Prolog

The Epidemiologic Approach and the Uses of Epidemiology

In 1976, public attention was focused on Philadelphia not only because of the bicentennial of the signing of the Declaration of Independence but also because of a mysterious epidemic of pneumonia that struck there soon after the Fourth of July. An apparently new disease[1] had struck 221 people at Philadelphia's Bellevue-Stratford Hotel, many of whom were attending an American Legion Convention—thus giving rise to the name "Legionnaires' Disease," or Legionellosis, for this virulent pneumonia. A majority of the cases occurred within a 12-day interval, and 6.8 percent of the conventioneers developed the disease. Thirty-four persons (16 percent of the cases) died.

It was through the news coverage of this investigation that many Americans first heard of that small band of scientists known as *epidemiologists*. Although the expected white lab coats and microscopes were very much in evidence among some of the scientists searching out the causes of this epidemic, the epidemiologists did not conduct their investigation in the fashion most people expected. Instead of working with test tubes and microscopes in laboratories, they spent their time asking people questions and poking into every corner of the hotel—

[1] It was eventually learned that previously there had been at least two smaller epidemics of the same disease—one in Washington, D.C. in 1965 and the other at the same Philadelphia hotel in 1974. There had also been previous epidemics of Pontiac Fever, a nonpneumonic disease caused by the same bacteria as Legionnaires' Disease.

even examining the contents of the waste baskets. Stranger still, they seemed as interested in the people who did not get sick as in those who did—even surveying American Legion members who had decided not to attend the convention. It is the comparison of groups (e.g., the sick with the well, attenders with nonattenders) that is the essence of the epidemiologic approach.

When a group of people gathered for an occasion such as a convention are stricken by an epidemic illness, food poisoning is always suspected. Epidemiologists soon found, however, that there was no association between eating at certain convention functions or at certain restaurants and occurrence of the disease. The possibility of contaminated water supply is also a consideration and the investigators did find a statistically significant association between consumption of drinking water at the hotel and occurrence of the disease. However, of 69 ill delegates from whom information was obtained, 24 had not consumed any water at the Bellevue-Stratford Hotel. Epidemiologists concluded that the association simply represented the fact that those who had spent more time at the hotel were more likely to have consumed some water there, while it was the amount of time spent in the hotel that was causally linked with the disease.

The possibility of person-to-person transmission of the disease was also examined by the epidemiologists. They found that persons who had shared a room with someone who developed the disease were not significantly more likely to develop the disease than those with a disease-free roommate. Likewise, there was no evidence of transmission of the disease to family members by cases who had returned home before becoming ill.

The possibility that the disease was airborne was suggested to the epidemiologists by the higher frequency of the disease among Legionnaires staying at the Bellevue-Stratford than among those staying elsewhere in Philadelphia. This was more strongly indicated when surveys of both ill and well Legionnaires revealed that among Legionnaires who did not stay at the Bellevue-Stratford, the frequency of the disease was higher among those who had spent more time in the lobby of the hotel. Cases even occurred in persons who had not entered the hotel but who had spent time on the sidewalk in front of the hotel where air from the lobby passed out through the front door.

Acting on the basis of this evidence, epidemiologists isolated the disease organism now known as *Legionella pneumophila* in water from the hotel's air-conditioning system cooling tower. The organism showed a striking ability to survive in sterile water and was likely to thrive in

conditions of elevated temperature and in which organic matter i present in a cooling tower. As air passes through a cooling tower in th heat-exchange process, a cloud of droplets (known as "drift") i generated, which can be expected to contain any bacteria present in th cooling tower water. This "drift" may be disseminated over a wide are and in some cases may be drawn into the air-conditioning system itsel through its air intakes, thus spreading *L. pneumophila* throughout th air-conditioned area.

The Epidemiologic Approach

Like the names of most sciences, the term *epidemiology* is derive from Greek root words. *Epi* for upon—as in epidermis, the layer of dea skin cells on top of the dermis, the living skin. *Demos* for the people—a in democracy. *Logos* for thought or study—as in logic or biology. Thu epidemiology is the study of that which befalls the people; the study o the diseases, accidents, and disasters that befall us all.

The epidemiologic approach to the study of these events is rooted i the basic assumption that these events do not befall the population in purely random or chance fashion. When two populations differ in th extent to which they suffer from a disease, an epidemiologist presume that some other difference between the communities is causally relate to the disease. In short, epidemiologists believe in causes—not i luck—as the determiner of who gets sick.

Keeping this assumption in mind we can begin to define epidemiolog more precisely. Lilienfeld (1978) found that epidemiology is defined in variety of different ways by different authors. The one commonalit seems to be the frequent use of the phrase, "the distribution of." By th distribution of disease, for instance, we mean that an epidemiologis wants to know what groups of people, places, and time suffer greatl from a disease, and what characteristics high-rate groups may have i common. Consistent with Lilienfeld's review, we propose the followin definition: Epidemiology is the study of the distribution and determ nants of the varying rates of diseases, injuries, or other health states i human populations.

