Second Edition

MAUSNER & BAHN

Epidemiology–

An Introductory Text

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1985

W. B. SAUNDERS COMPANY

Philadelphia
London
Toronto
Mexico City
Rio de Janeiro
Sydney
Tokyo

PREFACE

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

We consider it important that all health professionals—not just those who serve as health officers or who 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.

In reading the medical literature, it is also important to follow critically a chain of evidence and to avoid the major pitfalls of epidemiologic inference. Epidemiologic sophistication fosters a questioning attitude; without it medical practices may be introduced and accepted even though they may lack adequate support from well-controlled studies.

Finally, health workers have an increasing role in providing preventive services and in maintaining the health of a community. It is important, then, to familiarize oneself with the methods appropriate to the epidemiologic study of acute and chronic disease, the analytic methods of demography, and the theory behind screening programs.

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.

We mourn the premature death, in 1980, of Anita K. Bahn, coauthor of the first edition of this text.

In addition to those who contributed to the first edition we would

like to acknowledge the contributions of Richard Morton, Donald Balaban, Richard Burian, Helen C. Chase, Samuel Greenhouse, Douglas Eubanks, Douglas Edwards, Morton Levin, Ralph M. Richart, and Ira Rosenwaike. Beth Sonnenshein contributed greatly by providing references to government publications. We want to express our appreciation to the staff of the National Center for Health Statistics for their helpfulness and efficiency in providing health data. For assistance with typing we are indebted to Vickie Taylor and Frances Seeds for their unfailing willingness and cooperation.

Finally, as was true of the first edition, all of our contacts with the publisher, W. B. Saunders Company, were helpful and pleasant. We want to thank the staff of W. B. Saunders for their skilled and friendly assistance in helping us bring this project to completion.

The debt we owe our husbands, Bernard Mausner and Leon Josowitz, for their unfailing support and encouragement is beyond measure.

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CONTENTS

EPIDEMIOLOGIC ORIENTATION TO HEALTH AND DISEASE

1

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 *frequencies* and types of illnesses and injuries in *groups* of people and with the *factors* that 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 causal factors and thus 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 in 1936:

> 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.

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, 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 the third population medicine. In different settings, population medicine is also referred to as community medicine, preventive medicine, or social medicine, or, more traditionally, as public health. This field is concerned with the study of health and disease in human populations.

The concerns of population medicine are quite different from those of the clinical disciplines. **Clinical medicine** focusses 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 the basic sciences, clinical sciences, and population medicine are all highly interrelated. A physician is guided toward a correct diagnosis in an individual patient not only by the patient's history, physical findings, and laboratory data, but also by knowledge of the distribution of diseases by such factors as age, sex, ethnicity, and socioeconomic status. For example, cancer of the pancreas, which is difficult to diagnose on clinical grounds, is more probable in an elderly smoker than in an adolescent. Knowledge of the attributes of the patient can help guide the selection of diagnostic procedures.

Information about the illnesses prevalent in the community also contributes to diagnosis. For a patient with fever and respiratory disease, for example, the physician will want to know if an influenza epidemic is in progress or if there has been a recent upsurge in streptococcal isolations.

Conversely, assessment of the level of occurrence of disease in a population is dependent on the accuracy of the diagnoses made on individual patients and on the completeness with which reportable diseases are made known to public health authorities. Such reporting can lead to containment of an outbreak resulting from contamination of food or water or can show the need for an intensified immunization program against measles. In addition, the accuracy of both individual diagnoses and epidemiologic assessment is dependent on adequate labo-

ratory support. This is particularly important for organisms that require special techniques for isolation and identification, such as *Legionella*, the agent of legionnaire's disease.

Tuberculosis, although on the wane, provides a good illustration of the three different approaches to the same disease. The basic sciences are concerned with various aspects of the tubercle bacillus—its structure and antigenic composition, growth in different media, and 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 of chemotherapy.

As a community problem, the control of tuberculosis involves other considerations. Several points are at issue: (1) recognition of its high occurrence in particularly susceptible groups, such as infants, alcoholics, and recent Oriental immigrants to the United States; (2) awareness of the need to follow up household contacts of cases; and (3) the assurance of chemotherapy continuing for an adequate period. Tuberculosis used to require long periods of institutional care. Outpatient chemotherapy, by removing the need for inpatient supervision, has all but eliminated the need for beds for tuberculosis patients.

Although there is a trend toward increasing integration of the basic sciences, clinical sciences, and community medicine, each of these three approaches has its major locus of activity and specific methods. The basic sciences are primarily sited in the laboratory and use experimental techniques. Clinical activities are carried out in hospital wards, emergency rooms, ambulatory care clinics, and the offices of private physicians. Epidemiologic knowledge, largely based on observational studies, is gathered from a variety of sources by professionals called *epidemiologists* whose responsibility it is to develop a comprehensive picture of health problems in the community. In part, the information needed can be derived from the records of clinical facilities; however, these may vary in accuracy and completeness. Furthermore, since community diagnosis requires information about the health problems and needs of all segments of the population, including those not under medical supervision, it may be necessary to carry out surveys of samples of the population. On the basis of the information obtained, health services needed to supplement those already in existence may be developed.

