CHAPTER 2

Practical Applications of Epidemiology

LEARNING OBJECTIVES

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

- discuss uses and applications of epidemiology
- define the influence of population dynamics on community health
- state how epidemiology may be used for operations research
- discuss the clinical applications of epidemiology
- cite causal mechanisms from the epidemiologic perspective

CHAPTER OUTLINE

Introduction

This chapter provides a broad overview of the range of applications of the epidemiologic approach. As the basic method of public health, epidemiology touches many aspects of the health sciences. The late Jerry Morris, professor of community health at the London School of Hygiene and Tropical Medicine, articulated seven uses for epidemiology.[1] (Refer to **Figure 2–1**.) These uses include one group related to health status and health services and another set related to disease etiology. The first part of this chapter covers applications in health status and health services. For example, by describing the occurrence of disease in the community, epidemiology helps public health practitioners and administrators plan for allocation of resources. Once needed services are implemented, the epidemiologic approach can help evaluate their function and utility. (See **Exhibit 2–1** for a statement of seven uses of epidemiology.)

The second part of the chapter focuses on applications of epidemiology that are relevant to disease etiology. The causes of many diseases remain unknown; epidemiologists in research universities and federal and private agencies continue to search for clues as to the nature of disease. Knowledge that is acquired through such research may be helpful in efforts to prevent the occurrence

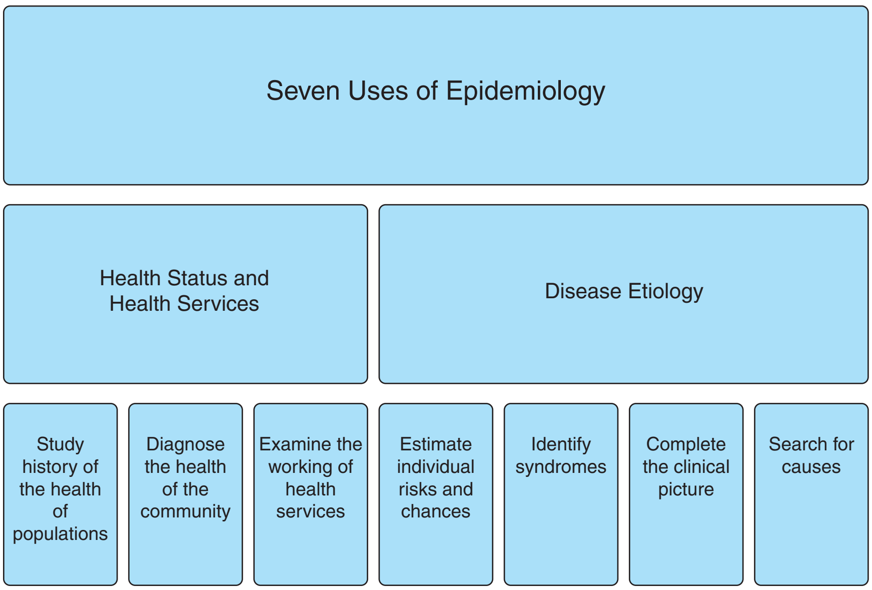


FIGURE 2–1 The seven uses of epidemiology. *Source:* Data from Morris JN. *Uses of Epidemiology*, 3rd ed., pp. 262–263, © 1975, Elsevier.

EXHIBIT 2–1

Seven Uses of Epidemiology

The epidemiological method is the only way of asking some questions in medicine, one way of asking others, and no way at all to ask many. Several uses of epidemiology have been described:

1. To study the *history of the health of populations*, and of the rise and fall of diseases and changes in their character. Useful projections into the future may be possible.
2. 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. Ways of life change, and with them the community's health; new measurements for monitoring them must therefore constantly be sought.
3. 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. The success of services delivered in reaching stated norms, and the effects on community health—and its needs—have to be appraised, in relation to resources. Such knowledge may be applied in action research pioneering better services, and in drawing up plans for the future. Timely information on health and health services is itself a key service requiring much study and experiment. Today, information is required at many levels, from the local district to the international.
4. To estimate from the group experience what are the *individual* risks on average of disease, accident and defect, and the chances of avoiding them.
5. To *identify syndromes* by describing the distribution and association of clinical phenomena in the population.
6. To *complete the clinical picture* of chronic diseases and describe their natural history: by including in due proportion all kinds of

continues

EXHIBIT 2–1 *continued*

patients, wherever they present, together with the undemanding and the symptomless cases who do not present and whose needs may be as great; by following the course of remission and relapse, adjustment and disability in defined populations. Follow-up of cohorts is necessary to detect early subclinical and perhaps reversible disease and to discover precursor abnormalities during the pathogenesis, which may offer opportunities for prevention.

