INTRODUCTION TO

Public Health

Third Edition

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CHAPTER

4

Epidemiology: The Basic Science of Public Health

Epidemiologic Surveillance

.-E. A. Winslow, the great public health leader of the early 20th century, called epidemiology he diagnostic discipline of public health."[1(p.vii)] Epidemiologic methods are used to investigate uses of diseases, to identify trends in disease occurrence that may influence the need for medal and public health services, and to evaluate the effectiveness of medical and public health inrventions. Epidemiology is used to perform public health's assessment function called for in e Institute of Medicine's *The Future of Public Health*[2] (see Chapter 1).

Epidemiology studies the patterns of disease occurrence in human populations and the factors that influence these patterns. The term is obviously related to epidemic (derived from the Greek word meaning "upon the people"). An epidemic is an increase in the frequency of a disease above the usual and expected rate, which is called the endemic rate. Thus, epidemiologists count cases of a disease, and when they detect signs of an epidemic, they ask who, when, and where questions: Who is getting the disease? Where and when is the disease occurring? From this information, they can often make informed guesses as to why it is occurring. Their ultimate goal is to use this knowledge to control and prevent the spread of disease.

How Epidemiology Works

The first example of the use of epidemiology to study and control a disease occurred in London between 1853 and 1854, and it stands as an illustration of what epidemiology is and how it works. It was conducted by a British physician, John Snow, who is known as the father of modern epidemiology.

Snow was concerned about a cholera epidemic that had struck London in 1848. He noticed that death rates were especially high in parts of the city with water supplied by two private companies, both of which drew water from the Thames River at a point heavily polluted with sewage. Between 1849 and 1854, the Lambeth Company changed its source to an area of the Thames that was free of pollution from London's sewers. Snow noticed that the number of cholera deaths declined in the section of London supplied by the Lambeth Company, while there was no change in the sections supplied by the Southwark and Vauxhall Company. He formulated the hypothesis that cholera was spread by polluted drinking water.[3]

In 1853 there was a severe outbreak of cholera concentrated in the Broad Street area of London, in which some houses were supplied by one water company and some by the other. This provided an opportunity for Snow to test his hypothesis in a kind of "natural experiment," in which "people of both sexes, of every age and occupation, and of every rank and station . . . were divided into two groups without their choice, and, in most cases, without their knowledge . . ."[4(p.6–7)] Snow went to each house in which someone had died of cholera between August 1853 and January 1854 to determine which company supplied the water. When he tabulated the results, he found that in 40,046 houses supplied by the Southwark and Vauxhall Company, there were 1263 deaths from cholera. By comparison, in 26,107 houses supplied by the Lambeth Company, only 98 deaths occurred. The rate of cholera deaths was thus 8.5 times higher in houses supplied by the Southwark and Vauxhall Company than those supplied by the Lambeth Company. This was convincing evidence that deaths from cholera were linked with the source of water (see **Table 4-1**).

Table 4-1 Deaths from Cholera by Company Supplying Water to the Household

Water Company	Number of Houses	Deaths from Cholera	Deaths per 10,000 Houses
Southwark and Vauxhall Company	40,046	1263	315
Lambeth Company	26,107	98	37
Rest of London	256,423	1422	59

Source: Snow, J. "On the Mode of Communication of Cholera." London: John Churchill, New Burlington Street, England, 1855.

Snow would not have been able to formulate his hypothesis without the data on cholera deaths, which had been collected by the British government as part of a system for routine compilation of births and deaths, including cause of death, since 1839. Now, the governments of all developed countries collect data on births, deaths, and other vital statistics, as discussed in Chapter 8. These data are often used for epidemiologic studies.

