CHAPTER 7

Epidemiology: General Principles

WHEN ATTEMPTS are made to understand the causes of diseases, there are two general approaches which may be taken. The first of these deals with the identification and tracing of the agent of the disease after it has entered or affected the individual host, and to this approach the name of *etiology* is usually given. This word is derived from the Greek *aitia*, cause, and *logos*, description or science. Here is a broad term for the "science of causes," which through common usage has come to be restricted for the most part to the study of the individual patient. The second approach looks further afield. The patient is seen set in his environment and as part of a group of similar patients, human or otherwise, all reacting to the same disease. This broader field of study involves consideration of many predisposing factors to disease as well as the apparent exciting cause and is thus concerned with the frequency of the disease in the group. To this approach to the study of disease the name *epidemiology* is commonly given. The term is de-

rived from the Greek word *epi*, on or upon, then *demos*, the people, combined again with *logos* to denote description or science.

A good present-day definition of epidemiology is that of Clark, who calls it a science concerned with the study of factors that influence the occurrence and distribution of health, disease, defect, disability, or death in groups of individuals.[1] More practical is Gordon's concept that epidemiology is chiefly concerned with "the diagnostic procedure in mass disease."[2] Epidemiology, Gordon says, "is the counterpart of diagnosis with the same relationship to public health practice that clinical diagnosis has to treatment." As a science, epidemiology is closely related to ecology, that aspect of biology dealing with the mutual relations between organisms and their environment. Epidemiology, in fact, has been called medical ecology.

Practical epidemiology, of course, grew out of an effort to control epidemics of disease. An *epidemic* can be defined as the occurrence of a group of illnesses of similar nature clearly in excess of normal expectancy, and derived from a common or propagated source.[3] In contrast, *endemic* disease (*en*, in; *demos*, a people) has been taken to mean the usual low level of disease, chronic or acute, found within a population. Epidemics were originally considered to involve infectious disease only. In recent years the term has come to mean far more. The epidemiological approach is of great value in the study of noninfectious diseases, chronic diseases, mental and physical disabilities such as alcoholism, and even automobile accidents. Since the study of diseases in groups is peculiarly the responsibility of the public health worker, some description of the methods used in epidemiology, and of the terminology associated with it, will be of value at this point.

To understand the terms in which the epidemiologist must think, it will help to take a closer look at the science of *ecology* (another Greek word, from *oikos*, house, and *logos*). In its broadest, or holistic, sense, ecology views life in all its manifestations as a single system in process of interaction with the inorganic environment. Plant ecology, animal ecology, and human ecology are major sub-divisions of this system, but each must be viewed against the background of the whole. More practically, ecology aids the study of specific disturbances in ecological balance. A specific mass disease in man, or even a social phenomenon such as juvenile delinquency, may be studied in relation to all the animate things which either help to cause it or are affected by it or by its removal from the scene. Thus control of malaria in certain parts of India not only stimulates population growth (which is an undesirable phenomenon because it puts new strain upon an already inadequate food supply) but at the same time permits cultivation of land which previously could not be cultivated, thus in part perhaps restoring the balance. The ecological problem here is to determine the exact balance which will result, not only for human beings but for the other animal and plant inhabitants of the region.

The area of thought involved by ecology is extremely broad. Nevertheless, Gordon has developed with Adams five laws which they believe have general applicability.[4] These laws are:

1. All living things tend to produce more young than are needed to maintain the species. The resulting overpopulation, whether relative or absolute, brings into play a series of checks and counterchecks which dominates all biology.
2. A suitable food supply in adequate amount is the main factor in maintenance of a species. Species compete with each other and frequently rely upon each other for food supply. A balance thus occurs between species.
3. The physical environment of a species, including water, air, temperature, and similar natural forces, must be suited to its well-being.
4. Maintenance and survival depend on interspecies relations which permit survival from attack of natural enemies. This involves such cooperation between the species as is represented by parasitism.
5. Man, through his intelligence and by conscious effort, is able to control his environment to a remarkable extent. Culture, social structure of communities, species dominance, development of technologies, and social adaptation are important related concepts.