7. 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. To confirm particular causes of the chronic diseases and the patterns of multiple causes, describing their mode of operation singly and together, and to assess their importance in terms of the relative risks of those exposed. Postulated causes will often be tested in naturally occurring experiments of opportunity and sometimes by planned experiments. ■

Source: Reprinted from Morris JN. *Uses of Epidemiology*. 3rd ed. Edinburgh, UK: Churchill Livingstone, 262–263, © 1975, with permission of Elsevier.

of disease. Results of these epidemiologic studies are often quite newsworthy and sometimes controversial. More and more frequently, medical journals such as the *New England Journal of Medicine* (*NEJM*) are publishing reports of epidemiologic studies.[2] Among the key reasons for the proliferation of these studies are, first, that they concentrate on associations between diseases and possible lifestyle factors, such as a habit, type of behavior, or some element of the diet, that presumably can be changed. Consequently, "The reports are . . . often of great interest to the popular media and the public, as well as to physicians interested in preventive medicine."[2(p 823)] A second reason is that the major diseases that are predominant in American society are "chronic, degenerative diseases that probably have several contributing causes, some of which have to do with lifestyle, operating over long periods."[2(p 823)] An *NEJM* editorial pointed out:

> It is usually very difficult to investigate such risk factors through experimental (or interventional) studies. In some cases it is impractical and in some it is unethical.

> For example, researchers cannot expose half of a group of children to lead for 10 years to compare their IQs 20 years later with those of the unexposed children. We must therefore rely on epidemiologic (or observational) studies.[2(p 823)]

Because of the increasingly important function that epidemiology performs in clinical decision-making, this chapter also touches on some of the valuable considerations of this application. Finally, a few words of caution are presented on limitations of epidemiology in determining the cause of disease. Coverage of the general concept of *causality* will permit a fuller understanding of these issues. The term causality refers to the relationship between cause and effect.

Applications for the Assessment of the Health Status of Populations and Delivery of Health Services

As Morris noted, principal uses of epidemiology under this category include the history of the health of populations, diagnosis of the health of the community, and the working of health services.[1]

Historical Use of Epidemiology: Study of Past and Future Trends in Health and Illness

An example of the historical use of epidemiology is the study of changes in disease frequency over time. (These changes are known as secular trends.) Illnesses and causes of mortality that afflict humanity, with certain exceptions, have shown dramatic changes in industrialized nations from the beginning of modern medicine to the present day. In general, chronic conditions have replaced acute infectious diseases as the major causes of morbidity and mortality in contemporary industrialized societies. Mortality data shed light on the overall health status of populations, suggest long-term trends in health, and help to identify subgroups of the population that are at greater risk of mortality than other subgroups.

Figure 2–2 identifies the top 10 causes of death for two contrasting years: 1900 and 2009, a period of more than one century. The data show that influenza and pneumonia dropped from the top position in 1900 to eight in 2009. In 2009 diseases of the heart were the leading cause of death, followed in second place by cancer. The overall crude death rate from all causes declined greatly during this period of about one century—from 1719.1 to 793.7 per 100,000 population.