Because it is preferable to recognize that an epidemic is occurring before many people start dying, governments also use a system called epidemiologic surveillance, requiring that certain "notifiable" diseases be reported as soon as they are diagnosed. These are usually infectious diseases whose spread can be prevented if the appropriate actions are taken. In the United States, approximately sixty diseases have been identified by law as notifiable at the federal level, including, for example, tuberculosis, hepatitis, measles, and syphilis. Some states require reporting of additional infectious diseases. There may also be requirements for reporting birth defects, cancer, and other noninfectious conditions. All physicians, hospitals, and clinical laboratories must report any case of a notifiable disease or condition to their local health department, which in turn reports to the state health department and the Centers for Disease Control and Prevention (CDC). The timely reporting of cases of notifiable diseases allows public health authorities to detect an emerging epidemic at an early stage. Measures can then be taken to control the spread of infectious diseases, as discussed later in this chapter and in Chapter 9. Reporting of chronic diseases is less widespread, but some public health agencies have urged a system to monitor conditions such as birth defects, Alzheimer's disease, asthma, and a variety of cancers.[5] Such a system would help to identify causes of these diseases, including environmental causes that could be controlled or eliminated, preventing further harmful effects.

While the surveillance system was created to control the spread of known diseases, the established network of reporting can facilitate the recognition that a new disease may be emerging. The first step in recognizing that a community is facing a new problem is usually a report to the local or state health department or the CDC by a perceptive physician who notices something unusual that he or she thinks should be investigated further. This is how AIDS came to be recognized early in the epidemic, as discussed in the Prologue.

A Typical Epidemiologic Investigation—Outbreak of Hepatitis

Hepatitis A is a notifiable disease in all fifty states. Because it is caused by a virus that contaminates food or water, it is important to identify the source of any outbreak so that wider exposure to the virus can be prevented. Although hepatitis is not usually fatal to basically healthy people, it can make people quite sick for several weeks and can sometimes require hospitalization.

Because hepatitis is a notifiable disease, the local public health department is able to recognize when an outbreak occurs. A county may normally record only a few cases of hepatitis each year. This is the endemic level, the background level in a population. A sudden increase in the number of cases signifies an epidemic and calls for an epidemiologic investigation to determine why it is occurring.

The investigation requires asking the who, where, and when questions. This kind of medical detective work is nicknamed "shoeleather epidemiology." The investigator starts with the reported cases—the who—although other, unreported cases may turn up once the investigator starts asking questions. Each victim must be interviewed and asked the when question: on what date did the first symptoms appear? Knowing that hepatitis has an incubation period of about thirty days, it is possible to work back to an estimated date of exposure. The where question is the hardest: where did the victims obtain their food and water during the period of likely exposure and what sources did they have in common?

It may be that they all had eaten at the same restaurant. The epidemiologist would visit the restaurant and might find that the chef had developed hepatitis about a month earlier and been hospitalized; so the contamination of the food had stopped, and the epidemic would also stop. Alternatively, the chef may have had only a mild, perhaps unrecognized case and continued to work, thereby continuing to spread the infection. The health department might have to close the restaurant down, if necessary, until the chef is declared healthy.

Such investigations are a frequent task of epidemiologists at local health departments. A large number of these investigations deal with food poisoning outbreaks caused by contamination with *Salmonella* or *Shigella*, bacteria that commonly infect carelessly prepared or preserved food, both of which cause notifiable diseases. The Milwaukee cryptosporidiosis outbreak described in the Prologue was solved by such an epidemiologic investigation. Although cryptosporidiosis was not a notifiable disease, the epidemic was recognized because it was so severe and widespread. If the disease had been notifiable, it might have been recognized and halted earlier. Cryptosporidiosis was added to the national list of notifiable diseases in 1995. Table 4-2 gives a list of diseases that were reportable at the national level in 2007.

Table 4-2 Infectious Diseases Designated as Notifiable at the National Level and Number of Cases Reported During 2007

AIDS	37,503
Anthrax	1
Botulism, total	
Foodborne	32
Infant	85
Other	27
Brucellosis	131
Chancroid	23
Chlamydia trachomatis, genital inf.	1,108,374
Cholera	7
Coccidioidomycosis	8121
Cryptosporidiosis	11,170
Cyclosporiasis	93
Domestic arboviral diseases	
California serogroup virus disease	
neuroinvasive	50
nonneuroinvasive	5
Eastern equine encephalitis virus disease	
neuroinvasive	3
nonneuroinvasive	1
Powassan virus disease, neuroinvasive	7
St. Louis encephalitis virus disease	
Neuroinvasive	8
Nonneuroinvasive	1
West Nile virus disease	
Neuroinvasive	1227
Nonneuroinvasive	2403