A director-general of the World Health Organization, speaking from an ecological point of view, has closely identified public health interests with the interests of conservationists:

> The ecologist conceives the term "conservation" as the wise management and utilization of natural resources for the greatest good of the largest number. One may debate the position of man in such a universe, but only as to what level of hierarchy he may allocate himself. That he exists and affects his own kind and all else in the world is not debatable . . . man's history justifies the claim that he, like most other animal and plant life, is "an endangered species" . . . Man, in his struggle for survival, poses as many true ecological challenges as the more familiar lion, rhinoceros or whooping crane. The environment truly may be his friend or enemy.[5]

MULTIFACTORIAL DISEASE

The broad ecological view of man set in an environment which not only affects his resistance but also contains the agents of disease gives the epidemiologist a very practical approach to problems of mass disease. He soon finds that the conquest of most diseases depends upon many more factors than a mere knowledge of the biological mechanism which operates after the agent of the disease has entered the host. To the presence of the "main" cause of the disease must usually be added a list of contributing causes before the disease can affect large segments of a population. The result is a "chain" or "web" of causation which the public health worker may be able to break at various places. This multifactorial nature of disease is seen strikingly among the chronic diseases, where time permits the entry of a large number of factors, and is particularly apparent in those diseases such as diabetes where there is no obvious agent to trace. The epidemiologist studies the well people in addition to the sick in the community. He thus has more types of data at his disposal than has a physician treating an individual patient, and for this reason has more opportunity to consider disease as a multifactorial problem. The physician, to be sure, has the same need, but can do less about environmental factors than his public health colleague. The epidemiologist, because of this multiplicity of factors, finds himself constantly dependent upon biostatistics in the design of his studies and in the assembly and analysis of his data.

The broad look the epidemiologist must take at disease removes him somewhat from the actual treatment of individual cases. He can do much more about the prevention and control of future disease than about the cure of current disease. In this respect

Schneider has given us a good military analogy.[6] Epidemiology deals with the strategic aspect of the fight against disease, and medicine with the tactical. Epidemiology defines *when* and *where* action may be most effective against a disease rather than dealing with the *how* of treating it.

Both in the descriptive and in the planning phases of his work, the infectious-disease epidemiologist finds himself thinking of disease and health as "no more than selected instances among the many results of the total interaction between man and his environment."[2] To these two factors in the problem must usually be added a third: the agent of disease, if an agent exists. Thus the first step in epidemiologic (or ecologic) analysis involves a separation of the factors involved in a disease into three main groups: those pertaining to the *host* (namely, man), those pertaining to the *agent*, and those pertaining to the *environment*. The epidemiologist who deals more with noninfectious conditions is likely to refer to factors concerning *person, place,* and *time*. It will be useful for us to examine some of the common factors seen under each of these major headings, using for convenience the infectious-disease terminology.

HOST FACTORS

It is obvious that for a disease to obtain significant frequency in a population there must be a good reservoir of susceptible hosts. One would not expect as many cases of measles in a given community the following year if there had been a measles epidemic among the children the year before. So reliable and predictable is this phenomenon that it can be used in the absence of immunization programs to predict a cycle for such epidemics. This is the interval in which a new group of children grows up, sufficient in number to constitute a good chain for the communication of this highly infectious disease. Here, of course, we have an example of *active immunity* to disease acquired through infection.

Of equal interest is *natural resistance*. Thus tuberculosis is more common in the black race than in the white race for reasons perhaps genetic, perhaps associated with growth, development, physiology, specific immunity, or antibodies. The comparative natural resistance of the white race to tuberculosis is one of the constants

of aid to a planner of an antituberculosis campaign. Natural resistance to disease will vary with the individual as well as with the race, and beyond a certain point such variation cannot be eliminated from the studies made by the epidemiologist.

Among variables affecting natural resistance there are a number which the epidemiologist can expect to find present in most of his studies. These are *age, sex, race,* and *family*. An example has already been given of racial variation in resistance to disease. *Race* is a difficult characteristic to assess, in part because so many of the divisions commonly thought of as racial in our society today are not that at all, but ethnic. The Jews, for instance, are an ethnic group, not a race. Another reason for difficulty in this area is that racial heredity, a legitimate host factor, is so closely linked in its effects to environmental factors such as social custom and cultural development that a clear distinction is very difficult. Custom has its effect upon diet, and diet in turn is usually dependent upon the availability of certain foods in the environment. Thus it is extremely hard to say whether the preference of Italians for leafy vegetables, oils, and wine is an ethnic (hence host) factor or an environmental factor in the causation or prevention of disease.