David Lilienfeld (1978) proposed a new definition of epidemiolog "Epidemiology is a method of reasoning about disease that deals wit biological inferences derived from observations of disease phenomen in population groups" (p. 89). Lilienfeld's definition has much to recommend it, but it also incorporates two assumptions about the scope of epidemiology that this author finds objectionable: that epidemiology is only concerned with (1) disease and (2) biological inferences about disease. Although both statements might have been accurate about epidemiology as it was practiced a half-century ago, the scope of contemporary epidemiology has been expanded to include injuries and other nondisease health states, and is increasingly coming to encompass psychological and sociological inferences in its examination of its subject matter.

In examining the burden of disease on any community, an epidemiologist is always concerned with rates of disease—with the proportion of the population that is affected by the disease. In subsequent chapters we will examine a variety of rates that are used by epidemiologists. At this point we will discuss two rates that are widely used in epidemiology: the *incidence rate* and the *prevalence rate*.

Incidence is a measure of the rate at which new events occur in a population. The numerator of this rate is the number of new events (usually the number of newly diagnosed or reported cases of a particular disease) occurring during a specified period of time. The denominator is the "population at risk," the total number of persons in the community who could have experienced the new event (who could have become new cases of the disease). Ideally, then, this is a population figure that excludes persons who already have the disease or who could not possibly have developed the disease. In actual practice, however, the total population is usually used as the population-at-risk denominator because the number of persons within the population who are not at risk is usually unknown. The result of this division is multiplied by a constant (some power of 10, such as 1,000 or 100,000) to obtain a whole number:

$$\text{Incidence} = \frac{\text{Number of new events during time period}}{\text{Population at risk}} \times 1{,}000$$

Prevalence is a measure of the proportion of the population experiencing an event (usually a disease) at a designated time or during a given time period—in the former case it is known as *point prevalence*; in the latter case it is known as *period prevalence*. The prevalence rate takes this form:

$$\text{Prevalence} = \frac{\text{Number of events (both new and old)}}{\text{Population at risk}} \times 1{,}000$$

Uses of Epidemiology

What is the value of such an examination of diseases, injuries, c health states? J. N. Morris (1975) has identified seven uses of epidem ology that provide the basis for the discussion that follows. These use are not necessarily unique to epidemiology; some of them are share with other biomedical sciences. The special importance of epidemiolog in this regard is that it places the findings of other disciplines int perspective, considering disease as a population-based phenomenon i an environmental context.

First and foremost, epidemiology is concerned with identifying th causes of disease, as in the case of Legionnaires' Disease recounte earlier. Epidemiology shares this function to some degree with the field of pathology, microbiology, biochemistry, and the other biomedica sciences, but epidemiology differs in the breadth of its approach and i the use of population-based methods. This has allowed epidemiology t develop more complex models with which to explain disease causatio in a manner that better fits the real world than do laboratory-base models. Epidemiologic methods have also been applied to the study c causation of nondisease entities, such as traffic accidents or murders

Second, epidemiology completes the clinical picture of a disease. Thi refers to the fact that physicians (or others who treat disease) inevitabl have a distorted view of the nature and distribution of the disease. Thi is in part because persons with mild cases of a disease are less likel to seek treatment, thus making clinicians likely to overestimate th severity of the disease. An example is found in the medical literature o the abuse of the drug PCP, or phencyclidine. It is difficult to understan why anyone would want to take a drug that can cause paranoia, violer and sometimes self-destructive behavior, respiratory difficulties, coma and, in some cases, death. The point is, however, that these effects c PCP are relatively rare, but they are the effects that bring PCP users t emergency rooms where they are observed by physicians, and thus the have formed the clinical picture of PCP abuse.

In part, the distortions of the clinical picture arise from the fact tha we are not all equally likely to seek medical care when we are il Women, for instance, are more likely than men to seek medical care fc the same condition. This can lead physicians to falsely conclude tha certain conditions are more common among women simply because the see more women with the disease. Similarly, the poor generally must b sicker before they will seek medical care than the rich. This may caus physicians to falsely conclude that some diseases are less commo among the poor than among the rich. Alternately, it could caus physicians to falsely assume that the disease is, in fact, a more severe disease when it occurs among the poor. Distortions may also result from differences in access to diagnosis and treatment. An interesting example is provided by the early reports on child abuse, which identified this problem as being almost entirely associated with poverty. In fact, we now know that child abuse is almost as common in wealthy families as in poor families. When we first became concerned with child abuse, however, most cases were being identified through routine x-ray procedures in hospital emergency rooms. Parents of lower-class status who had injured their children were more likely to take them to the emergency room for treatment where the abuse would be identified. Parents of upper-class status were more likely to take their child to a family physician, who was likely to identify abuse as the cause of the child's injuries or to report the abuse even if it was apparent.

