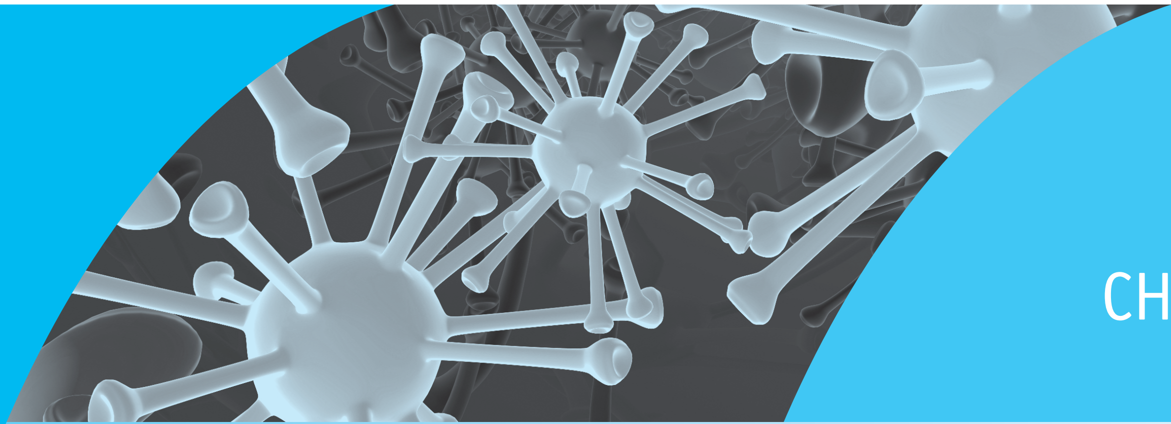


CHAPTER 1

History, Philosophy, and Uses of Epidemiology

Learning Objectives

By the end of this chapter you will be able to:

- Define the term *epidemiology*
- Describe two ways in which epidemiology may be considered a liberal arts discipline
- State three important landmarks in the history of epidemiology
- Describe three uses of epidemiology

CHAPTER OUTLINE

I. Introduction
II. Definition of Epidemiology
III. The Evolving Conception of Epidemiology as a Liberal Art
IV. Application of Descriptive and Analytic Methods to an Observational Science
V. History of Epidemiology and Development of Epidemiologic Principles
VI. Brief Overview of Current Uses of Epidemiology
VII. Ethics and Philosophy of Epidemiology
VIII. Conclusion
IX. Study Questions and Exercises

INTRODUCTION

As a member of contemporary society, you are besieged constantly with information about the latest epidemic, which now ranges from HIV/AIDS to the obesity and diabetes epidemics

TABLE 1-1 List of Important Terms Used in This Chapter

Analytic epidemiology	Exposure	Pandemic
Descriptive epidemiology	John Snow	Population
Determinant	Morbidity	Prevention of disease
Distribution	Mortality	Risk
Epidemic	Natural experiment	Risk assessment
Epidemiologic transition	Observational science	Risk factor
Epidemiology	Outcome	Uses of epidemiology

to outbreaks of foodborne illness such as the 2008 outbreak of salmonellosis that occurred during spring and summer.

Epidemiology is an exciting field with many applications that are helpful in solving today's health-related problems. (Refer to Figure 1-1.) For example, epidemiology can demonstrate the risks associated with smoking, as well as those related to exposure to second-hand cigarette smoke among nonsmokers. Currently, youth violence is an issue that confronts students, teachers, and administrators at both urban and suburban schools; epidemiologic research can identify factors related to such violence and suggest methods for its prevention. Other contributions of epidemiology include the identification of factors associated with obesity and substance abuse, both of which are major societal issues. Epidemiology can provide insights into these problems as well.

Now, let's consider the outbreak of foodborne salmonellosis mentioned previously. Salmonellosis is an infection caused by *Salmonella* bacteria, which can produce gastrointestinal symptoms (cramping, diarrhea, and fever) that begin 12 to 72 hours after the onset of infection. The majority of patients recover without treatment, but in some cases the condition is life-threatening.

The 2008 outbreak affected more than 1,400 persons and is believed to have contributed to two deaths. Cases appeared in 43 states, most frequently in Texas, Arizona, and Illinois. The source of contamination was mysterious. All patients were affected with an uncommon strain of *Salmonella* Saintpaul that had a distinctive genetic fingerprint. Initially, epidemiologic investigations implicated raw tomatoes. The public was advised not to eat red plum (red Roma) and round red tomatoes, which had been linked to the outbreak. This news was indeed disturbing; tomatoes generally are considered to be a healthful vegetable. They are used extensively in many popular items of the American diet, including salads, ketchup, spaghetti sauce, pizza, and salsa.

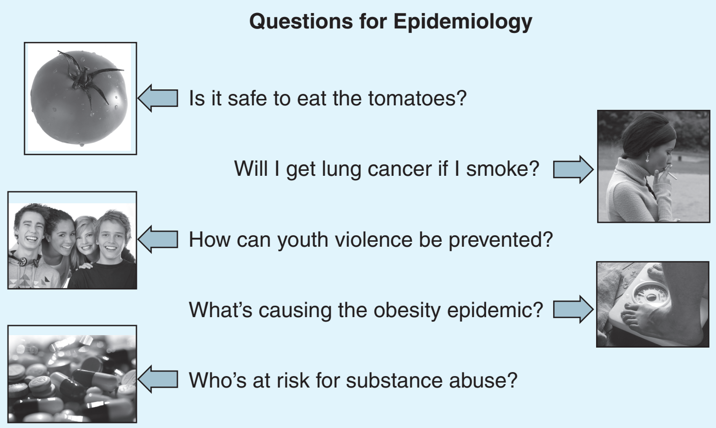
Investigators searched for contaminated tomatoes in Mexico, where many of the vegetables destined for its northern neighbor are grown, and also in the United States. Despite this diligent work, the origin of the bacteria that sickened so many persons was never definitively linked to tomatoes. Eventually, jalapeño and serrano peppers were targeted as the offending foods, but only those harvested or packed in Mexico.

The *Salmonella* outbreak illustrates a foodborne-disease episode that reached epidemic proportions. Individual *Salmonella* cases may arise sporadically; usually such occurrences are not epidemics. However, because in this instance a large number of persons were affected across the United States, the *Salmonella* outbreak could be considered an epidemic.

What is meant by the term epidemic? An **epidemic** refers to "the occurrence in a community or region of cases of an illness, specific health-related behavior, or other health-related events clearly in excess of normal expectancy."[1] Figure 1-2 demonstrates the concept of an epidemic in the case of the annual occurrence of a hypothetical disease. The "normal expectancy" is six cases per year. In three years, 2016, 2019, and 2020, the occurrence of the disease was in excess of normal expectancy.

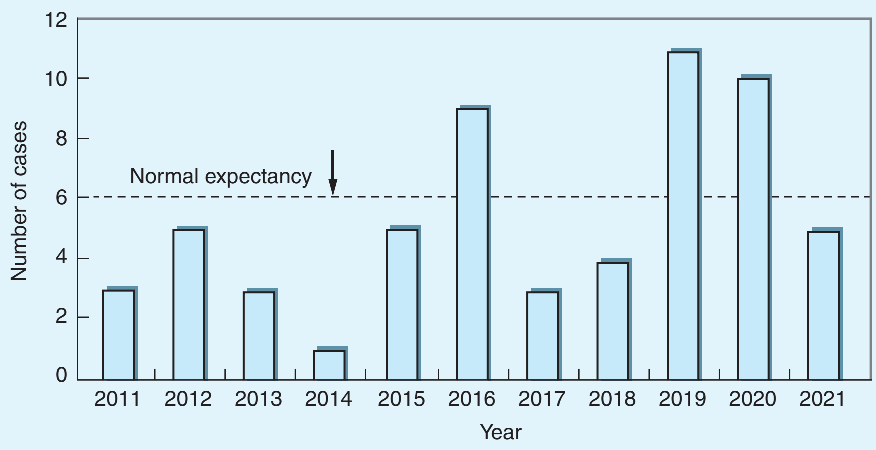
It is possible in some instances for a single case of a disease to represent an epidemic. With respect to a new occurrence of an infectious disease not previously found in an area or the occurrence of an infectious disease that has long been absent, a single case or a few cases of that disease would be regarded as an epidemic. At present, examples of infrequently occurring diseases in the United States are measles and polio. A small outbreak of measles, polio, or other infrequently occurring infectious disease requires the immediate attention of public health officials and would be treated as an epidemic.

FIGURE 1-1 Examples of the types of questions that can be answered by epidemiologic research.



Source: © adsheyn/ShutterStock, Inc.; © Zdenka Micka/ShutterStock.com; © Yuri Areurs/ShutterStock, Inc.; Courtesy of Bill Branson/National Cancer Institute; © Photos.com.

FIGURE 1-2 Annual occurrence, normal expectancy, and epidemic frequency of a hypothetical disease.