Age, on the contrary, is a very easy host factor with which to deal. Population statistics are easy to divide by age groups and it is almost automatic for the student of a disease to form a picture quite early of the age distribution of that disease. Age, of course, may operate through physiological changes, as for instance in dental caries, or through the mental growth and habits of the individual, the latter being the controlling factor in the high frequency of automobile accidents among teen-age boys. *Sex* is an equally easy characteristic to tabulate. Many diseases vary in their sex occurrence, but not nearly as many as vary in their occurrence with age. Some diseases show a sex variation merely because sex and occupation are linked. Thus tularemia is more common among Midwestern farmers than among their wives because of more frequent contact with ticks, rabbits, and other vectors of this disease.

Familial heredity is a very difficult characteristic to measure and will seldom prove an important factor in the epidemiological study of large groups. The dentist, however, has usually seen familial variations in occlusion, dental caries, and periodontal disease among his own patients. Familial inheritance of tooth form and face form is often seen and is easily recognized. Tooth structure, too, varies in different families, but whether this is truly the result of heredity or is the result of dietary and other habits within the family is a matter which can seldom be determined with accuracy. In medicine, familial tendencies in poliomyelitis and in hemophilia are among the many which are commonly known.

Inextricably associated with all of the host factors so far enumerated, one should look for *customs* and *habits*. Religious custom removes beef as a food in India. Social custom in Peru dictates that "sick" people should boil the water they drink and "well" people should use unboiled water.[7] Both these customs hinder the work of the public health official in one way or another. In this country, commercial sponsorship of certain products has developed habits of nationwide importance. The use of dentifrices and the use of soap are excellent examples of the results of such sponsorship. Both have induced good health habits. Cigarette advertising, on the other hand, is to be regretted by health workers.

The variable reaction of the host to the presence of a disease agent needs careful consideration. The spirochetes of Vincent's infection are present in practically all normal mouths yet do not cause disease. Not until lowered resistance or possibly an added dosage of spirochetes from outside occurs are the organisms in a position to multiply and cause trouble. The *resistance of the host* therefore is a cardinal factor to be looked for, not so much in terms of specific immunity as in terms of *general health* at a given time.

Closely akin to the subject of lowered resistance is that of *concomitant disease.* A diabetic is more susceptible to tuberculosis than a previously healthy individual, and tuberculosis conversely predisposes to diabetes. This opens up the interesting field of *synergism* and *antagonism.* Diseases occurring together may behave in three possible ways. First, there may be no reaction at all, each disease following its own course quite independently of the other. Second, the result may be greater than the sum of the independent effects of the two diseases; this is called synergism. Third, one disease may limit the effect of the other, a process which is called antagonism. Taylor and Gordon list many of these phenomena, both as they occur between pairs of infectious diseases and as they occur between infectious diseases and congenital anomalies or modifications of endocrine or metabolic functions.[8] The interaction of diabetes and tuberculosis, of course, is synergism. Diabetes, however, has been reported to be antagonistic to rheumatic fever, rheumatoid arthritis, and peptic ulcer. With congenital anomalies there are two excellent dental examples of synergism: cleft palate predisposes to sinusitis, and the mulberry molars of congenital syphilis (Hutchinson's teeth) are predisposed to dental caries. The epidemiologist may occasionally be able to turn synergism or antagonism to practical use. The antagonism between vaccinia (cow pox) and smallpox is the basis for smallpox vaccination. More important, he must constantly be on watch for the effects of *other* diseases on the one he is studying.

AGENT FACTORS

Many diseases have apparent agents, which may be either *biological, chemical,* or *physical.* Some well-understood diseases, however, have no apparent agent at all. Such a disease is diabetes. Obesity, to be sure, is so frequently associated with diabetes, and carbohydrates are so directly the cause of diabetic coma, that fats and carbohydrates might appear to be agents in this instance. Both, however, are essential nutrients and are of harm only when the human pancreas is unable to deal with them.