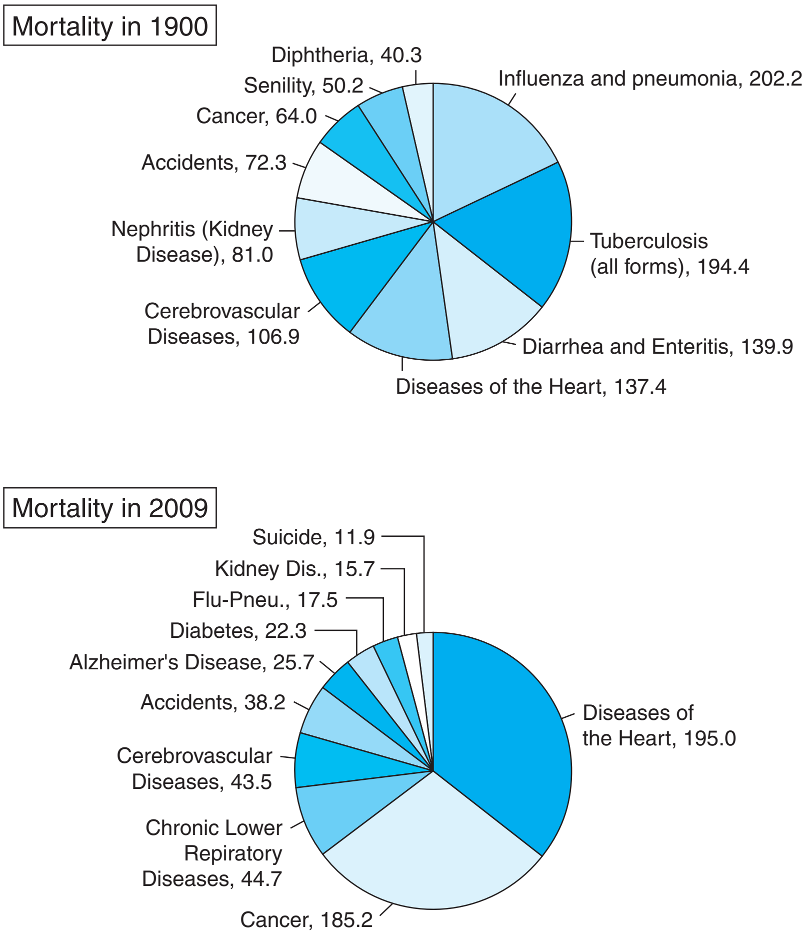
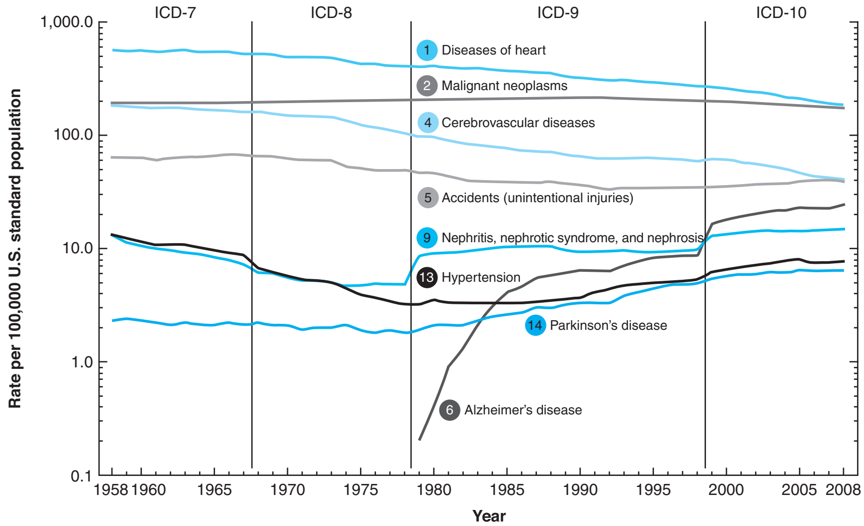


FIGURE 2–2 The ten leading causes of mortality, 1900 and 2009, rank, cause, and crude death rate per 100,000 (not age-adjusted). Data for 1900 exclude infant mortality. *Sources:* Data from U.S. Bureau of the Census, Statistical Abstract of the United States: 1957, p. 69 ; United States Public Health Service, Vital Statistics Rates in the United States 1900–1940, Washington, DC: United States Government Printing Office, 1947; and from Kochanek KD, Xu JQ, Murphy SL, at al. Deaths: Preliminary Data for 2009, National Vital Statistics Reports. Vol 59, No 4, p. 5. Hyattsville, MD: National Center for Health Statistics, 2011.

Since the early 1960s, the leading causes of death over decades of time have shown marked changes (**Figure 2–3**). For example, death rates for heart disease, cancer, and stroke have shown long-term declining trends. Increases have been reported for Alzheimer's disease, kidney disease, and hypertension.



Notes: ICD is the International Classification of Diseases. Circled numbers indicate ranking of conditions as leading causes of death in 2008. Age-adjusted death rates per 100,000 U.S. standard population; see "Technical Notes."

FIGURE 2–3 Age-adjusted death rates for selected leading causes of death: United States, from 1958 to 2008. *Source:* Reproduced from Miniño AM, Murphy SL, Xu JQ, Kochanek KD. Deaths: Final Data for 2008. National Vital Statistics Reports; Vol. 59, No. 10. Hyattsville, MD: National Center for Health Statistics. 2011.