The use of the word *epidemic* is not limited to communicable diseases. The term is applied to chronic diseases and other conditions as well. Illustrations are the "epidemic of obesity," the "epidemic of diabetes," or the "epidemic of heart disease." Related to epidemic is **pandemic**, defined as "an epidemic occurring worldwide, or over a very wide area, crossing international boundaries, and usually affecting a large number of people."[1] The 1918 influenza pandemic discussed later in the chapter and periodic less-severe global influenza epidemics illustrate this concept.

The previous discussion leads to the question: what is the scope of epidemiology? This chapter will begin with a definition of the term epidemiology and illustrate how the study of epidemiology imparts skills that are useful in a variety of pursuits. As part of this exploration, the author will highlight the key historical developments in epidemiology and demonstrate how these developments have influenced the philosophy and practice of epidemiology. Some of these historical developments include concerns of the ancient Greeks about diseases caused by the environment, the observations of Sir Percival Pott on scrotal cancer among chimney sweeps in England, the work of John Snow on cholera, and modern work on the etiology of chronic diseases.

Epidemiology is one of the basic sciences of public health; epidemiologic methods are applied to a variety of public health-related fields: health education, health care administration, tropical medicine, and environmental health. Epidemiologists quantify health outcomes by using statistics; they formulate hypotheses, and they explore causal relationships between exposures and health outcomes. A special concern of the discipline is causality: do research findings represent cause-and-effect associations or are they merely associations? A simple example of a causal association would be whether a specific contaminated food such as tomatoes caused an outbreak of gastrointestinal disease; a more complex example is whether there is a causal association between smoking during the teenage years and the subsequent development of lung cancer later in life.

Although the foregoing examples of the applications of epidemiology are primarily health related, epidemiology is a body of methods that have general applicability to many fields. Exhibit 1-1 provides an example of school-related violence, a topic of public health and societal concern.

The aforementioned exhibit regarding violence in schools illustrates the potential applications of epidemiology for solving a broad range of problems that affect the health of populations. Specifically, epidemiology can be used as a research tool that seeks answers to the following types of questions with respect to violence in schools:

- Violent episodes are most likely to affect which types of schools and universities?
- What are the characteristics of victims and perpetrators of violent acts?
- What interventions might be proposed for the prevention of violent acts and how successful are they likely to be?

DEFINITION OF EPIDEMIOLOGY

"**Epidemiology** is concerned with the distribution and determinants of health and diseases, morbidity, injuries, disability, and mortality in populations. Epidemiologic studies are applied to the control of health problems in populations."[2 (p6)] The term epidemiology originates from the Greek: *epi* (upon) + *demos* (people) + *logy* (study of). The key characteristics of epidemiology are discussed below.

Exhibit 1-1

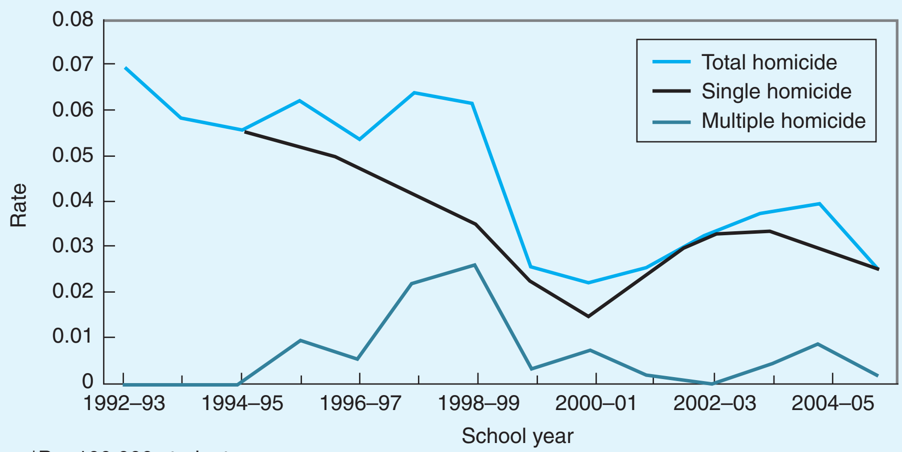
What Is Epidemiology About? The Example of Violence in Schools

An episode of violence on a school or university campus represents a tragic event that all too frequently rivets the attention of the national media. Since the mid-1960s, more than a dozen fatal shootings have occurred on U.S. college campuses. Among the most deadly were shootings at the University of Texas at Austin on August 1, 1966 (17 dead, including the gunman, and 31 injured), and at Virginia Tech University on April 16, 2007 (33 dead, including the gunman, and 26 injured). On February 15, 2008, a gunman killed five students and injured 16 others at Northern Illinois University in DeKalb, Illinois.

At the secondary-school level, highly publicized shootings also have grabbed the headlines. One of these was the 1999 violence at Columbine High School in Littleton, Colorado; this shooting took 15 lives and injured 23 persons. Although they command our attention, violent episodes that cause multiple homicides on school premises are actually highly unusual. Nevertheless, the National Academy of Sciences declared that youth violence "reached epidemic levels" during the 1990s. A total of 35 shooting incidents transpired at secondary schools or school-sponsored events from 1992 to 2001.

In what sense can school violence be regarded as an epidemic? Perhaps the answer is that any incident of violence (especially shootings) on school premises is significant. The U.S. Centers for Disease Control and Prevention produced epidemiologic data on school-associated student homicides that occurred during the years 1992 to 2006 (see Table 1-2 and Figure 1-3). These data suggest that the preponderance of homicide victims were male students and students in urban areas. The table also demonstrates an approach of epidemiology—comparing data according to the characteristics of homicides and the settings in which the homicides occurred.

FIGURE 1-3 Total, single-, and multiple-student school-associated homicide rates* among students aged 5–18 years, by school years—United States, July 1992–June 2006.



*Per 100,000 students.

Source: Reprinted from Centers for Disease Control and Prevention. School-associated student homicides—United States, 1992–2006. *MMWR.* 2008;57:35.

TABLE 1-2 Total, Single-, and Multiple-Student School-Associated Homicide Rates* among Students Aged 5–18 Years, by Sex and Selected School Characteristics—United States, July 1999–June 2006

	Total				Single victim				Multiple victims			
Characteristic	**No. of deaths**	**Rate**	**Rate ratio**	**(95% CI[†])**	**No. of deaths**	**Rate**	**Rate ratio**	**(95% CI)**	**No. of deaths**	**Rate**	**Rate ratio**	**(95% CI)**
All students	**116[§]**	**0.03**	—	—	**101**	**0.03**	—	—	**15**	**<0.01**	—	—
Sex												
Female	23	0.01	1.00	—	17	0.01	1.00	—	6	<0.01	1.00	—
Male	93	0.05	4.39	(2.78–6.93)	84	0.04	5.37	(3.19–9.04)	9	<0.01	1.63	(0.58–4.58)
School level/ grade												
Elementary/ middle	25	<0.01	1.00	—	22	<0.01	1.00	—	3	<0.01	1.00	—
Secondary	90	0.08	18.47	(11.86–28.73)	78	0.07	18.19	(11.34–29.20)	12	0.01	20.53	(5.79–72.74)
NCES school locale[¶]												
Central city	50	0.06	3.47	(1.80–6.66)	45	0.05	3.81	(1.86–7.80)	5	0.01	1.91	(0.37–9.82)
Urban fringe/ large town	17	0.02	0.86	(0.40–1.84)	15	0.01	0.93	(0.41–2.12)	2	<0.01	0.56	(0.08–3.95)
Rural small town	11	0.02	1.00	—	9	0.01	1.00	—	2	<0.01	1.00	—
School type												
Private	5	0.01	1.00	—	5	0.01	1.00	—	0	<0.01	—	—
Public	110	0.02	1.22	(0.50–2.99)	95	0.01	1.05	(0.43–2.59)	15	<0.01	—	—

*Per 100,000 students.
[†]Confidence interval. (This term is defined in Chapter 5.)
[§]Associated with 109 events.
[¶]National Center for Education Statistics. Includes only data from 1999 to 2004 because information on the number of students enrolled in private schools in various locales during 2004–2006 is not available.
Source: Reprinted from Centers for Disease Control and Prevention. School-associated student homicides—United States, 1992–2006. *MMWR.* 2008;57:35.

Population Focus

The unique focus of epidemiology is upon the occurrence of health and disease in the population. The definition of a **population** is "all the inhabitants of a given country or area considered together. . . ."[1] The population approach contrasts with clinical medicine's concern with the individual; hence epidemiology is sometimes called population medicine. The examples of the *Salmonella* outbreak and violence in schools demonstrated epidemiologic investigations that were focused on entire populations groups (such as the United States). A third example involves epidemiologic studies of lung disease; these investigations might examine the occurrence of lung cancer mortality across counties or among regional geographic subdivisions known as census tracts. Investigators might want to ascertain whether lung cancer mortality is higher in areas with higher concentrations of "smokestack" industries in comparison with areas that have lower levels of air pollution or are relatively free from air pollution. In contrast with the population approach used in epidemiology, the alternative approach of clinical medicine would be for the clinician to concentrate on the diagnosis and treatment of specific individuals for the sequelae of foodborne illnesses, injuries caused by school violence, and lung cancer.