(continues)

Table 4-2 *(Continued)*

Ehrlichiosis	
Human granulocytic	834
Human monocytic	828
Human (other and unspecified)	337
Giardiasis	19,417
Gonorrhea	55,991
H. influenzae, invasive disease	
All ages, serotypes	2541
Age <5 years	
Serotype b	22
Nonserotype b	199
Unknown serotype	180
Hansen disease (Leprosy)	101
Hantavirus pulmonary syndrome	32
Hemolytic uremic syndrome, postdiarrheal	292
Hepatitis viral, acute	
A	2979
B	4519
C	845
Influenza-associated pediatric mortality	77
Legionellosis	2716
Listeriosis	806
Lyme disease	27,444
Malaria	1408
Measles, total	43
Meningococcal disease, all serogroups	1977
Mumps	800
Novel influenza A virus infections	4
Pertussis	19,454
Plague	7
Psitticosis	12
Q fever	171
Rabies, animal	5862
Rabies, human	1
Rocky Mountain spotted fever	2271
Rubella	12
Salmonellosis	47,995
Shiga toxin-producing E. coli (STEC)	4847
Shigellosis	19,758

(continues)

Table 4-2 *(Continued)*

Streptococcal disease, invasive, group A	5294
Streptococcal toxic-shock syndrome	132
Streptococcal pneumoniae, invasive disease, drug resistant	
all ages	3329
age <5 yrs	563
Streptococcus pneumoniae, invasive disease, nondrug-resistant	2032
Syphilis	
all stages	40,920
congenital (age <1 yr)	430
primary and secondary	11,466
Tetanus	28
Toxic-shock syndrome	92
Trichinosis	5
Tuberculosis	13,299
Tularemia	137
Typhoid fever	434
Vancomycin-intermediate Staphylococcus aureus	37
Vancomycin-resistant Staphylococcus aureus	2
Varicella (chicken pox) (morbidity)	40,146
Varicella mortality	6
Vibriosis	549

No cases of diphtheria, western equine encephalitis virus disease; poliomyelitis infection; rubella, congenital syndrome; severe acute respiratory syndrome-associated coronavirus syndrome (SARS-CoV); smallpox; and yellow fever were reported in 2007.

Source: Centers for Disease Control and Prevention, *Morbidity and Mortality Weekly Report* 56, No. 53 (2009): 22–23.

With some diseases, even a single case amounts to an epidemic. Measles, which is highly contagious, is preventable by vaccination. Although measles immunization for children was required by all states beginning in the 1970s, a number of measles epidemics occurred between 1989 and 1991 on college campuses. A reported case triggered a need for mass immunizations on campus. When epidemiologists found that many of the affected students had been immunized as infants, they concluded that a second vaccination was necessary for teenagers. The new policy put a halt to measles epidemics on campuses.

Since the bioterror attacks in the fall of 2001, the CDC has added to the list of notifiable diseases several infectious diseases caused by potential agents of bioterrorism. As discussed in Chapter 29, the first sign of a bioterror attack could be the report of a single case identified in a hospital emergency room.

Legionnaires' Disease

In July 1976, the American Legion held a four-day convention in Philadelphia. Before the event was over, conventioneers began falling ill with symptoms of fever, muscle aches, and pneumonia. By early August, 150 cases of the disease and 20 deaths had been reported to the Pennsylvania Department of Health, and the CDC was called in to help determine what was causing the epidemic. The investigation determined that the site of exposure was most likely the Hotel Bellevue-Stratford, one of four Philadelphia hotels where convention activities were held.[6,7] Delegates who stayed at the Bellevue-Stratford had a higher rate of illness than those who stayed at other hotels, and many of those who fell ill had attended receptions in the hotel's hospitality suites. However, cases also occurred in people who had only been near, not in, the hotel, suggesting that exposure could have occurred on the streets or sidewalks nearby. The evidence suggested that the causative agent was airborne, but it did not appear to spread person-to-person to the patients' families.