The best-known agents are *microbiological.* During the "Golden Age of Bacteriology" in the past century and early part of this century, an extraordinarily successful search was on for microbiological agents of disease, with consequent scant emphasis upon host and environmental factors. The search continues today, though with less of a single-track approach and with proportionally less attention to bacteria, more to viruses. Less space will be devoted here to these agents of disease than their importance would appear to warrant. The reason is that they can usually be isolated and first studied after they enter an experimental animal or an individual patient. In dental disease, streptococci have only recently been demonstrated to be causative agents—*streptococcus mutans* in particular. The concept of caries as an infectious disease is now leading to the concept that it is also contagious. This is one of the hypotheses that needs testing in connection with the recent decline in childhood caries in developed countries, discussed in Chapter 8. The trouble here is that human caries takes so long to develop that the sources of bacteria are virtually impossible to pinpoint.

Chemical agents are often hard to identify after they have done their work, hence are more often left to the epidemiologist to study. Fluoride, though it may be a nutrient under certain circumstances and a preventive of disease under other circumstances, can be the agent of disease if it is present in gross excess. The question of dosage here is all-important, as it is with chemical agents generally, so many of which are essential to the human body in small quantities. Heavy metals such as lead and mercury cause pathologic processes without the offsetting advantage of acting as recognized nutrients in small dosage. Poisonings of various sorts come under the heading of disease with a chemical agent. Many, of course, involve large enough dosages so that identification after ingestion is fairly easy.

Physical agents may vary all the way from radioactive fallout to the steering wheel of an automobile. Fallout is a "chronic" agent where accumulation is possible, and dosage must be figured not only in terms of the immediate amount but in terms of cumulative effect. Damaging effects may occur both to the individual exposed and also, through *mutagenesis,* to his or her offspring. The steering wheel of an automobile is an "acute" agent. Except at the moment of collision, it is a constructive, not a damaging, factor.

ENVIRONMENTAL FACTORS

The oldest field for mass study in the analysis of human diseases, and perhaps the most fruitful in terms of predisposing causes, is the environment. Before bacteria were known to exist, many diseases were explained solely in terms of terrestrial and meteorological influences. Thus the name "malaria" is merely a contraction of the Italian words for "bad air." The chief aspects of the environment which demand the attention of the epidemiologist are the physical environment, the biological environment, and the social environment. The sources, reservoirs, and carriers of disease are also important aspects of the environment. They may be either physical or biological.

The aspects of the *physical environment* which may appear to influence the occurrence of disease are almost innumerable.

Sometimes the factor may be a very specific one such as sunshine, with an easily recognizable connection to disease. Sunshine also acts to synthesize vitamin D and prevent rickets. Sometimes, however, the factor will be a vague one such as climate, where an interplay of many subfactors may operate in the causation of disease, giving the epidemiologist a very tangled skein to unravel. The many so-called tropical diseases may all be said to have a strong climatic factor, but each has a detailed epidemiology of its own. Dental caries occurs much more frequently in cold, moist climates, as we shall see later. Several subfactors undoubtedly contribute to this phenomenon.

The major climatological factors are obvious aspects of the physical environment to study: sunshine, temperature, rainfall, humidity and altitude. So also are the inanimate carriers of disease: air, water, soiled articles, and sewage. A water supply, by the way, may serve either as a vehicle for disease (as when it carries the typhoid bacillus with it), or as a protective agent (as when it carries an optimal quantity of fluoride for the prevention of dental caries). Untreated sewage is a major vehicle for disease. Air pollution is one of the big health problems of modern city life.

The *biologic environment* is a very important category for the epidemiologist. Food and nutrition fall within it, linking it to all forms of deficiency disease. Nutrition is also involved in many diseases on a basis other than that of deficiency manifestation. Thus lack of meat and dairy products affected the occurrence of tuberculosis in Denmark during World War I.[9] An increase in tuberculosis mortality followed the intensive export of meat and dairy products in an attempt to aid other countries at war, and later, when the submarine blockade made such export impossible, tuberculosis mortality returned quickly to prewar levels.