In determining the reasons for these trends, one must take into account certain conditions that may affect the reliability of observed changes. According to MacMahon and Pugh, these are "variation in diagnosis, reporting, case fatality, or some other circumstance other than a true change of incidence."[3(p 159)] Specific examples follow:

- Lack of comparability over time due to altered diagnostic criteria. The diagnostic criteria used in a later time period reflect new knowledge about disease; some categories of disease used in earlier eras may be omitted altogether. The diagnostic criteria may be more precise at a later time; for instance, considerable information has been obtained over three quarters of a century about chronic diseases. In some cases, when changes in diagnostic procedures are due to known alterations in diagnostic coding systems, the changes will be abrupt and readily identifiable.
- Aging of the general population. As the population ages due to the reduced impact of infectious diseases, improved medical care, and a decline in the death rate, there may be greater uncertainty about the precise cause of

death. Also, there may be inaccurate assignment of the underlying cause of death when older individuals are affected by chronic disease because multiple organ systems may fail simultaneously.
- Changes in the fatal course of the condition. Such changes would be reflected over the long run in decreases in the number of people with disease who actually die of it.

Despite the factors that reduce the reliability of observed changes in morbidity and mortality, **Figure 2–4** identifies four trends in disorders: disappearing, residual, persisting, and new epidemic disorders.[4] Changes in the occurrence and patterns of morbidity and mortality are the results of a range of factors including improvements in medical care (e.g., development of new immunizations and medicines), alterations in environmental conditions (e.g., increased levels of pollution in the presence of toxic chemicals in our food), and appearance of new or more virulent forms of microbial disease agents. The four trends are defined as follows:

- *Disappearing disorders* are those disorders that were formerly common sources of morbidity and mortality in developed countries but that at present have nearly disappeared in their epidemic form. Under this category are smallpox (currently eradicated), poliomyelitis, and other diseases such as

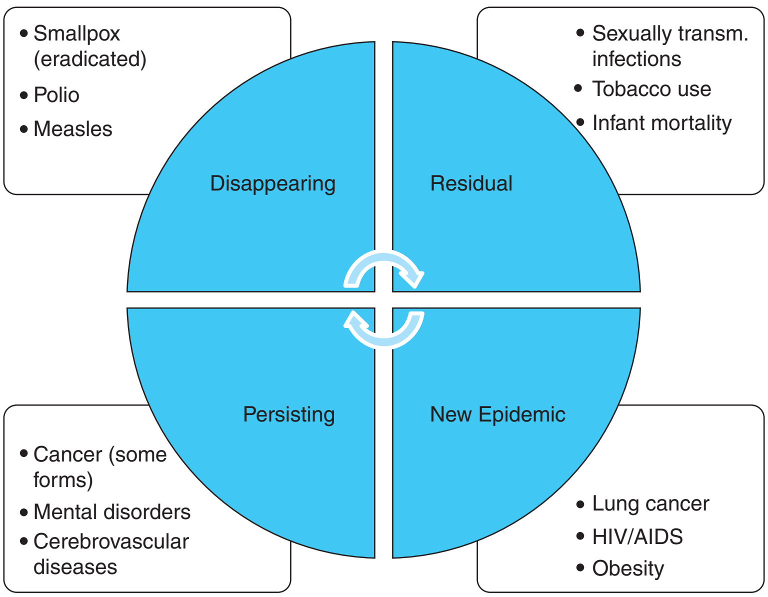


FIGURE 2–4 Four trends in disorders.

measles that have been brought under control by means of immunizations, improvement in sanitary conditions, and the use of antibiotics and other medications.

- *Residual disorders* are diseases for which the key contributing factors are largely known but specific methods of control have not been effectively implemented. Sexually transmitted diseases, perinatal and infant mortality among the economically disadvantaged, and health problems associated with use of tobacco and alcohol are examples.
- *Persisting disorders* are diseases that remain common because an effective method of prevention or cure evades discovery. Some forms of cancer and mental disorders are representative of this category.
- New epidemic disorders are diseases that are increasing markedly in frequency in comparison with previous time periods. The reader may surmise that examples of these are lung cancer and, most recently, acquired immune deficiency syndrome (AIDS). The emergence of new epidemics of diseases may be a result of the increased life expectancy of the population, new environmental exposures, or changes in lifestyle, diet, and other practices associated with contemporary life. Increases in the levels of obesity and type 2 diabetes in many parts of the world, notably in developed countries and also in developing areas, are examples of this category of disorders.

Predictions About the Future

The study of population dynamics in relation to sources of morbidity and mortality reveals much about possible future trends in a population's health. A population pyramid represents the age and sex composition of the population of an area or country at a point in time.[5] By examining the distribution of a population by age and sex, one may view the impacts of mortality from acute and chronic conditions as well as the quality of medical care available to a population.