While the epidemiologists were conducting their investigation, they enlisted the help of the CDC's biomedical scientists to look for evidence of viruses or bacteria in the body tissues of the victims. They also considered the possibility of a toxic chemical, but no evidence of a cause could be found. It was not until the following January that the biomedical scientists found the bacteria that were responsible for the epidemic, which by then was called Legionnaires' disease. The hotel was searched for the source of the bacteria. It was eventually found in the water of a cooling tower used for air conditioning. *Legionella* bacteria had been pumped into the cooled air and inhaled by the victims.

Once the *Legionella* bacteria were identified, they were found to be responsible for a number of other outbreaks of pneumonia around the country. The bacteria were also identified in preserved blood and tissue samples collected in 1965 from victims of a previously unsolved outbreak of pneumonia which affected some eighty patients at St. Elizabeth's psychiatric hospital in Washington, D.C., killing fourteen of them.[7] Thus Legionnaire's disease had probably been around but had gone unrecognized as a specific disease at least since the invention of air conditioning. Federal air-conditioning standards were changed after the Philadelphia epidemic; stringent requirements for cleaning of cooling towers and large-scale air-conditioning systems were introduced. Legionellosis is now a notifiable disease.

Eosinophilia-Myalgia Syndrome

Although infectious agents are usually suspected first in any outbreak of a new disease, epidemiologists must also consider exposure to a toxic substance as an alternative cause. Physicians and epidemiologists found this to be the case in a puzzling outbreak first reported in New Mexico. In October 1989, several Santa Fe doctors were comparing notes on three patients suffering from a novel condition involving fatigue, debilitating muscle pain, rashes, and shortness of breath. Blood tests on all three had revealed very high counts of white blood cells called eosinophils. The doctors knew of no known condition that could explain these findings. However, they were struck by the fact that all three patients, when questioned about drugs or medications they were taking, had mentioned a health food supplement called L-tryptophan. L-tryptophan is a "natural" substance, a component of proteins, that had been publicized as a treatment for insomnia, depression, and premenstrual symptoms. Believing that more than coincidence was involved in these three cases, the doctors reported them to the New Mexico State Health Department.[8]

The Health Department reported the cases to the CDC and began an investigation to determine whether additional cases existed and whether there was a consistent link with L-tryptophan. By searching the records of clinical laboratories in Santa Fe, Albuquerque, and Los Alamos, they discovered twelve additional patients whose blood had exhibited high white-cell counts since May 1. A team of health department investigators interviewed these twelve people and found that they all had used L-tryptophan. They also interviewed 24 people of the same age and sex as the patients who lived in the same neighborhoods—a control group—and found that only two had taken the supplement. This strongly suggested that there was a link between L-tryptophan exposure and the illness. The CDC notified other state health departments, which conducted their own investigations, and by November 16 the CDC received reports from 35 states of 243 possible cases of the new disease, called eosinophilia-myalgia syndrome (EMS). On November 17, the Food and Drug Administration announced a nationwide recall of products containing L-tryptophan. The publicity brought forth a flood of new reports of the syndrome, but then new cases began to drop off. By August 1, 1992, 1511 cases had been reported by all 50 states. Many patients were left with permanent disabilities and 38 people had died, but the epidemic was over.[9]

Why had this natural substance caused such severe consequences? L-tryptophan is an amino acid, present in many foods including meat, fish, poultry, and cheese. It is also added to infant formulas, special dietary foods, and intravenous and oral solutions administered to patients with special medical needs. No cases of EMS had been reported from these products. Tests on the recalled tablets indicated that a toxic contaminant, formed as a result of a recent change in one factory's method of production, may have been responsible for the epidemic of 1989. However, there is evidence that earlier, unrecognized cases had occurred since the product was introduced in 1974.[10] The fact that many people took the supplements with no apparent harm suggests that individual variations in susceptibility may exist.