Another major problem in the biological environment is that of *animals hosts* and *vectors* of disease. Hogs may harbor *Trichinella spiralis*, transmitting trichinosis to humans who eat the meat insufficiently cooked. Various animals may be hosts for *Clostridium tetani*, their feces carrying tetanus to humans where wounds provide a portal of entry. Vectors are, by definition, arthropods.[3] Many insects are important vectors of disease: mosquitoes, fleas, lice, ticks, and flies. The classic example here is the control of yellow fever through the elimination of a certain type of mosquito (*Aëdes aegypti*) by Gorgas in the swamps of Central America. Until this was done, the Panama Canal could not be built.

The *social environment,* sometimes called socioeconomic environment, may actually influence disease through changing the physical environment of the host. It is more common, however, for social factors to exert an indirect influence through the educational status of the host population. Poor people with limited educational opportunities are less likely to understand the reasons for personal hygiene and for the avoidance of sources of infection than are people with better opportunities. This situation appears to explain the higher incidence of periodontal disease reported by Russell among low-income populations.[10] It is seldom, however, that an economic barrier alone is the deciding factor. The poorest segment of the population should receive welfare payments or other governmental aids sufficient to purchase minimum essential nutrients, and public medical care should be provided free of charge, but such is not often the case. Payments, commodity distributions, and food stamp programs fall far short of full coverage of the needy population, part of the trouble being these people's lack of ability to avail themselves of services which are actually offered.[11] Factors in the social and economic environment underlying such a situation can sometimes be measured with considerable clarity, sometimes not. An index for this purpose is described in Chapter 10.

INTERPLAY OF FACTORS

Various concepts will help in an understanding of the interplay of factors as they cause disease. Simplest of all is to consider the factors to be a *chain,* with disease occurring when the chain is complete and intact. Each link is as important as another in the chain, and the chain is no stronger than its weakest link. The chain can be broken by attack upon any link, whichever is most convenient. A variant of this concept is that of a *web,* where interconnections between factors are more numerous than in a chain. Webs can be broken, too.

Another helpful concept is that of the *seesaw,* with the host and the disease agent at opposite ends of the seesaw and the environment the fulcrum, as shown in Fig. 10. The greater the resistance

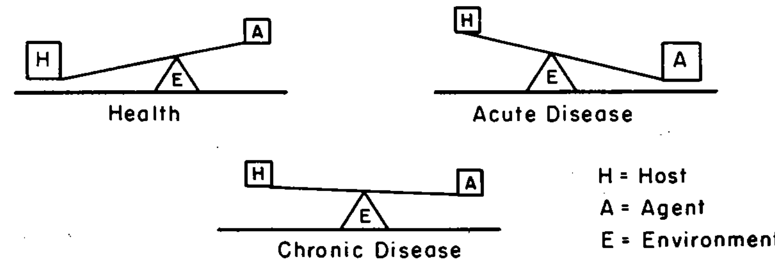

Figure 10. Balance of factors in disease.

of the host, the more he "weighs." If he outweighs the agent factor, he wins his health. A virulent disease agent, however, outweighs a susceptible host and disease is the result. The fulcrum, environment, can be shifted either toward the host or toward the agent, giving the one away from which it has been shifted additional leverage. An equilibrium, with the host and the disease agent weighing the same amount, represents symbiosis. If the weight or the placement of the fulcrum slightly favors the agent, the result is chronic disease, where both the host and the disease agent remain alive. It is only an unsuccessful agent of disease that kills its host and therefore, in the long run, itself as well.

MEASUREMENT OF MASS DISEASE

For the epidemiologist or the ecologist, the unit of observation is a group of living things within a natural environment. Three ecological groupings are commonly distinguished, according to increasing complexity: a *population,* a *community,* and an *ecosystem.*[4] A population is essentially a group of one kind of living thing. A community, or, as the ecologist would call it, a biotic community, is a more complex affair, embracing all populations in a rather small geographic area, both plant and animal, including man. This definition will not be used here, however, since it is too easily confused with the commoner use of the word community to imply a group of human beings living together in a local area with manmade limits. The ecosystem is the largest unit of all. Geographically it may include as large an area as can be found within which all animate and inanimate things can influence each other and blend into an organizational pattern. Dynamic behavior is an outstanding characteristic of an ecosystem, with an equilibrium existing between the various animate species, all of which react in a manner determined by the physical environment.