Figure 2–5 shows the age and sex distribution of the population of developed and developing countries for three time periods: 1950, 1990, and 2030. The left and right sides of each chart compare males and females, respectively. The x-axis (bottom of each chart) gives the number of the population in millions. The y-axis (left side of each chart) presents ages grouped into 5-year intervals. The following trends in the age and sex distributions are evident:

- **Developing countries**. In 1950 and 1990, less developed countries had a triangular population distribution. A triangular distribution is associated with high death rates from infections, high birth rates, and other

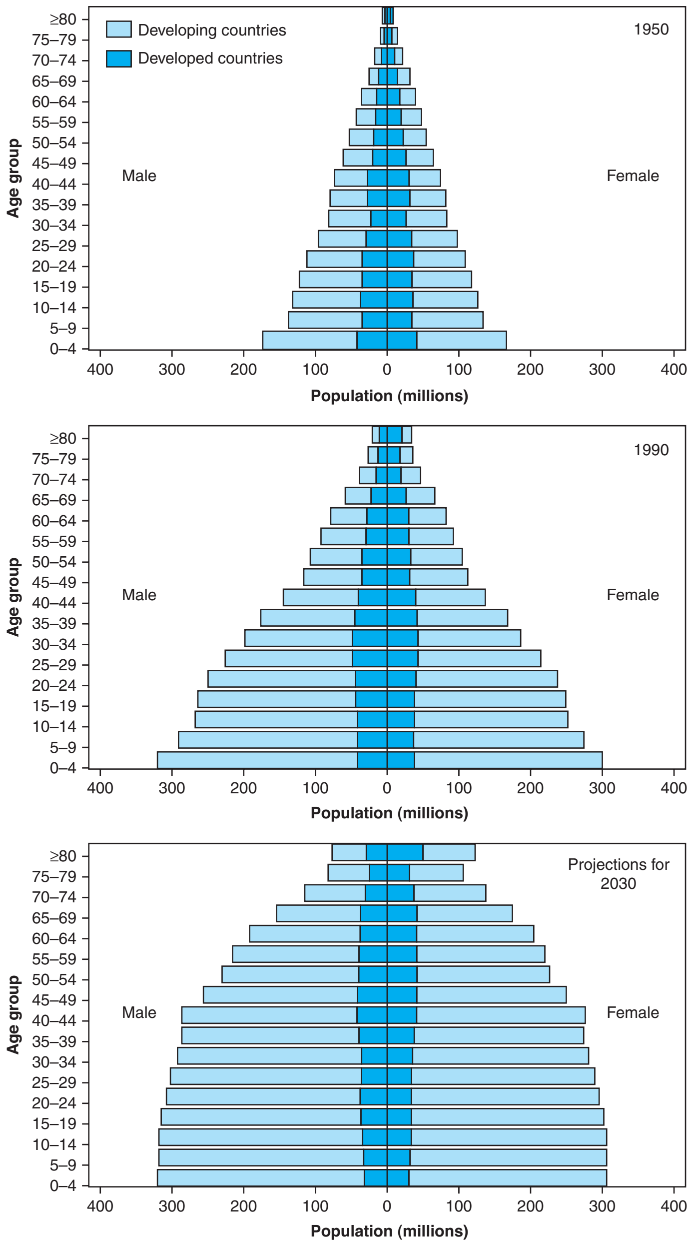


FIGURE 2–5 Population age distribution for developing and developed countries, by age group and sex–worldwide, 1950, 1990, and 2030.
Source: Adapted and reprinted from Centers for Disease Control and Prevention, MMWR 2003;52(6):103. The United Nations and the U.S. Bureau of the Census are the authors of the original material.

conditions that take a heavy toll during the childhood years. These deaths result from a constellation of factors associated with poverty and deprivation: poor nutrition, lack of potable water, and unavailability of basic immunizations, antibiotics, and sewage treatment. Consequently, fewer children survive into old age, causing smaller numbers of the population in the older groups. By 2030, improvements in health in developing countries are likely to result in greater survival of younger persons, causing a projected change in the shape of the population distribution.