Serious outbreaks of illness caused by toxic contamination of food, through production errors, or outright fraud, have occurred a number of times over the past few decades. It is usually epidemiologists who identify the source of the problem. To many public health experts, the EMS epidemic of 1989 resembled an illness with similar symptoms that affected some 20,000 people in Spain in 1981, killing more than 300 of them within a few months. An infectious agent had first been suspected, but epidemiologists noted an odd geographical distribution of the outbreak. Patients lived either in a localized area south of Madrid or in a corridor along a road north of the city. The epidemiologists found that the affected households had bought oil for cooking from itinerant salespeople, who were illegally selling oil that had been manufactured for industrial use.[11] Laboratory scientists investigating the nature of the contaminants and how they might have caused the symptoms have not specifically identified a single chemical as being responsible. They now suspect that a range of chemicals, even at very low concentrations, may induce autoimmune responses in susceptible people, causing the body's immune system to attack its own tissues. Such outbreaks caused by toxic contamination of foods and drugs may be much more common than is generally recognized.[12] In the cases of toxic oil syndrome and EMS, government action to remove the contaminated product put an end to the epidemic. However, survivors still suffer from symptoms.

Epidemiologic surveillance is a major line of defense in protecting the public against disease. It is the warning system that alerts the community that something is wrong, that a gap has opened in the protective bulwark against preventable disease or that a new disease has appeared on the horizon. The sooner the surveillance system kicks in, the sooner action can be taken to stop the epidemic. Before the health department is notified, individual doctors are trying to cure individual patients, often unaware that the problem is more widespread. After the epidemic is recognized, all the resources of the community—local, state, or national—can be mobilized to prevent the disease's spread. Whether it uses vaccination campaigns against measles, isolation of hepatitis-infected food workers, new regulations on air conditioning systems, or recall of contaminated food or drugs, the government must act to protect the health of the public. Epidemiologic surveillance has become even more important as concerns about bioterrorism have increased, as Chapter 29 discusses.

Epidemiology and the Causes of Chronic Disease

Epidemiology has had a different role to play in investigating the causes of the diseases common in older age, such as cancer and heart disease, which are quite different from infectious diseases or acute poisoning. Until the 20th century, these conditions were thought of as a natural part of aging, and no one thought to look for causes or tried to prevent them.

Cancer, heart disease, and other diseases of aging do not have single causes. They tend to develop over a period of time, are often chronic and disabling rather than rapidly fatal, and cannot be prevented or cured by any vaccine or "magic bullet." The best hope for protecting the public against these diseases is to learn how to prevent them, or at least how to delay their onset. Prevention, however, requires an understanding of the cause or causes of a disease and the factors that influence how it progresses. Epidemiology has made major contributions to the current understanding of the causes of heart disease and some cancers and what can be done to prevent them. Epidemiologic studies will continue to yield information on how people can protect themselves against cancer, Alzheimer's disease, and other afflictions of aging.

Epidemiologic studies of these chronic diseases are much more complicated and difficult than investigations of acute outbreaks of infectious diseases or toxic contamination. Except for the clear link between smoking and lung cancer (discussed later in this chapter), most chronic diseases cannot be attributed to a single cause. There may be many different factors that play a part in causing a disease, factors that epidemiologists call "risk factors." The long period over which these diseases develop also contributes to the difficulty of determining the causative factors. Epidemiologists must determine which of a person's many experiences over the previous decades are relevant, and what significant exposures might have occurred ten or twenty years ago that may have increased the person's risk of developing the disease today.

Epidemiology has developed a number of methods to study chronic diseases and to try to answer the difficult questions. This chapter describes a few of the best-known studies that have had major impacts on understanding the causes of heart disease and cancer. Chapter 5 discusses in a more systematic way the major types of epidemiologic studies.

Heart Disease

Since the 1920s, when infectious disease mortality had dropped to approximately its current low levels, heart disease has been the leading cause of death in the United States for both men and women. Deaths from heart disease increased dramatically during the first half of the 20th century, as seen in **Figure** 4-1. After World War II, one in every five men was affected with heart disease before the age of sixty, and little was known about why. In 1948, an epidemiologic study was launched in Framingham, Massachusetts, to investigate factors that might be causing the problem. It was the first major epidemiologic study of a chronic disease. More than half of the middle-aged population of the town, more than 5000 healthy people, were examined, and data were recorded on their weight, blood pressure, smoking habits, the results of various blood tests, and other characteristics. Two years later, the same people were examined again, and these tests have been and continue to be repeated every two years for the rest of their lives.[13]