Distribution

The term **distribution** implies that the occurrence of diseases and other health outcomes varies in populations, with some subgroups of the populations more frequently affected than others. Epidemiologic research identifies subgroups that have increased occurrence of adverse health outcomes in comparison with other groups. In the present text, we will encounter many illustrations of differential distributions of health outcomes: for example, variations in the occurrence of cancer, heart disease, and asthma in populations.

Determinants

A **determinant** is defined as "any factor that brings about change in a health condition or other defined characteristic."[1] Examples of determinants are biologic agents (e.g., bacteria and viruses), chemical agents (e.g., toxic pesticides and chemical carcinogens), and less specific factors (e.g., stress and deleterious lifestyle practices).

Related to determinants are **exposures**, which pertain either to contact with a disease-causing factor or to the amount of the factor that impinges upon a group or individuals.[1] Epidemiology searches for associations between exposures and health outcomes. Examples of exposures are contact with infectious disease agents through consumption of contaminated foods and environmental exposures to toxic chemicals, potential carcinogens, or air pollution. In other cases, exposures may be to biological agents or to forms of energy such as radiation, noise, and extremes of temperature. For an epidemiologic research study to be valid, the level of exposure in a population must be defined carefully; the task of exposure assessment is not easily accomplished in many types of epidemiologic research. Also related to determinants are risk factors, which are discussed later in the chapter.

Outcomes

The definition of **outcomes** is "all the possible results that may stem from exposure to a causal factor. . . ."[1] The outcomes examined in epidemiologic research range from specific infectious diseases to disabling conditions, unintentional injuries, chronic diseases, and other conditions associated with personal behavior and lifestyle. These outcomes may be expressed as types and measures of **morbidity** (illnesses due to a specific disease or health condition) and **mortality** (causes of death). Accurate clinical assessments of outcomes are vitally important to the quality of epidemiologic research and the strength of inferences that can be made. Without such assessments, it would not be possible to replicate the findings of research.

Quantification

Epidemiology is a quantitative discipline; the term **quantification** refers to counting of cases of illness or other health outcomes. Quantification means the use of statistical measures to describe the occurrence of health outcomes as well as to measure their association with exposures. The field of descriptive epidemiology quantifies variation of diseases and health outcomes according to subgroups of the population (refer to Chapter 4).

Control of Health Problems

Epidemiology aids with health promotion, alleviation of adverse health outcomes (e.g., infectious and chronic diseases), and prevention of disease. Epidemiologic methods are applicable to the development of needs assessments, the design of prevention programs, and the evaluation of the success of such programs. Epidemiology contributes to health policy development by providing quantitative information that can be used by policy makers. Chapter 7 describes the role of epidemiology in the policy arena.

Here is a brief comment about public health, epidemiology, and the prevention of disease (with the linkage between prevention and the natural history of disease). The **natural history of disease** refers to the course of disease from its beginning to its final clinical endpoints. The period of prepathogenesis is the time period in the natural history of disease before a disease agent (e.g., a bacterium) has interacted with a host (the person who develops the disease). The agent simply exists in the environment. Pathogenesis occurs after the agent has interacted with a host. Three modes of prevention are directed toward the periods of prepathogenesis and pathogenesis.

From the public health point of view, the three types of prevention are primary, secondary, and tertiary. **Primary prevention** involves the prevention of disease before it occurs; primary prevention targets the stage of prepathogenesis and embodies general health promotion and specific prevention against diseases. Methods of primary prevention include the creation of a healthful environment, implementation of health education programs, and administration of immunizations against specific infectious diseases. **Secondary prevention** takes place during the early phases of pathogenesis and includes activities that limit the progression of disease. Illustrations are programs for cancer screening and early detection of other chronic diseases. Finally, **tertiary prevention** is directed toward the later stages of pathogenesis and includes programs for restoring the patient's optimal functioning; examples are physical therapy for stroke victims and fitness programs for recovering heart attack patients.

THE EVOLVING CONCEPTION OF EPIDEMIOLOGY AS A LIBERAL ART

Epidemiology is often considered to be a biomedical science that relies on a specific methodology and high-level technical skills.[3] Nevertheless, epidemiology in many respects also is a "low-tech" science that can be appreciated by those who do not specialize in this field.[4] The text box lists skills acquired through the study of epidemiology; these skills enlarge the appreciation of many academic fields: laboratory sciences, mathematics, the social sciences, history, and literature.

Skills acquired through training in epidemiology

1. Use of the interdisciplinary approach
2. Use of the scientific method
3. Enhancement of critical thinking ability
   a. Reasoning by analogy and deduction
   b. Problem solving
4. Use of quantitative and computer methods
5. Communication skills
6. Inculcation of aesthetic values

The Interdisciplinary Approach

Epidemiology is an **interdisciplinary science**, meaning that it uses information from many fields. Here are a few examples of the specializations that contribute to epidemiology and the types of contribution that they make:

- Mathematics and biostatistics (for quantitative methods)
- History (for historical accounts of disease and early epidemiologic methods)
- Sociology (social determinants of disease)
- Demography and geography (population structures and location of disease outbreaks)
- Behavioral sciences (models of disease; design of health promotion programs)
- Law (examining evidence to establish causality; legal bases for health policy)

Many of the issues of importance to contemporary society do not have clearly delineated disciplinary boundaries. For example, prevention of school violence requires an interdisciplinary approach that draws upon information from sociology, behavioral sciences, and the legal profession. In helping to develop solutions to the problem of school violence, epidemiology leverages information from mathematics (e.g., statistics on the occurrence of violence), medicine (e.g., treatment of victims of violence), behavioral and social sciences (e.g., behavioral and social aspects of violence), and law (legal basis for development of school-related antiviolence programs). Through the study of epidemiology, one acquires an appreciation of the interdisciplinary approach and a broader understanding of a range of disciplines.

Use of the Scientific Method

Epidemiology is a scientific discipline that makes use of a body of research methods similar to those used in the basic sciences and applied fields including biostatistics. The work of the epidemiologist is driven by theories, hypotheses, and empirical data. The scientific method employs a systematic approach and objectivity in evaluating the results of research. Comparison groups are used to examine the effects of exposures. Epidemiology uses rigorous study designs: cross-sectional, ecologic, case-control, and cohort. Chapter 6 will provide more information about these designs.

Enhancement of Critical Thinking Ability

Critical thinking skills include the following: reasoning by analogy, making deductions that follow from a set of evidence, and solving problems. We will learn that epidemiologists use analogical reasoning to infer disease causality. Suppose there are two similar diseases. The etiology of the first disease is known, but the etiology of the second disease is unknown. By analogy, one can reason that the etiology of the second disease must be similar to that of the first.

Also, epidemiologists gather descriptive information on the occurrence of diseases; they use this information to develop hypotheses regarding specific exposures that might have been associated with those diseases. Finally, epidemiologists are called into action to solve problems, for example, trying to control the *Salmonella* outbreak that was believed to be associated with tomatoes.

Use of Quantitative and Computer Methods

Biostatistics is one of the core disciplines of epidemiology. Because of the close linkage between the two fields, epidemiology and biostatistics sometimes are housed in the same academic department in some universities. Through your training in epidemiology, you will acquire quantitative skills such as tabulating numbers of cases, making subgroup comparisons, and mapping associations between exposures and health outcomes. In research and agency settings, epidemiologists use computers to store, retrieve, and process health-related information and to perform these types of analyses.

Communication Skills

As a core discipline of public health, epidemiology is an applied field. Information from epidemiologic analyses can be used to control diseases, improve the health of the community, evaluate intervention programs, and inform public policy. One of the skills needed by applied epidemiologists is the ability to disseminate information that could be useful for controlling health problems and improving the health status of the population.

Inculcation of Aesthetic Values

Aesthetic values are concerned with the appreciation of beauty, which would seem to have no relevance to epidemiology.

Nevertheless, you can hone your aesthetic values by reading about the history of epidemiology and descriptions of epidemics and health problems found in literature. The writings of the great thinkers such as Hippocrates and John Snow, who contributed so greatly to epidemiology, are compelling as works of literature. Many other writings relevant to epidemiology are extant. Two are *The Jungle* (by Upton Sinclair), which describes deplorable sanitary conditions in Chicago slaughterhouses in 1906, and Camus' *The Plague*, an account of the ravages of disease.

APPLICATION OF DESCRIPTIVE AND ANALYTIC METHODS TO AN OBSERVATIONAL SCIENCE

In examining the occurrence of health and disease in human populations, researchers almost always are prohibited from using experimental methods because of ethical issues such as potential harm to subjects. Studies of the population's health present a challenge to epidemiologic methods. First and foremost, epidemiology is an **observational science** that capitalizes upon naturally occurring situations in order to study the occurrence of disease. Thus, in order to study the association of cigarette smoking with lung diseases, epidemiologists might examine and compare the frequency of lung cancer and other lung diseases among smokers and nonsmokers.