Third, epidemiology has allowed us to identify syndromes—to "lump and split" related conditions into groups that make scientific and clinical sense. For instance, the traditional division of diabetes mellitus into categories of juvenile-onset diabetes and adult-onset diabetes has been replaced by the similar but more clinically useful distinction between insulin-dependent and insulin-independent diabetes. Similarly, epidemiologists have been able to identify varieties of hepatitis and behavioral groupings of juvenile delinquents that have great relevance both for enhancing our understanding of causation and for developing effective treatment methods.

Fourth, epidemiologic methods can be applied to determining the effectiveness of therapeutic and preventive measures. The procedures by which new drugs must be tested for safety and effectiveness before they can be marketed in the U.S. are essentially epidemiologic procedures. Unfortunately, many common medical procedures have never been tested in any truly scientific manner to determine their effectiveness. In recent years, however, epidemiologic methods have been used to set a standard for the groups of women who should have periodic mammography (breast x-rays) for the detection of breast cancer—weighing the value for each group of early detection against the risk that the x-rays may cause the cancer. Epidemiologic studies have cast serious doubt on the value of coronary bypass surgery for many, perhaps most, patients undergoing this increasingly common surgery.

Fifth, epidemiology provides the means with which to monitor the health of a community, region, or nation. It can identify the health problems of greatest importance and the target populations most appropriate for intervention. Rational health planning is made possible by an epidemiologic data base.

Sixth, risks identified for groups by epidemiologists can be applied to the individual members of those groups as probability statements. This is the basis for the health hazard appraisals that have become so popular in recent years. Although many doubts exist about the validity of such predictions for individuals rather than groups, and about the value of such predictions as ways to motivate behavior, this use has achieved great popularity among health educators and program planners concerned with changing health behavior.

Seventh, by studying trends over time in the history of a disease, it is possible to make predictions about the future. The relative stability of accidental death rates over more than three-quarters of a century suggests that neither lowered speed limits nor elevated drinking ages will have much effect on death rates because the raising of speed limits and the lowering of drinking ages had no apparent effect in the past. On the other hand, reducing federal funding for immunization programs predictably is followed by measles epidemics that leave a few children unnecessarily blind, deaf, brain damaged, or dead.

Historical studies may also contribute to our understanding of the causes of disease. An outstanding example of a historical pattern that suggests a causal relationship is the increase in lung cancer mortality in relation to increasing cigarette smoking. Another historical application of epidemiology that has grown in recent years is the study of the influence of disease patterns on social and political history. Was the plague the primary cause of the fall of the Roman Empire (by decimating the Roman army and disrupting the Roman economy)? Was Napoleon defeated more by typhus among his troops and by his own hemmorhoids than by the military forces allied against him? Historians such as Zinsser (1942) and Cartwright (1972) have speculated that disease patterns may in fact have influenced greatly social and political history.

As can be seen by the brief overview given, epidemiology has many uses. As epidemiologic methods have been applied to an ever broadening array of problems, the range of potential uses has grown. This growth may only be at its beginning stages today.

Recommended Reading

Morris, J. N. (August 13, 1955). Uses of epidemiology. *British Medical Journal* 2, 395–401.

Morris, J. N. (1975). *Uses of epidemiology* (3rd ed.). New York: Churchill Livingstone.

Public Health Reports. (1980). *Landmarks in American epidemiology*, *95*(2). Special issue.
Stallones, R. A. (1980). To advance epidemiology. *Annual Review of Public Health*, *1*, 69–82.

PART I

Background to Epidemiology

> To those who say, "How can we admit the possibility of infection while the religious law denies it," we reply that the existence of contagion is established by experience, investigation, the evidence of the senses and trustworthy reports. These facts constitute a sound argument. The fact of infection becomes clear to the investigator who notices how he who establishes contact with the afflicted gets the disease, whereas he who is not in contact remains safe, and how transmission is effected through garments, vessels and earrings.
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> — *ibn-al-Khatib, 14th-century Moorish scholar*

To understand any contemporary science it is necessary to have some understanding of its roots. Chapter 1 provides a historical overview of changing concepts of the causation of disease. Epidemiologic methods originally developed in an attempt to compensate for the failures of germ theory in the explanation of infectious disease. Gradually, epidemiologic theory grew from the infectious disease oriented model of classic epidemiologic theory (Chapter 2). Today, epidemiology provides a theoretical framework for health service, including disease prevention and health promotion.