As early as ten years later, the Framingham Heart Study had revealed a great deal about how to predict which of their subjects were likely to develop heart disease. The study identified three major risk factors: high blood pressure, high blood cholesterol, and smoking. As a result of the findings, concepts of "normal" blood pressure and cholesterol levels changed significantly. Doctors had previously believed that blood pressure naturally increased as people aged and that the increase was normal and healthy. The Framingham Study found that some people maintained their youthful blood pressure and cholesterol values as they got older and that these people remained healthier. Weight gain and lack of exercise were found to be associated with increased blood pressure and cholesterol values and with an increased risk of heart disease.[14]

Remarkably, the Framingham findings had a major impact on the course of the heart disease epidemic. Publicity on the information gained by the study, confirmed and supported by other studies, persuaded some people to change their behavior and formed the basis of public health programs to encourage others to do the same. By the 1970s, it was clear that death rates from heart disease were falling in the United States. The Framingham Study itself found in 1970 that the death rate over the previous ten years had declined by 60 percent since 1950.[14] This improvement was associated with a decline in risk factors: in 1970, blood cholesterol levels were lower; blood pressure was lower; and smoking was less common. These beneficial trends have continued. In 2004, the age-adjusted death rate from heart disease was 66 percent lower than it was in 1950.[15]

Meanwhile, the Framingham Study has continued and expanded, and much more has been learned. For example, a smoker's risk of heart disease rapidly drops back to that of nonsmokers soon after the smoker quits; but low-tar, low-nicotine cigarettes are no better than the old-fashioned kind in their effects on risk of heart disease.[14] Various forms of cholesterol have been identified, including high-density lipoprotein (HDL) cholesterol—the "good" kind that is protective—and low-density lipoprotein (LDL) cholesterol—the "bad" kind. Drinking alcohol in moderation has been found to increase HDL cholesterol and to protect against heart disease. Exercise also raises HDL levels. The scope of the Framingham Study has expanded: in 1978, the subjects began to be given neurological examinations in addition to tests for cardiac risk factors. The investigators are watching for the development of Alzheimer's disease in the aging study population, hoping that they will be able to detect risk factors for this increasingly common and tragic condition.[16]

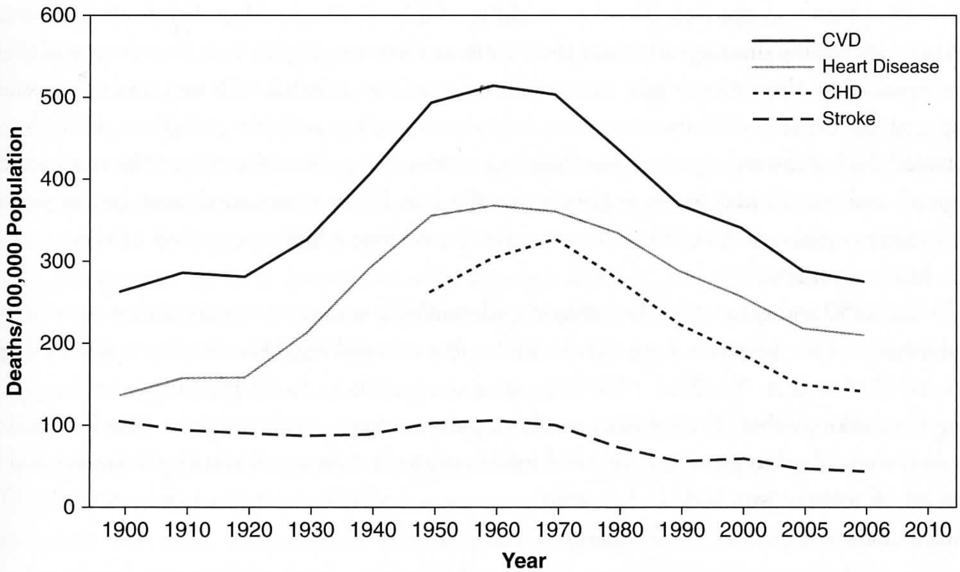

FIGURE 4-1 Death Rates for Coronary Heart Disease in the United States, 1900–2006. (Death rates not age-adjusted. Data for 2006 is preliminary.)
Source: National Heart, Lung, and Blood Institute 2008 Fact Book, p. 35. www.nhlbi.nih.gov/about/factbook/factbookFinal.pdf (Accessed November 6, 2009).