The term **descriptive epidemiology** refers to epidemiologic studies that are concerned with characterizing the amount and distribution of health and disease within a population. Health outcomes are classified according to the variables: person, place, and time. Examples of person variables are demographic characteristics such as sex, age, and race/ethnicity. Place variables denote geographic locations including a specific country or countries, areas within countries, and places where localized patterns of disease may occur. Some time variables are a decade, a year, a month, a week, or a day. Descriptive studies, regarded as a fundamental approach by epidemiologists, aim to delineate the patterns and manner in which disease occurs in populations.[5] These studies, which are focused on the development of hypotheses, set the stage for subsequent research that examines the etiology of disease.

Analytic epidemiology examines causal (etiologic) hypotheses regarding the association between exposures and health conditions. The field of analytic epidemiology proposes and evaluates causal models for etiologic associations and studies them empirically. "Etiologic studies are planned examinations of causality and the natural history of disease. These studies have required increasingly sophisticated analytic methods as the importance of low-level exposures is explored and greater refinement in exposure-effect relationships is sought."[6(p945)]

One approach of analytic epidemiology is to take advantage of naturally occurring situations or events in order to test causal hypotheses. These naturally occurring events are referred to as **natural experiments**, defined as "naturally occurring circumstances in which subsets of the population have different levels of exposure to a supposed causal factor in a situation resembling an actual experiment, where human subjects would be randomly allocated to groups."[1] However, in a natural experiment persons usually are not assigned randomly to the groups. An example is the work of John Snow, discussed later in this chapter. Many past and ongoing natural experiments are relevant to environmental epidemiology. When new public health-related laws are introduced, these laws become similar to natural experiments that could be explored in epidemiologic research. For example, epidemiologists could study the effects of the 2008 California law that requires adult drivers to use hands-free cellular telephones upon the frequency of automobile crashes. Other examples of natural experiments that have evolved from laws are the addition of fluoride to the public water supply in order to prevent tooth decay and the requirement that children wear safety helmets while riding bicycles.

HISTORY OF EPIDEMIOLOGY AND DEVELOPMENT OF EPIDEMIOLOGIC PRINCIPLES

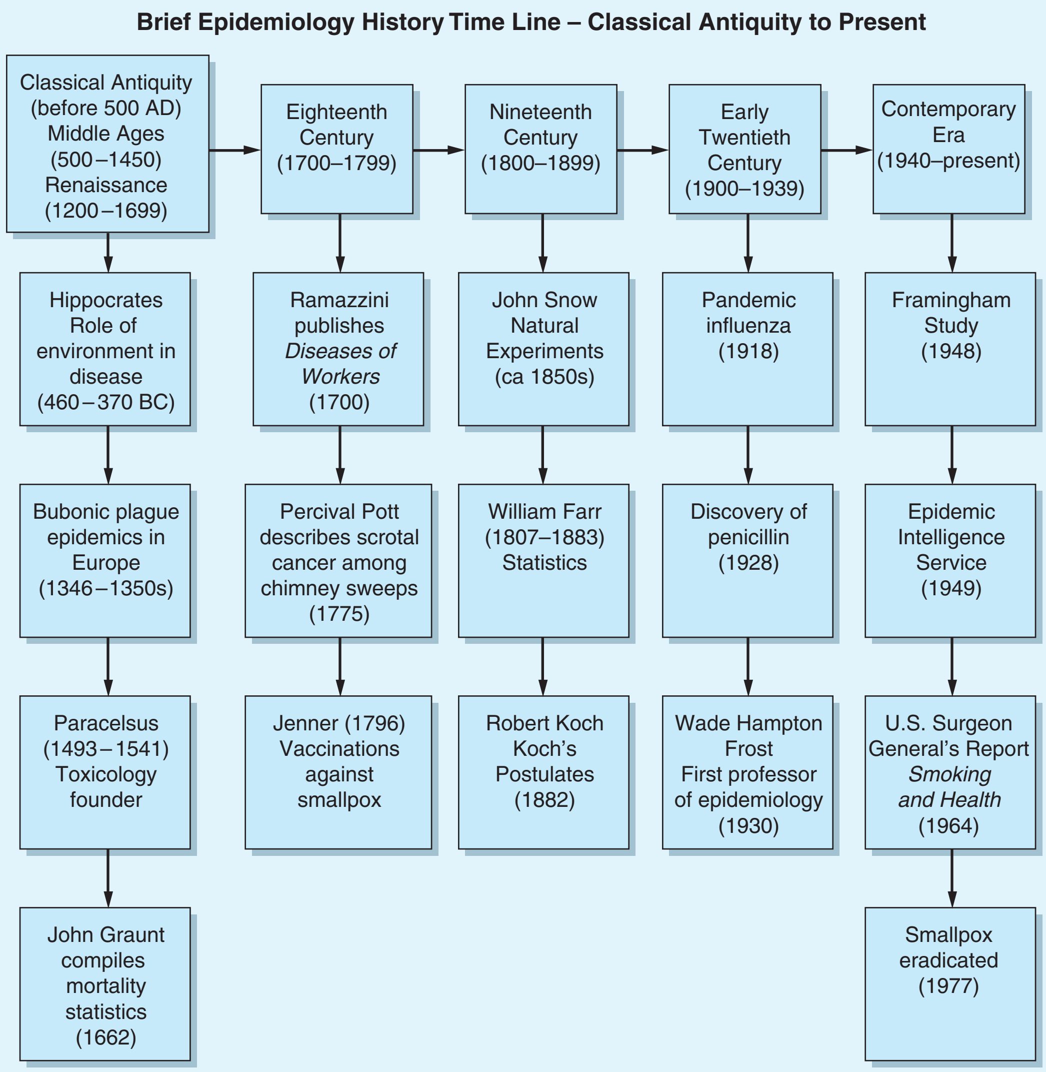
The history of epidemiology originated as early as classical antiquity (before about 500 AD), and later during the medieval period was marked by bubonic plague epidemics in Europe. The Renaissance was the time of Paracelsus (toxicologist) and John Graunt, pioneering compiler of vital statistics. During the eighteenth and nineteenth centuries, breakthroughs occurred in the development of a vaccination against smallpox and the formulation of epidemiologic methods. The period from the beginning of the twentieth century to the present has seen a rapid growth in epidemiology; two of the achievements of this period were identification of smoking as a cause of cancer and eradication of smallpox. (Refer to Figure 1-4 for a brief epidemiology history time line.)

The Period of Classical Antiquity (before 500 AD)

Hippocrates (460 BC–370 BC).

The ancient Greek authority Hippocrates contributed to epidemiology by departing from superstitious reasons for disease outbreaks. Until Hippocrates' time, supernatural explanations were used to account for the diseases that ravaged human populations. In about 400 BC, Hippocrates suggested that environmental factors such as water quality and the air were implicated in the causation of diseases. He authored the historically important book *On Airs, Waters, and Places.* Hippocrates' work and the writings of many of the ancients did not delineate specific known agents involved in the causality of health problems but referred more generically to air, water, and food.

FIGURE 1-4 History of epidemiology.



In this respect, early epidemiology shares with contemporary epidemiology the frequent lack of complete knowledge of the specific agents of disease, especially those associated with chronic diseases.

Middle Ages (approximately 500–1450)

Black Death.

Of great significance for epidemiology is the Black Death, which occurred between 1346 and 1352 and claimed up to one-third of the population of Europe at the time (20 to 30 million out of 100 million people). The Black Death was thought to be an epidemic of bubonic plague, a bacterial disease caused by *Yersinia pestis.* (Refer to Figure 1-5 for a drawing of plague victims during a later period.) Bubonic plague is characterized by painful swellings of the lymph nodes (buboes) in the groin and elsewhere in the body. Other symptoms often include fever and the appearance of black splotches on the skin. (Refer to Figure 1-6.) Untreated, bubonic plague kills up to 60% of its victims. The bites of fleas harbored by rats and some other types of rodents can transmit plague.

FIGURE 1-5 Black Death.

Source: © National Library of Medicine.

FIGURE 1-6 This patient presented with symptoms of plague that included gangrene of the right foot causing necrosis of the toes.

Source: Reprinted from Centers for Disease Control and Prevention. Public Health Image Library, ID# 4139. Available at: http://phil.cdc.gov/phil/home.asp. Accessed August 2, 2008.

Renaissance (approximately 1200–1699)

Paracelsus (1493–1541).

Paracelsus was one of the founders of the field of toxicology, a discipline that is used to examine the toxic effects of chemicals found in environmental venues such as the workplace. Active during the time of da Vinci and Copernicus, Paracelsus advanced toxicology during the early sixteenth century. Among his contributions were several important concepts: the dose-response relationship, which refers to the observation that the effects of a poison are related to the strength of its dose, and the notion of target organ specificity of chemicals.