In summary, population medicine necessitates a systematic way of studying both the patterns of occurrence of disease in a community and the patterns of delivery of medical care, since the services offered both influence and are influenced by the amount and nature of disease and by the changes in modes of therapy. Epidemiology is the discipline that provides this systematic approach.

HEALTH AND DISEASE

Although we have defined epidemiology in terms of disease, its central concern is maintenance of health through the prevention of disease. 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 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.

In recent years, this statement has been amplified to include the ability to lead a socially and economically productive life (Mahler, 1981). The definition given may represent an unobtainable ideal, but the goal, nevertheless, is to achieve maximum well-being for all segments of the population. Perhaps a more realistic formulation is that proposed by Dubos (1968). After noting the utopian character of the WHO definition, Dubos goes on to say that health is not to be considered "an ideal state of well-being achieved through the complete elimination of disease, but as a modus vivendi enabling imperfect men to achieve a rewarding and not too painful existence while they cope with an imperfect world." 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 also will focus primarily on measurement of morbidity and mortality even though our ultimate goal is a more positive one.

The Need for Rates

Central to the measurement of disease and identification of high-risk groups in a population is the *rate*, relating cases or events to a population base. The numerator of a rate is the number of people with the disease being counted; the denominator is the population at risk of the disease or event. Note that in a rate (1) the numerator is the number of people to whom something happens, and (2) everyone in the denominator must be at risk of entering the numerator. Rates of disease are called *morbidity* rates; rates of death, *mortality* rates.

$$Rate = \frac{Number\ of\ events,\ cases,\ or\ deaths}{Population\ in\ same\ area}\ in\ a\ time\ period$$

The fallacy of looking only at numbers of cases without relating them to the population from which the cases derive is shown by the following hypothetical data, comparing the number of deaths associated with two modes of transportation, automobiles and private aviation:

	Automobiles	Private Aviation
Number of fatalities per year	1,000	50
Number exposed to risk	100,000	1,000
Rate of fatal injury	$\frac{1,000}{100,000} = 0.01$	$\frac{50}{1,000} = 0.05$

Note that the number of deaths among drivers is twenty times that among pilots, but since the number of drivers exposed is one hundred times greater, the actual fatality rate is lower for drivers than for pilots. In summary, then, epidemiologic statements require specification of a denominator as well as a numerator.

In contrast, clinically oriented studies usually focus only on the numerator, such as the fatalities in the chart, or the number of sick persons who seek medical care.

For a further example of the difference in the two approaches, consider two reports on ulcer disease. A clinical report bore the title "Problem of the gastric ulcer reviewed: Study of 1,000 cases" (Smith et al., 1953). An epidemiologic study of gastric ulcer indicated annual incidence rates of 0.44 per 1000 persons aged 15 years and older (Bonnevie, 1975) and noted that, in contrast to earlier studies, gastric ulcer is now more common in males than in females.

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

THE NATURAL HISTORY OF DISEASE

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. By "natural history" we refer to the course of disease over time, unaffected by treatment. Like the "seven ages of man," 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 that 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 probability that overt coronary heart disease will develop; immune suppression is believed to increase the risk of developing cancer.

Factors whose presence is associated with an increased probability that disease will develop later are called *risk factors*. The need to identify such factors is becoming more apparent with the growing awareness that chronic diseases represent our major health challenge.

Risk factors may be immutable or susceptible to change. Such factors as age, sex, race, and family history, which are not subject to change, are often major determinants of risk. However, 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 identifying persons who deserve close medical supervision.

It should be pointed out that even when there is a strong statistical association between a risk factor and a disease, this does not mean that *all* individuals with the risk factor will necessarily develop the disease

nor that *absence* of the risk factor will ensure absence of the disease. Our inability to identify all the factors contributing to risk of disease limits our ability to predict for individuals.

Stage of Presymptomatic Disease

At this stage there is no manifest disease, but usually through the interaction of factors pathogenetic changes have started to occur. At this stage, the changes are essentially below the level of the "clinical horizon," the imaginary dividing line above which disease manifests itself through detectable signs or symptoms. Examples of presymptomatic disease are atherosclerotic changes in coronary vessels prior to any signs or symptoms of illness, and premalignant (and, unfortunately, sometimes malignant) alterations in tissue.

Stage of Clinical Disease

By this stage sufficient end-organ changes have occurred so that there are recognizable signs or symptoms of disease. It is important, whenever possible, to subdivide this stage for better management of cases and for purposes of epidemiologic study. There are several possible bases for classification. Depending on the specific disease, classification may be based on morphological subdivision or on functional or therapeutic considerations.

Different classificatory schemes are used for different diseases. Cancer is usually classified on morphological grounds that express the extent of disease, i.e., the location of the tumor and its histological type and extent. A commonly used procedure is to place each tumor into one of three categories: localized, with regional metastases, or with generalized spread.

The importance of staging for prognosis of cancer can be seen in Figure 1–1, which gives five-year relative survival rates for cancer of different organs according to whether the cancer was localized or showed regional spread at the time of diagnosis. While prognoses vary according to the different sites of cancers, it is uniformly true that at each site survival is better for localized cases than for those with regional involvement. Clearly, stage is the major influence on prognosis.