An offshoot of the original study, the Framingham Offspring Study, was created in 1971; it included about 5000 children of the original participants and their spouses. Investigators use comparisons of risk factors within families and across generations, hoping to sort out the roles of genetics and environment in heart disease and other common disorders. The younger study population is being tested with more advanced medical technologies and more sophisticated blood tests, including genetic tests. In 2001, the National Institutes of Health announced another expansion to form the Third Generation Study, which enrolled grandchildren of the study's original participants.[17] The diseases now being studied include diabetes, lung disorders, osteoporosis, arthritis, eye diseases and hearing disorders.[13]

Lung Cancer

Epidemiologic studies seeking causes of cancer began soon after the Framingham Study. However, studies of most kinds of cancer had much less success than the studies of heart disease; epidemiologists had few strong clues about possible causes or risk factors.

An exception was the link between smoking and lung cancer. Mortality from lung cancer had been increasing dramatically since the 1930s, as shown in **Figure 4-2**. Because it was logical to suppose that the cause might be something that was inhaled, the two main hypotheses proposed to explain this increase were tobacco smoking and air pollution, both having increased during the same period that lung cancer was rising. Several early studies conducted in England and the United States beginning in the late 1940s questioned lung cancer patients about their smoking habits. All of these studies found that a high proportion of these patients were heavy smokers.

In late 1950 and early 1952, two major epidemiologic studies were started that convincingly established a link between lung cancer and tobacco smoking. The British epidemiologists Richard Doll and A. Bradford Hill sent out a questionnaire to all physicians in the United Kingdom, asking whether they were smokers, past smokers, or nonsmokers. Smokers and ex-smokers were asked to provide additional information on their age at starting to smoke and the amount of tobacco smoked, and ex-smokers were asked when they had quit smoking. Over 40,000 doctors responded to the survey.[18]

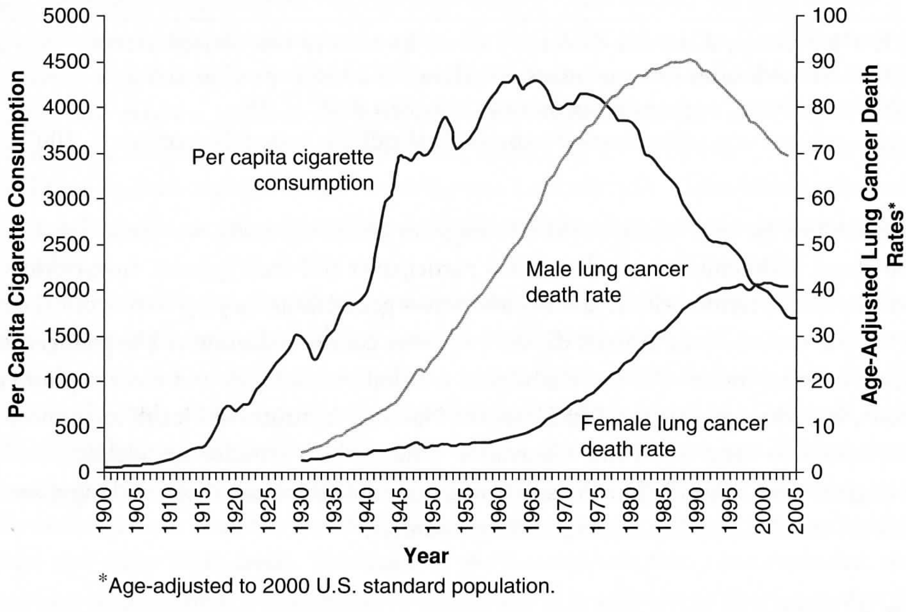

FIGURE 4-2 Cigarette Consumption and Lung Cancer Deaths in the United States, 1900–2005. *Source: Cancer Statistics 2009: A Presentation from the American Cancer Society.* Slide 27. Reprinted by the permission of the American Cancer Society, Inc. from www.cancer.org. All rights reserved.