John Graunt (1620–1674).

In 1662, John Graunt published *Natural and Political Observations Mentioned in a Following Index, and Made Upon the Bills of Mortality*. This work recorded descriptive characteristics of birth and death data, including seasonal variations, infant mortality, and excess male over female mortality. Graunt is said to be the first to employ quantitative methods to describe population vital statistics by organizing mortality data in a mortality table. Because of his contributions to vital statistics, Graunt has been called the Columbus of statistics.

Eighteenth Century (1700–1799)

Ramazzini (1633–1714).

Bernardino Ramazzini is regarded as the founder of the field of occupational medicine.[7] He created elaborate descriptions of the manifestations of occupational diseases among many different types of workers.[8] His descriptions covered a plethora of occupations, from miners to cleaners of privies to fabric workers. The father of occupational medicine is also considered to be a pioneer in the field of ergonomics, by pointing out the hazards associated with postures assumed in various occupations. Ramazzini authored *De Morbis Artificum Diatriba* (Diseases of Workers), published in 1700. His book highlighted the risks posed by hazardous chemicals, dusts, and metals used in the workplace.

Sir Percival Pott (1714–1788).

Sir Percival Pott, a London surgeon, is thought to be the first individual to describe an environmental cause of cancer. In 1775, Pott made the astute observation that chimney sweeps had a high incidence of scrotal cancer (in comparison with male workers in other occupations).[9] He argued that chimney sweeps were prone to this malady as a consequence of their contact with soot.

In a book entitled *Chirurgical Observations Relative to the Cataract, the Polypus of the Nose, the Cancer of the Scrotum, the Different Kinds of Ruptures, and the Mortification of the Toes and Feet*, Pott developed a chapter called "A Short Treatise of the Chimney Sweeper's Cancer." This brief work of only 725 words is noteworthy because "… it provided the first clear description of an environmental cause of cancer, suggested a way to prevent the disease, and led indirectly to the synthesis of the first known pure carcinogen and the isolation of the first carcinogenic chemical to be obtained from a natural product. No wonder therefore that Pott's observation has come to be regarded as the foundation stone on w[h]ich the knowledge of cancer prevention has been built!"[10(p521)] In Pott's own words,

> . . . every body . . . is acquainted with the disorders to which painters, plummers, glaziers, and the workers in white lead are liable; but there is a disease as peculiar to a certain set of people which has not, at least to my knowledge, been publickly noteced; I mean the chimney-sweepers' cancer. . . . The fate of these people seems singularly hard; in their early infancy, they are most frequently treated with great brutality, and almost starved with cold and hunger; they are thrust up narrow, and sometimes hot chimnies, where they are bruised, burned, and almost suffocated; and when they get to puberty, become peculiary [sic] liable to a noisome, painful and fatal disease. Of this last circumstance there is not the least doubt though perhaps it may not have been sufficiently attended to, to make it generally known. Other people have cancers of the same part; and so have others besides lead-workers, the Poictou colic, and the consequent paralysis; but it is nevertheless a disease to which they are particularly liable; and so are chimney-sweepers to the cancer of the scrotum and testicles. The disease, in these people . . . seems to derive its origin from a lodgment of soot in the rugae of the scrotum.[10(p521–522)]

Following his conclusions about the relationship between scrotal cancer and chimney sweeping, Pott established an occupational hygiene control measure—the recommendation that chimney sweeps bathe once a week.

Edward Jenner (1749–1823).

In 1798, Jenner's findings regarding the development of a vaccine that provided immunity to smallpox were published. Jenner had observed that dairymaids who had been infected with cowpox (transmitted by cattle) were immune to smallpox. The cowpox virus, known as the vaccinia virus, produces a milder infection in humans than does the smallpox virus. Jenner created a vaccine by using material from the arm of a dairymaid, Sarah Nelmes, who had an active case of cowpox. In 1796, the vaccine was injected into the arm of an eight-year-old boy, James Fipps, who was later exposed to smallpox and did not develop the disease. Concluding that the procedure was effective, Jenner vaccinated other children including his own son. Figure 1-7 displays an 1802 cartoon by British satirist James Gillray. The cartoon implied that people who were vaccinated would become part cow.

Nineteenth Century (1800–1899)

John Snow and cholera in London during the mid-nineteenth century.

Over the centuries, cholera has inspired great fear because of the dramatic symptoms and mortality that it causes. Cholera is a potentially highly fatal disease marked by profuse watery stools, called rice water stools. The onset of cholera is sudden and marked by painless diarrhea that can progress to dehydration and circulatory collapse; severe, untreated cholera outbreaks can kill more than one-half of affected cases. At present, the cause of cholera is known (the bacterium *Vibrio cholerae*); the level of fatality is often less than

FIGURE 1-7 The Cow Pock—or—the Wonderful Effects of the New Inoculation.

Source: Drawing by James Gillray, 1802. Reprinted from National Institutes of Health, National Library of Medicine. Smallpox: A Great and Terrible Scourge. Available at: http://www.nlm.nih.gov/exhibition/smallpox/sp_vaccination.html. Accessed August 2, 2008.

1% when the disease is treated. One of the methods for transmission of cholera is through ingestion of contaminated water (see Figure 1-8).

John Snow (1813–1858) was an English anesthesiologist who innovated several of the key epidemiologic methods that remain valid and in use today. For example, Snow believed that the disease cholera was transmitted by contaminated water and was able to demonstrate this association. In Snow's time, the mechanism for the causation of infectious diseases such as cholera was largely unknown. The Dutchman Anton van Leeuwenhoek had used the microscope to observe microorganisms (bacteria and yeast). However, the connection between microorganisms and disease had not yet been ascertained. One of the explanations for infectious diseases was the **miasmatic theory of disease**, which held that ". . . disease was transmitted by a miasm, or cloud, that clung low on the surface of the earth."[11(p11)] This theory was applied to malaria, among other diseases.

FIGURE 1-8 Typical water supply that is contaminated with *Vibrio cholerae,* the infectious disease agent for cholera.

Source: Reprinted from Centers for Disease Control and Prevention. Public Health Image Library, ID# 1940. Available at: http://phil.cdc.gov/phil/home.asp. Accessed August 3, 2008.

John Snow, M.D., the forerunner of modern epidemiologists

Snow's contributions included:

- Powers of observation and written expression
- Application of epidemiologic methods
  - Mapping (spot maps)
  - Use of data tables to describe infectious disease outbreaks
- Participation in a natural experiment
- Recommendation of a public health measure to prevent disease (removal of the pump handle; see text)

Snow noted that an outbreak of "Asiatic" cholera had occurred in India during the early 1800s. Snow wrote, "The first case of decided Asiatic cholera in London, in the autumn of 1848, was that of a seaman named John Harnold, who had newly arrived by the *Elbe* steamer from Hamburgh, where the disease was prevailing."[12(p3)] Subsequently, cholera began to appear in London.

During the mid-1800s, Snow conducted an investigation of a cholera outbreak in London. A section of London, designated the Broad Street neighborhood (now part of the Soho district), became the focus of Snow's detective work (refer to the map shown in Figure 1-9). His procedures for investigating the cholera outbreak demonstrated several important innovations (summarized in the text box titled "John Snow, M.D., the forerunner of modern epidemiologists").

Here is Snow's graphic description of the cholera outbreak that occurred in 1849. "The most terrible outbreak of cholera which ever occurred in this kingdom, is probably that which took place in Broad Street, Golden Square, and the adjoining streets, a few weeks ago. . . . The mortality in this limited area probably equals any that was ever caused in this country, even by the plague; and it was much more sudden, as the greater number of cases terminated in a few hours. . . . Many houses were closed altogether, owing to the death of the proprietors; and, in a great number of instances, the tradesmen who remained had sent away their families: so that in less than six days from the commencement of the outbreak, the most afflicted streets were deserted by more than three-quarters of their inhabitants."[12(p38)]

FIGURE 1-9 Map of cholera cases in the Broad Street area. Each case is indicated by a short line.

Source: Reprinted from Snow J. *Snow on Cholera.* Harvard University Press; © 1965.

Snow's pioneering approach illustrated the use of both descriptive and analytic epidemiology. One of his first activities was to plot the cholera deaths in relation to a pump that he hypothesized was the cause of the cholera outbreak. Each death was shown on the map (Figure 1-9) as a short line. An arrow in the figure points to the location of the Broad Street pump. "As soon as I became acquainted with the situation and the extent of this irruption of cholera, I suspected some contamination of the water of the much-frequented street-pump in Broad Street, near the end of Cambridge Street; . . . On proceeding to the spot, I found that nearly all the deaths had taken place within a short distance of the pump."[12(pp38–39)] The handle of the pump was later removed—a public health measure to control the outbreak. In Snow's time, many European cities took water for domestic use directly from rivers, which often were contaminated with microorganisms. (Refer to Figure 1-10, which suggests that pumps that dispensed river water were sources of deadly contamination.)