Functional and therapeutic classification is exemplified by the widely used categorization of cardiac disease of the New York Heart Association (1964). The following is adapted from their schema:

Functional Classification

Class I	No limitation of physical activity because of discomfort
Class II	Slight limitation of physical activity; patient comfortable at rest but ordinary activity produces discomfort

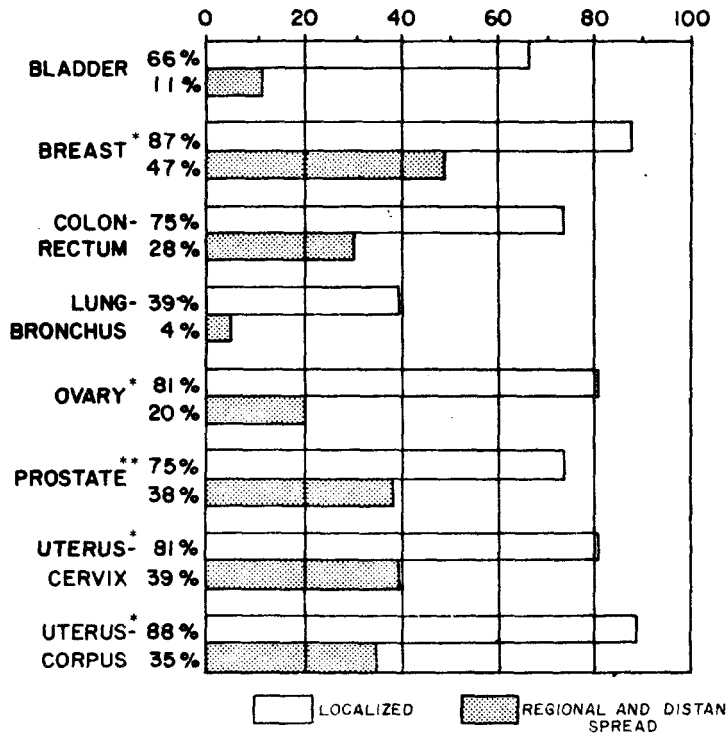

Figure 1-1 Five-year relative survival rates for patients diagnosed 1964-1973, selected sites of cancer. Relative survival is the ratio of the survival rate of an observed group to the survival of the general population similar in age, race and sex. (From Biometry Branch, National Cancer Institute, National Institutes of Health.)

* Female only.

** Male only.

Class III Marked limitation of physical activity; comfortable at rest but less than ordinary activity causes discomfort

Class IV Inability to carry out any physical activity without discomfort

Therapeutic Classification

Class A Physical activity need not be restricted in any way

Class B Ordinary physical activity need not be restricted, but patient is advised against severe efforts

Class C Ordinary physical activity should be moderately restricted

Class D Ordinary physical activity should be markedly restricted

Class E Complete bed rest advised; patient confined to bed or chair

Note that functional and therapeutic classifications do not always parallel each other. For example, a patient with a recent heart attack or active rheumatic carditis may not have symptoms upon physical exertion, but may be advised to remain at complete rest (Class I, E).

As suggested above, classification, or staging, of disease is of great

importance for epidemiologic study. Effective grouping reduces variability, yielding relatively homogeneous subgroups. This is important for evaluation of the effect of prophylactic or therapeutic agents (see discussion of clinical trials in Chapter 8); for comparative studies of disease in different groups, i.e., international, regional, occupational, and so on; and for clinical management of patients.

At present we do not have a complete understanding of the natural history of many diseases. We do not know why an individual with a number of risk factors, for example, may not progress to clinical disease. Much research in recent years has been directed to the follow-up of large groups over time (longitudinal studies) to attempt to gain this understanding.

Stage of Disability

Some diseases run their course and then resolve completely, either spontaneously or under the influence of therapy. However, there are a number of conditions which give rise to a residual defect of short or long duration, leaving the person disabled to a greater or lesser extent. On occasion a disease that is usually self-limited may later give rise to chronic disability. For example, a small proportion of cases of measles are followed by development of subacute sclerosing panencephalitis, a progressive neurologic disorder (Brody et al., 1972).

Although disability can be defined in various ways, in community surveys it usually means any limitation of a person's activities, including his psychosocial role as parent, wage earner, and member of his community. The National Health Survey (see Chapter 4) defines disability as "any temporary or long-term reduction of a person's activity as a result of an acute or chronic condition" (1958). Note that the emphasis is on loss of function rather than on structural defect. Individuals vary widely in their reaction to physical impairment. Two persons with the same amount of tissue damage from heart disease, for example, may show marked differences in their resultant level of disability. While there is a substantial amount of disability associated with acute illness, the extent of protracted disability resulting from chronic illness is of greater significance for society.

LEVELS OF PREVENTION

Implicit in the scheme just presented is the notion that a disease evolves over time and that as this occurs pathologic changes may become fixed and irreversible. Therefore, the aim is to push back the level of detection and intervention to the precursors and risk factors of