During the following years, Doll and his collaborators, by arrangement with the British Medical Association and the Registrar General of the United Kingdom, gathered information on which doctors had died each year and what was the cause of death. A little over four years after the survey began, several important conclusions were apparent: First, the death rate from lung cancer was about twenty times higher among smokers than among nonsmokers, increasing as the amount smoked increased. Second, the death rate among ex-smokers was lower than that of smokers and declined as the length of time increased since the doctor had quit smoking. Third, the contrast in lung cancer mortality between smokers and nonsmokers was the same whether the doctors lived in rural or urban areas. Therefore, the difference could not be attributed to air pollution. Fourth, deaths from heart attacks were also significantly higher among heavy smokers aged 35 to 54 than among nonsmokers.[19]

A similar study on a much larger group of people was conducted in the United States by epidemiologists E. Cuyler Hammond and Daniel Horn. They obtained smoking histories from almost 188,000 men and followed them over a period of 3 years and 8 months. For all the study participants who died, they obtained the cause of death from death certificates. Their findings confirmed and extended the results of the Doll and Hill study of British doctors. First, cigarette smokers were more than ten times more likely to die of lung cancer than nonsmokers. Second, cigarette smokers were about five times more likely to die of cancer of the lip, tongue, mouth, pharynx, larynx, and esophagus as nonsmokers. Several other types of cancer were also more common among smokers. Third, heavy smokers (two or more packs per day) were 2.4 times more likely to die of heart disease than nonsmokers.[20]

The British study continued until 1971, tracking all the doctors for twenty years, by which time about 33 percent of them had died. The longer period of observation confirmed the results obtained earlier. An interesting finding was that many physicians reacted to the earlier reports by quitting smoking. By 1971, the average number of cigarettes smoked per day by the physicians in the study was less than half what it had been in 1951, and as a result, lung cancer became relatively less common as a cause of death in this group.[19]

The Framingham Study and the two lung cancer studies are examples of prospective cohort studies, following large numbers of people over extended periods of time. These are considered among the most reliable kinds of epidemiologic studies for investigating causes of chronic diseases. Other such studies have been done and continue at present, many of them seeking causes of various kinds of cancer. Chapter 5 discusses the major types of epidemiologic studies. More on what is known about cancer and heart disease will be discussed in Chapters 11, 15, and 16.

Conclusion

Epidemiology is an important component of the assessment function of public health. Epidemiologists investigate epidemics of known and unknown diseases by counting the number of cases and how they are distributed by person, place, and time. Using this information, they can often determine a probable cause of a new disease or a reason for an outbreak of a previously controlled disease. This knowledge allows public health workers to institute measures that prevent and control the spread of the disease.

An early achievement of epidemiology was the recognition in the 19th century that cholera was spread by polluted water. In 1993, similar epidemiologic methods determined that polluted water had caused an outbreak of cryptosporidiosis in Milwaukee. The same approach has been successful in halting outbreaks of illness caused by toxic contaminations. "Shoeleather epidemiology" by local health departments provides the front line of defense against acute diseases. Epidemiologic surveillance, including mandatory reporting of notifiable disease, alerts a local health department that an epidemic is beginning in time for an agency to investigate the reasons and take preventive action.

Epidemiology also provides information on the causes of chronic disease. Formal long-term studies of heart disease and lung cancer provided the earliest information on the risk factors that contributed to these diseases. The Framingham Study, which has tracked citizens of Framingham, Massachusetts for six decades, identified high blood pressure, high blood cholesterol, and smoking as risk factors for heart disease. Two epidemiologic studies conducted in the 1950s—one on the smoking habits of British doctors and a similar study on a group of 188,000 American men—indicated a clear link between smoking and lung cancer.

Epidemiology's role in identifying causes of disease leads directly and indirectly to prevention and control. In some cases, regulatory action by a local government is necessary to eliminate the conditions that are causing disease. Sometimes simply publicizing the results of a study allows people to modify their behavior to avoid risk factors for a disease. For example, information released in the 1950s on results from the Framingham Study and the studies regarding smoking and lung cancer contributed to a significant decline in smoking in the United States, accompanied by a drop in mortality from both heart disease and lung cancer since the 1950s. To achieve additional improvements in public health, health agencies build on epidemiologic information to develop policy and plan programs aimed at reducing risk and promoting health in the population.

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