FIGURE 1-10 Death lurks at the pump.

Source: © SPL/Photo Researchers, Inc.

The natural experiment: Two water companies, the Lambeth Company and the Southwark and Vauxhall Company, provided water in such a manner that adjacent houses could receive water from two different sources. In 1852, one of the companies, the Lambeth Company, relocated its water sources to a section of the Thames River that was less contaminated. During a later cholera outbreak in 1854, Snow observed that a higher proportion of residents who used the water from the Southwark and Vauxhall Company developed cholera than did residents who used water from the Lambeth Company. The correspondence between changes in the quality of the water supply and changes in the occurrence of cholera became known as a natural experiment.

Collection and presentation of data in tabular format: Data from the outbreak of 1854 are presented in Table 1-3. The Lambeth Company provided cleaner water than the Southwark and Vauxhall Company. "The mortality in the houses supplied by the Southwark and Vauxhall Company was therefore between eight and nine times as great as in the houses supplied by the Lambeth Company. . . ."[12(p86)]

Here is a second example of Snow's contributions to epidemiology. In addition to utilizing the method of natural experiment, Snow provided expert witness testimony on behalf of industry with respect to environmental exposures to potential disease agents.[13] Snow attempted to extrapolate from the health effects of exposures to high doses of environmental substances to the effects of exposure to low doses. On January 23, 1855, a bill was introduced in the British Parliament called the Nuisances Removal and Diseases Prevention Amendments bill. This bill was a reform of Victorian public health legislation that followed the 1854 cholera epidemic.[13] The intent of the bill was to control release into the atmosphere of fumes from operations such as gas works, silk-boiling works, and bone-boiling factories. Snow contended that these odiferous fumes

TABLE 1-3 The Proportion of Deaths per 10,000 Houses—Cholera Epidemic of 1854

	Number of houses	Deaths from cholera	Deaths in each 10,000 houses
Southwark and Vauxhall Company	40,046	1,263	315
Lambeth Company	26,107	98	37
Rest of London	256,423	1,422	59

Source: Reprinted from Snow J. *Snow on Cholera.* Harvard University Press; © 1965;86.

were not a disease hazard in the community.[14] The thesis of Snow's argument was that deleterious health effects from the low levels of exposure experienced in the community were unlikely, given the knowledge about higher-level exposures among those who worked in the factories. Snow argued that the workers in the factories were not suffering any ill health effects or dying from the exposures. Therefore, it was unlikely that the much lower exposures experienced by the members of the larger community would affect their health.

William Farr (1807–1883).

A contemporary of John Snow, William Farr assumed the post of "Compiler of Abstracts" at the General Register Office (located in England) in 1839 and held this position for forty years. Among Farr's contributions to public health and epidemiology was the development of a more sophisticated system for codifying medical conditions than that which was previously in use. Also noteworthy is the fact that Farr used data such as census reports to study occupational mortality in England. In addition, he explored the possible linkage between mortality rates and population density, showing that both the average number of deaths and births per 1,000 living persons increased with population density (defined as number of persons per square mile).

FIGURE 1-11 Image of Robert Koch.

Source: © National Library of Medicine.

Robert Koch (1843–1910).

The German physician Robert Koch (Figure 1-11) verified that a human disease was caused by a specific living organism. He isolated the bacteria that cause anthrax (*Bacillus anthracis*) and cholera (*Vibrio cholerae*). One of his most famous contributions was identifying the cause of tuberculosis (*Mycobacterium tuberculosis*); this work was described in 1882 in *Die Aetiologie der Tuberkulose.* Koch's four postulates to demonstrate the association between a microorganism and a disease were formatted as follows:

1. The organism must be observed in every case of the disease.
2. It must be isolated and grown in pure culture.
3. The pure culture must, when inoculated into a susceptible animal, reproduce the disease.
4. The organism must be observed in, and recovered from, the experimental animal.[15]

Early Twentieth Century (1900–1940)

Pandemic influenza.

Also known as the Spanish Flu, this pandemic raged from 1918 to 1919 and killed 50 to 100 million persons globally. Estimates suggest that one-third of the world's population, which then was 1.5 billion, became infected and developed clinically observable illness. Instead of primarily attacking the young and the elderly as is usually the situation with influenza, the Spanish Flu took a heavy toll on healthy young adults. One hypothesis is that the influenza virus interacted with respiratory bacteria, causing numerous deaths from bacterial pneumonias. The death rate was so high that morgues were overflowing with bodies awaiting burial; adequate supplies of coffins and the services of morticians were unavailable. To handle the influx of patients, special field hospitals were set up. (See Figure 1-12.)

Discovery of penicillin.

Scottish researcher Alexander Fleming (1881–1955) discovered the antimicrobial properties of the mold *Penicillium notatum* in 1928. This breakthrough led to development of the antibiotic penicillin, which became available toward the end of World War II.

The Contemporary Era (1940 to the present)

From the mid-twentieth century to the present (first decade of the twenty-first century), epidemiology has made numerous contributions to society. These innovations include:

FIGURE 1-12 Emergency hospital during influenza epidemic, Camp Funston, Kansas.

Source: © National Museum of Health and Medicine, Armed Forces, Institute of Pathology, (NCI, 1903).

- Framingham Study. Begun in 1948, this pioneering research project is named for Framingham, Massachusetts. Initially, a random sample of 6,500 persons aged 30 to 59 years participated. This project has been responsible for gathering basic information about aspects of health such as the etiology of coronary heart disease. Chapter 6 will present more information on the Framingham study.
- Epidemic Intelligence Service. Alexander Langmuir was hired by the Centers for Disease Control and Prevention as the first chief epidemiologist. One of Langmuir's contributions was the establishment in 1949 of the Epidemic Intelligence Service (EIS). In the beginning, the mission of EIS was to combat bioterrorism. Presently, EIS officers aid in the rapid response to public health needs both domestically and internationally.
- Smoking and health. By the mid-twentieth century, a growing body of evidence suggested that cigarette smoking contributed to early mortality from lung cancer as well as other forms of morbidity and mortality. In 1964, the U.S. Surgeon General released *Smoking and Health*,[16] which stated that cigarette smoking is a cause of lung cancer in men and is linked to other disabling or fatal diseases.
- Smallpox eradication. As noted previously, Jenner pioneered development of a smallpox vaccine during the 1800s. Smallpox is an incurable disease caused by a virus. One form of the virus *variola major* produces a highly fatal infection in unvaccinated populations. Because of a highly effective surveillance and vaccination program that was intensified during the late 1960s, the ancient scourge of smallpox was brought under control. The last known naturally acquired case was reported in Somalia in 1977.
- Some newer developments. More recent contributions of epidemiology include helping to discover the associ-

ation between the human papillomavirus and cervical cancer, the correspondence between a bacterium (*Helicobacter pylori*) and peptic ulcers, and the correlation between genetic factors and cancers (e.g., breast cancer).

BRIEF OVERVIEW OF CURRENT USES OF EPIDEMIOLOGY

Epidemiologists are indebted to J.N. Morris,[17] who published a list of seven uses of epidemiology; five of these uses are shown in the text box.

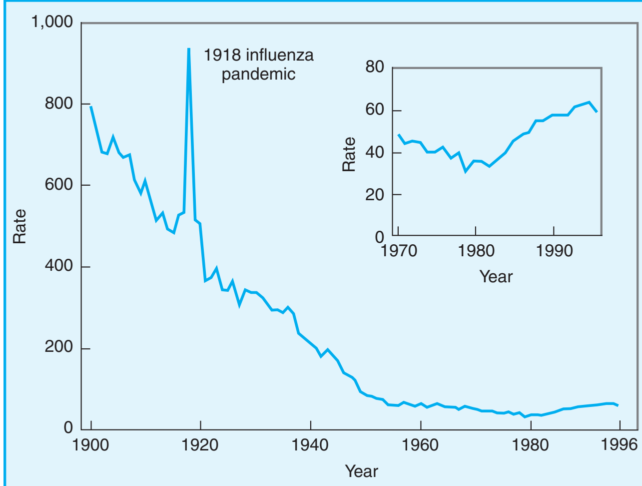
> Among the principal uses of epidemiology are the following:
>
> - Historical use: study the history of the health of populations
> - Community health use: diagnose the health of the community
> - Health services use: study the working of health services
> - Risk assessment use: estimate individuals' risks of disease, accident, or defect
> - Disease causality use: search for the causes of health and disease
>
> *Source:* Adapted from Morris JN. *Uses of Epidemiology.* 3rd ed. Edinburgh, UK: Churchill Livingstone; 1975:262–263.