For practical purposes it is the population with which the epidemiologist has to deal most often. Populations have such traits as density, dispersion, intrinsic rates of natural increase, age distribution, morbidity, and mortality.[4] All these are characteristic of groups rather than of individuals. A population, therefore, must be considered a unit in itself, with many powers and potentialities not present in any of its components.

EPIDEMICS

One of the first tasks of an epidemiologist in dealing with a reported health hazard is to determine whether he is dealing with disease of significantly greater prevalence than normal (*epidemic* disease) or with a continuing problem involving normal disease prevalence (*endemic* disease). Unlike the physician, who can usually say "yes" or "no" to the presence of a given disease in an individual patient, the epidemiologist will almost never find his population without some prevalence of the commoner diseases. The large majority of the population may be healthy, but a fraction will show disease, either slight, moderate, or severe. Within this fraction will also be seen varying degrees of complication and death, and in the wake of certain diseases, varying degrees of disability. To this series of variations, the term *biologic gradient of disease* has been applied.[2] A large proportion of the population diseased and a steep rise of complication and death in this group as severity increases are the usual marks of an epidemic. Small prevalence and low gradient are characteristic of endemic disease. Fig. 11 shows two such gradients for diphtheria in Copenhagen, Denmark. Where vaccination produces the low gradient seen in group A of the clinical cases, the steeper gradient for group B (the unvaccinated) can justly be called an epidemic.

Morbidity and mortality rates are necessary to measure the biological gradient of disease. Morbidity is cases of disease divided by population, then multiplied by a convenient power of ten (usually 1,000 or 100,000). Mortality is deaths divided by population, and again multiplied by a convenient power of 10.

Improvement in diagnostic method may easily produce a steady upswing in the reported incidence of disease which has no basis in fact. The increasing use of x-rays in the dental field is a good example here, and marked changes in the total findings of surveys are seen when x-ray findings are added to explorer findings, as described in Chapter 14. An apparent increase in incidence of dental disease may in fact be due to improved diagnostic technique. Tuberculosis workers have found the same difficulty in analyzing statistics on the morbidity of that disease. Public awareness, too, has much to do with the reporting of disease. An epidemic of any sort sensitizes people to a disease, and more subacute cases are reported at the end than at the beginning.

Seasonal variations in disease are fairly common, both among infectious diseases and among accidents. We are all familiar with the fact that poliomyelitis epidemics occurred, if at all, in the late summer. Similarly measles appears to occur more frequently in the early spring. Accidents will vary with the conditions responsible for them. Automobile accidents in the New England area seem

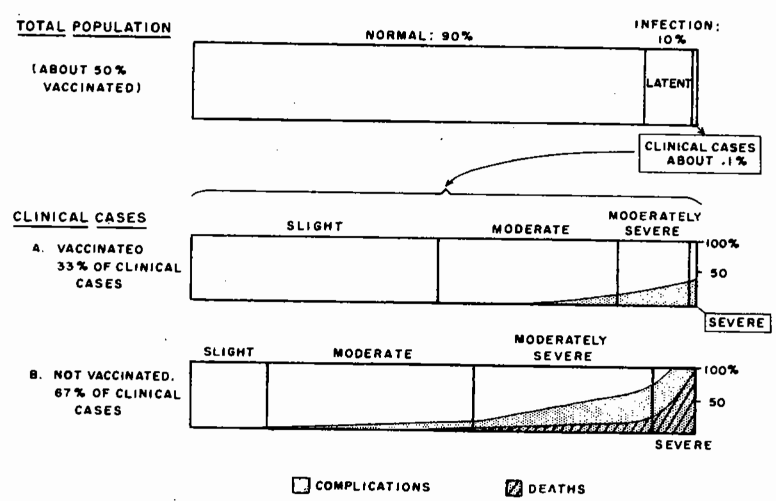

Figure 11. Biologic gradient of diphtheria in Copenhagen, Denmark, 1944. [Courtesy, Public Health Association of New York City.]

constituted the experimental phase of epidemiology. Few problems will present as complete a sequence of phases as does water fluoridation, yet this sequence must always be borne in mind. The epidemiological method will fall far short of its goal if the first phase, "descriptive epidemiology," is considered an end in itself.

