these chains as are well and truly laid guide investigation to the facts of the future; those that are ill-made fetter progress.

Need for Rates

Inherent in the definition of epidemiology is the necessity for measuring the amount of disease in a population or community by relating cases to a population base. Epidemiologic statements often consist of fractions, or *rates*, in which the *numerator* is the number of people with the disease and the *denominator* is the population in the same area at the same time. Rates of disease are called *morbidity* rates, rates of death *mortality* rates.

$$Rate = \frac{number\ of\ cases\ or\ deaths}{population\ in\ same\ area}\ in\ a\ time\ period$$

Clinical and epidemiologic studies deal with the same phenomena, but from somewhat different vantage points. In contrast to epidemiologic investigations, clinically oriented studies usually focus on sick people who come for care (i.e., the numerator only) and are not concerned with identifying and enumerating the population from which the cases arise. An example of the difference in the two approaches follows. A *clinical* report on ulcer disease bore the title, "Problem of the gastric ulcer reviewed: Study of 1000 cases" (Smith et al., 1953). An *epidemiologic* study of ulcer (Pulvertaft, 1959) presented mean annual incidence rates of peptic ulcer for a defined population base (York, England) and showed, for instance, that the rate was only 0.17 per 1000 females under 25 years of age but 0.96 for males.

Low as well as high rates of disease have provided useful clues to etiology. For example, absence of pellagra in attendants in men-

tal hospitals at a time when it was prevalent in patients led Goldberger (1914) to reject the then popular hypothesis that pellagra is of infectious origin in favor of an hypothesis of nutritional deficiency. The virtual absence of carcinoma of the cervix among nuns (Gagnon, 1950) in contrast to the high rate among prostitutes (Røjel, 1953) suggested that sexual activity was probably an important etiologic factor. To quote a contemporary British epidemiologist (Morris, 1955):

> The main function of epidemiology is to discover groups in the population with high rates of disease, and with low, so that causes of disease and of freedom from disease can be postulated. . . . The biggest promise of this method lies in relating diseases to the ways of living of different groups, and by doing so to unravel "causes" of disease about which it is possible to do something. . . .
>
> The great advantage of this kind of approach to prevention is that it may be applicable in the early stages of our knowledge of diseases, to disrupt the pattern of causation before the intimate nature of diseases is understood. Sufficient facts may be established for this by epidemiological methods alone, or in combination with others. The opportunity may thus offer to deal with one "cause," or with various combinations of causes. . . .

Health and Disease

The preceding paragraphs stress the importance of rates in epidemiology. However, even though epidemiologists are primarily interested in occurrence of disease, they are also concerned with distributions of physiologic variables, such as blood pressure, blood glucose, serum uric acid, and serum cholesterol, in healthy and diseased individuals. Studies of these variables permit evaluation of their contribution, singly and in combination, to the development of disease.

The fact that we have defined epidemiology operationally in terms of measurement of *disease* should not obscure the ultimate concerns of epidemiology, which are the *prevention* of disease and the *maintenance of health*. Unfortunately it is easier to define and measure disease, disability, and death than to produce an operational definition of health.

Health is a rather elastic concept; it may be defined merely as the absence of disease and disability or it may be given a much more positive meaning, as in the widely cited Constitution of the World Health Organization (1948):

> Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.

Attempts by national and international committees to quantify

health status have led to some promising suggestions for its measurement (Sullivan, 1966). Nevertheless, both physical and mental health are still measured mainly through their converse, disease and death. Thus, of necessity, this text too will focus primarily on measurement of disease and ill health even though our ultimate goal is a positive one.

NATURAL HISTORY OF DISEASE

When morbidity rates are constructed, each person in the group under study must be classified as having or not having a specific disease. This decision is often difficult to make. The development of disease is often an irregularly evolving process, and the point at which a person should be labelled "diseased" rather than "not diseased" may be arbitrary. Many diseases, especially chronic disease which may last years or decades, have a *natural life history.* Just as we think of the "seven ages of man," so chronic disease may be considered to extend over time through a sequence of stages. As knowledge accumulates, it has become apparent that factors favoring the development of chronic disease often are present early in life, antedating the appearance of clinical disease by many years.

Since each disease has its own life history, any general formulation is necessarily arbitrary. Nevertheless, it may be useful to develop a schematic picture of the natural history of disease as a framework within which to understand different approaches to prevention and control.

Stage of Susceptibility

In this stage disease has not developed, but the groundwork has been laid by the presence of factors which favor its occurrence. For example, fatigue and acute and chronic alcoholism heighten susceptibility to pneumonia; inadequate maternal nurturing predisposes to emotional illness; high serum cholesterol levels increase the likelihood that overt coronary heart disease will develop.

Factors whose presence is associated with an increased likelihood that disease will develop at a later time are called *risk factors.* The need to identify such factors is becoming more apparent as awareness grows that chronic diseases present our major health challenge. Some risk factors can be altered, as when smokers can be persuaded to give up smoking. Others are not now amenable to change, but their identification may still be useful for tagging per-