Historical Use

The historical use of epidemiology documents the patterns, types, and causes of morbidity and mortality over time. Since the early 1900s, in developed countries the causes of mortality have shifted from those related primarily to infectious and communicable diseases to chronic conditions. This use is illustrated by changes over time in the causes of mortality in the United States. For example, Figure 1-13 shows the decline in the rate of infectious disease mortality between 1900 and 1996. Mortality from infectious diseases rose sharply during the influenza pandemic of 1918 and then continued its downward trend. In the early 1980s, mortality from infectious diseases increased again because of the impact of human immunodeficiency virus (HIV) disease. Mortality from HIV disease subsequently declined and caused 12,543 deaths in 2005; during that year, the leading causes of death were heart disease, cancer, and stroke. (Refer to Chapter 2 for more information.)

The term **epidemiologic transition** describes a shift in the patterns of morbidity and mortality from causes related primarily to infectious and communicable diseases to causes associated with chronic, degenerative diseases. The epidemiologic transition coincides with the **demographic transition**, a shift from high birth rates and death rates found in agrarian societies to much lower birth and death rates in developed countries. Figure 1-14 shows the stage of epidemiologic transition across the top and the stage of demographic transition across the bottom. These two kinds of transition parallel one another over time. The figure is subdivided into four segments: pre-, early, late, and post-. Refer to the figure for the definitions of these stages. At present, the United States is in the posttransition stage, which is dominated by diseases associated with personal behavior, adverse lifestyle, and emerging infections.

FIGURE 1-13 Rate* of infectious disease mortality, by year—United States, 1900–1996.



*Per 100,000 population

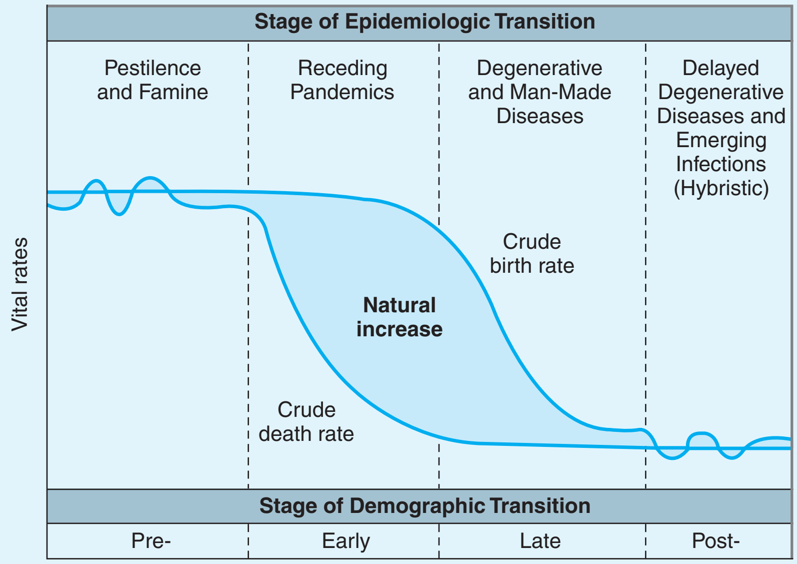
Source: Adapted from Armstrong GL, Conn LA, Pinner RW. Trends in infectious disease mortality in the United States during the 20th century. *JAMA.* 1999;281:63. Copyright © 1999 American Medical Association. All rights reserved. Insert: Reprinted from Centers for Disease Control and Prevention. CDC's 60th Anniversary: Director's Perspective—James O. Mason, M.D., Dr.P.H., 1983–1989. *MMWR.* 2006;55:1356.

Community Health Use

Morris described this use as follows: "To *diagnose the health of the community* and the condition of the people, to measure the true dimensions and distribution of ill-health in terms of incidence, prevalence, disability and mortality; to set health problems in perspective and define their relative importance; to identify groups needing special attention."[17(p262)]

Examples of characteristics that affect the health of the community are age and sex distributions, racial/ethnic makeup, socioeconomic status, employment and unemployment rates, access to healthcare services, population density, and residential

FIGURE 1-14 Demographic/epidemiologic transition framework.



Source: Reprinted from Rockett IRH. "Population and Health: An Introduction to Epidemiology," 2nd ed., *Population Bulletin,* vol. 54, no. 4, p. 9. Washington, DC: Population Reference Bureau, December 1999. Reprinted with permission of Population Reference Bureau.

mobility. These variables are reflected in a wide range of outcomes: life expectancy, social conditions, and patterns of morbidity and mortality. These characteristics will be covered in more detail in Chapter 4 (descriptive epidemiology) and Chapter 6 (analytic epidemiology—section on ecologic studies).

Health Services Use

Morris also proposed that epidemiology could be used "to study the *working of health services* with a view to their improvement. Operational research translates knowledge of (changing) community health and expectations in terms of needs for services and measure [sic] how these are met."[17(p262)]

Operations research is defined as a type of study of the placement of health services in a community and the optimum utilization of such services. Epidemiology helps to provide quantitative information regarding the availability and cost of healthcare services. Epidemiologic studies aid planners in determining what services are needed in the community and what services are duplicated unnecessarily. Provision of healthcare services is exceedingly costly for society; epidemiologic methods can be used to weigh cost issues against quality of services in order to maximize cost effectiveness. Epidemiologic findings are relevant to the current era of managed care through **disease management**; this term refers to a method of reducing healthcare costs by providing integrated care for chronic conditions, e.g., heart disease, hypertension, and diabetes.

Risk Assessment Use

According to Morris, this application was "to estimate from the group experience what are the *individual* risks on average of disease, accident and defect, and the *chances* of avoiding them."[17(p262)]

Risk is "the probability that an event will occur, e.g., that an individual will become ill or die within a stated period of time or by a certain age."[1] A **risk factor** is an exposure that is associated with a disease, morbidity, mortality, or adverse health outcome. For example, cigarette smoking increases the risk of contracting certain forms of cancer including lung cancer. Epidemiologic studies provide quantitative measurements of risks to health through a methodology known as **risk assessment**. One of the major cornerstones of health policy development, risk assessment (and its four components) will be covered in Chapter 7.

Disease Causality Use

With respect to this use, Morris wrote, "To *search for causes* of health and disease by computing the experience of groups defined by their composition, inheritance and experience, their behaviour [sic] and environments."[17(p263)]

The search for causes of disease and other health outcomes is one of the most important uses of epidemiology. In order to assess potential causal associations, epidemiologists need to consider a set of criteria that must be satisfied; refer to Chapter 2 for more information. Possible associations can be evaluated by analytic study designs; these designs include case-control and cohort studies. Other analytic studies involve natural experiments, randomized controlled clinical trials, and community trials. Analytic study designs are discussed in Chapter 6. We will learn that study designs, whether observational or analytic, can be arranged in a hierarchy according to our confidence in the validity of the information that they provide.

ETHICS AND PHILOSOPHY OF EPIDEMIOLOGY

Description of Ethics in Research

The final topic in this chapter relates to ethics and epidemiology. The term **ethics** refers to ". . . **norms for conduct** that distinguish between . . . acceptable and unacceptable behavior."[18] David B. Resnik, bioethicist for the National Institute of Environmental Health Sciences, has written the following statement about ethics in research:

> When most people think of ethics (or morals), they think of rules for distinguishing between right and wrong, such as the Golden Rule ("Do unto others as you would have them do unto you"), a code of professional conduct like the Hippocratic Oath ("First of all, do no harm"), a religious creed like the Ten Commandments ("Thou shalt not kill . . ."), or a wise aphorisms [sic] like the sayings of Confucius. This is the most common way of defining "ethics": ethics are **norms for conduct** that distinguish between . . . acceptable and unacceptable behavior . . . .
>
> Many different disciplines, institutions, and professions have norms for behavior that suit their particular aims and goals. These norms also help members of the discipline to coordinate their actions or activities and to establish the public's trust of the discipline. For instance, ethical norms govern conduct in medicine, law, engineering, and business. Ethical norms also serve the aims or goals of research and apply to people who conduct scientific research or other scholarly or creative activities, and there is a specialized discipline, research ethics, which studies these norms.
>
> There are several reasons why it is important to adhere to ethical norms in research. First, some of these norms **promote the aims of research**, such as knowledge, truth, and avoidance of error. For example, prohibitions against fabricating, falsifying, or misrepresenting research data promote the truth and avoid error. Second, since research often involves a great deal of cooperation and coordination among many different people in different disciplines and institutions, many of these ethical standards promote the **values that are essential to collaborative work**, such as trust, accountability, mutual respect, and fairness. For example, many ethical norms in research, such as guidelines for authorship, copyright and patenting policies, data sharing policies, and confidentiality rules in peer review, are designed to protect intellectual property interests while encouraging collaboration. Most researchers want to receive credit for their contributions and do not want to have their ideas stolen or disclosed prematurely. Third, many of the ethical norms help to ensure that researchers can be held **accountable to the public**. For instance, federal policies on research misconduct, on conflicts of interest, on the human subjects protections, and on animal care and use are necessary in order to make sure that researchers who are funded by public money can be held accountable to the public. Fourth, ethical norms in research also help to build **public support** for research. People [are] more likely to fund research project [sic] if they can trust the quality and integrity of research. Finally, many of the norms of research promote a variety of other important **moral and social values**, such as social responsibility, human rights, animal welfare, compliance with the law, and health and safety. Ethical lapses in research can significantly [do] harm to human and animal subjects, students, and the public. For example, a researcher who fabricates data in a clinical trial may harm or even kill patients, and a researcher who fails to abide by regulations and guidelines relating to radiation or biological safety may jeopardize his health and safety or the health and safety . . . [of] staff and students.[18]