METHODS OF EPIDEMIOLOGIC STUDY

There are various ways in which these methods can be used, ways which are common to all measurements of life processes and in particular to all dental diseases, not merely caries. A choice exists between cross-sectional and longitudinal studies. A *cross-sectional* study is a single effort made all at one time, either of necessity or because one is interested in the conditions seen at that particular time. It measures the effects of foregoing events, and is thus called *retrospective,* but its greater emphasis is upon the present. It is also called a case-history study. Thus one might perform a cross-sectional study of Eskimo children in Alaska merely because this was the only chance one had to get to Alaska, or perform a cross-sectional study of children in some nearby town in the current year because a new preventive measure was about to be introduced and it was desired to have data upon this particular year. In either case, the individuals making up the different age groups within the sample are *different* individuals. Human variability being what it is, the possibility exists that the children of age 12 in the sample, let us say, will show fewer DMF teeth per person than the children of age 11: a practical impossibility if one were studying progressive experience in the same persons. This trouble is most likely, of course, where samples are small. As samples increase in size, variability is controlled and a truer overall picture obtained in which such inconsistencies are infrequent.

The other kind is a *longitudinal* or *cohort* study. Here the *same* individuals are examined upon repeated occasions and the changes within the group recorded in terms of elapsed time between observations. This type of surveying does away with inter-age-group variability since the same persons are examined throughout. There is the added advantage, in the case of dental caries, that teeth can be followed as well as persons. This is particularly valuable in such studies as those which were made on the effect of topical fluoride

treatment. Knutson in his work upon this subject wished to avoid the possible confusing influence of previous cavities and fillings in the teeth he was studying.[14] In his follow-up examinations, therefore, after topical application of sodium fluoride, he confined his attention to those teeth which were known to have been present and unattacked by caries at the pretreatment examination. His final results were expressed in percentages of teeth attacked, not of individuals. Longitudinal-survey work is ordinarily more accurate than cross-sectional work, but sources of variability still exist and samples must not be too small. The extreme difficulty in longitudinal work lies in getting repeated access to the same persons over long intervals of time. There is also the danger that time will introduce complicating factors other than the one under study.

THE EPIDEMIOLOGIST

If epidemiology is taken in its broadest sense, any researcher into the occurrence of disease or disability in groups of people is in fact an epidemiologist. Only large health departments, however, can usually afford specialists in this field. According to Smillie, an epidemiologist should have the five following qualifications:

1. He should be familiar with statistical techniques.
2. He should be well grounded in the diagnosis of disease.
3. He should be familiar with the history of medicine, particularly that portion of it that relates to epidemics of disease.
4. He should have a good knowledge of bacteriology and immunology and a thorough understanding of physiology, particularly in relation to the various environmental factors that may influence the health of individuals.
5. He must develop a point of view which will interrelate disease processes as they affect the community as a unit, rather than the individual. Thus he must have a real knowledge of the principles of preventive medicine.[15]

The epidemiologist is essentially a planner. Data come to him from many sources and his recommendations may be carried out by a great variety of different personnel, such as physicians, sanitarians, dentists, school nurses, government regulatory bodies, and the like. The epidemiologist, however, must keep close supervision over the collection of data and also serve as consultant to those in the field of public health administration. It is he who must determine when an epidemic of disease starts and when it has ceased to exist. He may not be able to do very much about the actual control of the epidemic once it has started, but if not, it is he who should apply the lessons learned to the design of measures which will prevent future epidemics.

EPIDEMIOLOGIC PROBLEMS IN THE DENTAL FIELD

The two following chapters of this book are devoted to the epidemiologic problems in dental caries and periodontal disease. Other challenging problems exist in the study of malocclusion, of genetics (including the effects of trauma during gestation), of posteruptive trauma to the teeth (the epidemiology of dental accidents), and finally of oral neoplasms and of radiation hazards to the oral structures. Dentists must educate themselves to make best use of these opportunities, and particularly to take a broader view of host factors. In rising to the challenge, they will find before them one of the most productive and fascinating new vistas in dental research.