A description of syphilis

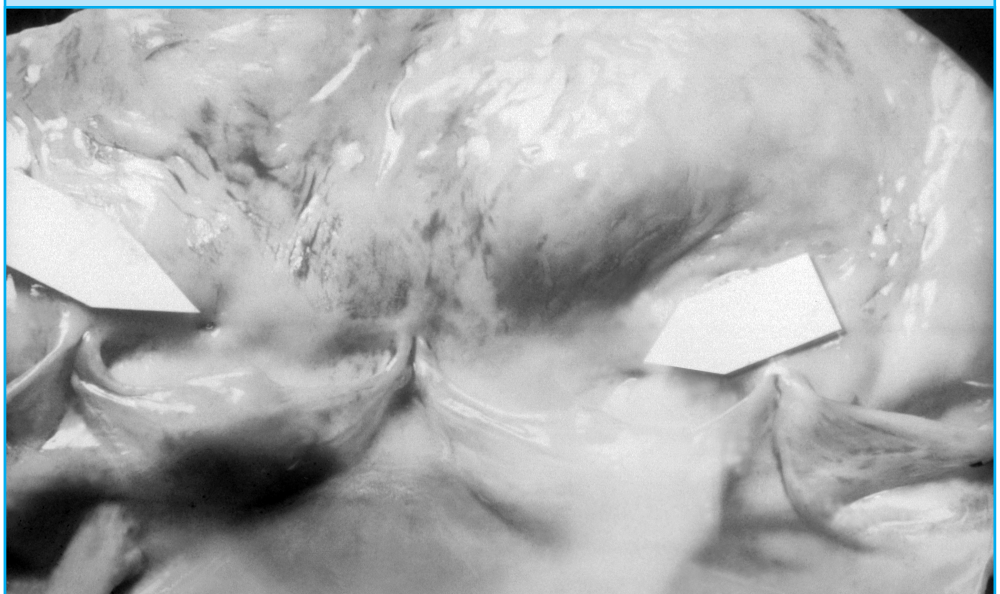
A sexually transmitted disease associated with the bacterial agent *Treponema pallidum,* syphilis can have both acute (having sudden onset) and chronic (long-term) phases. The initial infection (primary lesion) produces a painless sore (called a chancre) that appears approximately three weeks after exposure. After the primary lesion seems to resolve, a secondary infection (e.g., a rash on the palms of the hands and soles of the feet) may appear in about two months. This secondary infection resolves several weeks or months later and then becomes a latent infection. Some infections will remain latent for life and others will progress to tertiary syphilis, resulting in diseases of the central nervous system, cardiovascular system (see Figure 1-15), or other organs of the body.[20] At present, syphilis is treatable with penicillin and other antibiotics. Before the advent of modern antibiotics, compounds that contained mercury or arsenic were used to treat syphilis. These treatments were not completely effective and often were harmful.

Ethical Violation: U.S. Public Health Service Syphilis Study at Tuskegee

The U.S. Public Health Service in conjunction with the Tuskegee Institute began a syphilis investigation in 1932 that spanned forty years. (Refer to the text box for a description of syphilis.) The purpose of the study was to ". . . record the natural history of syphilis in hopes of justifying treatment programs for blacks. It was called 'The Tuskegee Study of Untreated Syphilis in the Negro Male.'"[19] A total of 600 African American Men (399 syphilis cases and 201 syphilis-free controls) participated in the study.

The participants in the Tuskegee Study never gave informed consent to participate. "Researchers told the men that they were being treated for 'bad blood,' a local term used to describe several ailments, including syphilis, anemia, and fatigue."[19] Appropriate treatment for syphilis was never offered, despite the fact that as early as 1947 penicillin was known to be efficacious. A class-action suit filed on behalf of the men in 1973 resulted in a $10 million settlement plus medical and health benefits. Figure 1-16 shows a nurse conversing with some of the participants in the study.

FIGURE 1-15 Stenosis (narrowing) of the coronary arteries due to cardiovascular syphilis.



Source: Reprinted from Centers for Disease Control and Prevention, Public Health Image Library, ID# 2339. Available at: http://phil.cdc.gov/phil/home.asp. Accessed August 3, 2008.

FIGURE 1-16 Tuskegee syphilis study participants with Nurse Rivers.

Source: Photo from the U.S. Public Health Service. Reprinted from the National Archives, Southeast Region. Available at: http://www.archives.gov/southeast/exhibit/popups.php?p=6.1.5. Accessed August 3, 2008.

Nowadays, universities maintain Human Subjects Review Boards to ensure that all research protocols that involve human beings and animals are reviewed to make certain that the procedures meet the requirements for informed consent and other ethical standards. In addition, many professional organizations have adopted codes of professional ethics to prevent ethical lapses by their members. For example, epidemiologists operate according to a set of core values that guide practice in the field. The American Council of Epidemiology (ACE) has developed a statement of ethics guidelines.[21] Five of the guidelines have been abstracted from the ACE ethics statement (refer to text box).

Ethics guidelines for epidemiologists

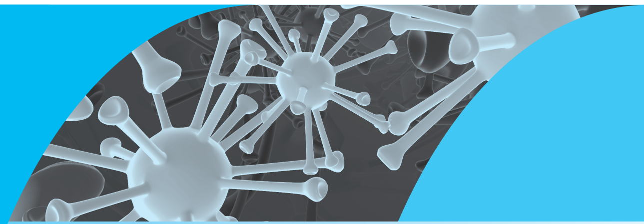
- Minimizing risks and protecting the welfare of research subjects
- Obtaining the informed consent of participants
- Submitting proposed studies for ethical review
- Maintaining public trust
- [Meeting] obligations to communities

Source: Adapted and reprinted from American College of Epidemiology, Ethics Guidelines. This article was published in *Annals of Epidemiology,* Vol 10, No 8, 2000, pp. 487–497, "Ethics guidelines." Available at: http://www.acepidemiology2.org/policystmts/EthicsGuide.asp. Accessed August 7, 2008.

CONCLUSION

Epidemiologists study the occurrence of diseases and health outcomes in populations. Findings from epidemiologic research are reported frequently in the popular media. For example, disease outbreaks such as those caused by foodborne illnesses often command public attention. Chapter 1 defined some of the terms that are used to describe disease outbreaks, discussed the scope and applications of epidemiology, and presented information on its interdisciplinary composition. Epidemiologic methods are applicable to many types of health-related issues, from infectious diseases to violence in schools. Although many people consider epidemiology to be primarily a medical subject, it is also a liberal arts discipline in many respects; epidemiology provides training in generally applicable skills such as critical thinking ability and use of the scientific method.

Epidemiology is primarily an observational science that involves describing the occurrence of disease in populations (descriptive epidemiology) and researching the etiology of diseases (analytic epidemiology). The history of epidemiology extends over many centuries, beginning during classical antiquity at the time of the ancient Greeks. Subsequent historical events included the identification of infectious disease agents and Snow's use of methods such as case mapping and data tabulation that remain relevant today. Recent history has included eradication of smallpox and development of improved procedures to control chronic diseases. Chapter 1 concluded with a review of the uses of epidemiology and a discussion of the ethical aspects of epidemiologic research.



Study Questions and Exercises

1. Define the following terms:
   a. epidemic
   b. pandemic
   c. epidemiology
2. Define and discuss three of the key characteristics of epidemiology.
3. In what respects does epidemiology differ from clinical medicine?
4. What are some examples of risk factors for disease that you experience in your life? Be sure to define what is meant by a risk factor.
5. Check your local library or go online to find works of literature that describe epidemics and epidemic detective work.
6. Distinguish between the descriptive and analytic approaches to epidemiology.
7. The following list shows individuals who contributed to the history of epidemiology. Describe each of their contributions.
   a. Hippocrates
   b. John Graunt
   c. Sir Percival Pott
   d. John Snow
   e. Robert Koch
8. Discuss four uses of epidemiology. For each use, give examples that were not mentioned in the textbook.
9. Find an article in the popular media (either in the print media or online) that illustrates one or more uses of epidemiology. Be prepared to discuss the article in class.

Young Epidemiology Scholars (YES) Exercises

The Young Epidemiology Scholars Web site provides links to teaching units and exercises that support instruction in epidemiology. The YES program is administered by the College Board and supported by the Robert Wood Johnson Foundation. The Web address of YES is www.collegeboard.com/yes. The following exercises relate to topics discussed in this chapter and can be found on the YES Web site.

History of epidemiology:

1. McCrary F, Stolley P. Examining the plague: An investigation of epidemic past and present.
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