- **Developed countries (industrialized societies)**. These countries manifest a rectangular population distribution. This rectangular shape was consistent for 1950 and 1990 and, with some exceptions, is projected also for 2030. Characteristically, infections take a smaller toll than in developing countries, causing a greater proportion of children to survive into old age; approximately equal numbers of individuals are present in each age group except among the very oldest age groups, with larger numbers of older women than men who survive. Because of reduced mortality due to infectious diseases and improved medical care in comparison with less developed regions, residents of developed countries enjoy greater life expectancy. With continuing advances in medical care, the population of developed countries will grow increasingly older. The U.S. Bureau of the Census estimates that about one-fifth of the U.S. population in 2030 will be 65 years of age and older. There will be a need for health services that affect aging and all of its associated dimensions. One illustration is increasing the availability of programs for the major chronic diseases, both with respect to preventive care in the early years and direct care in the older years.

Population Dynamics and Epidemiology

Population dynamics denote changes in the demographic structure of populations associated with such factors as births and deaths and immigration and emigration. This section presents definitions of two types of populations, fixed populations and dynamic populations, and illustrates how populations grow and wane. Noteworthy related concepts are the demographic transition and the epidemiologic transition.

Terminology: fixed populations and dynamic populations

A population may be either fixed or dynamic. A *fixed population* is one distinguished by a specific happening and consequently adds no new members; therefore, the population decreases in size as a result of deaths only.

Examples of a fixed population are survivors of the 9–11 terrorist attack in New York, residents of New Orleans during Hurricane Katrina, and persons who have had a medical procedure such as hip replacement. A *dynamic population* is one that adds new members through immigration and births or loses members through emigration and deaths.[7] An example of a dynamic population is the population of a county, city, or state in the United States.

Influences on population size

Three major factors affect the sizes of populations: births, deaths, and migration.[5] The latter term includes immigration and emigration—permanent movement into and out of a country, respectively. **Figure 2–6** demonstrates how the three variables affect the net size of a population.

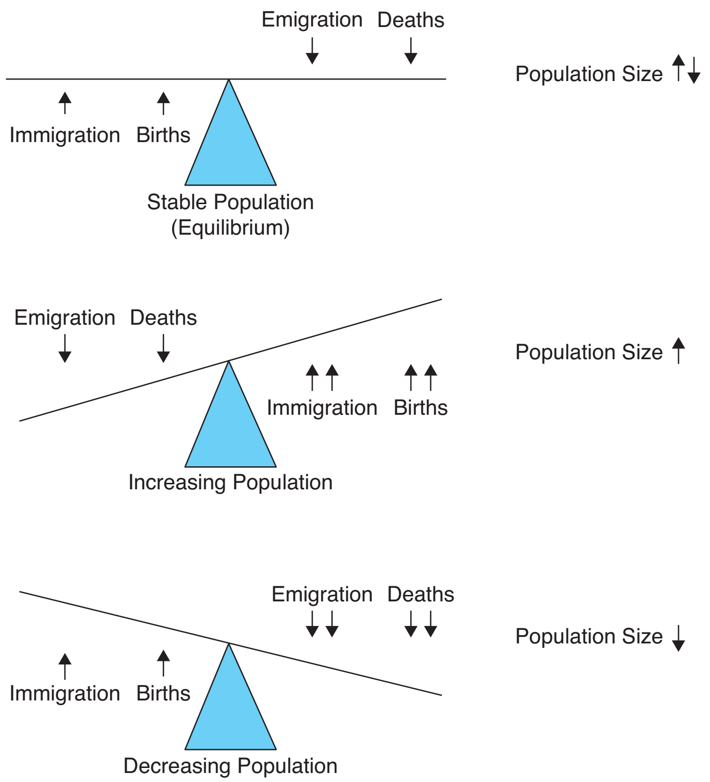


FIGURE 2–6 How births, deaths, and migration affect the net size of a population.

- **Population in equilibrium or a steady state**—the three factors do not contribute to net increases or decreases in the number of persons, meaning that the number of members exiting for various reasons equals the number entering.
- **Population increasing in size**—the net effect caused by the number of persons immigrating plus the number of births exceeds the number of persons emigrating plus the number of deaths.
- **Population decreasing in size**—the net effect caused by the number of persons emigrating plus the number of deaths exceeds the number of persons immigrating plus the number of births.

As the population pyramid portends, population characteristics are related to health patterns found in the community. The term *demographic transition* refers to the historical shift from high birth and death rates found in agrarian societies to much lower birth and death rates found in developed countries.[5] A decline in the death rate has been attributed in part to improvement in general hygienic and social conditions. Industrialization and urbanization contribute to a decline in the birth rate. The term *epidemiologic transition* is used to describe a shift in the pattern of morbidity and mortality from causes related primarily to infectious and communicable diseases to causes associated with chronic, degenerative diseases. The epidemiologic transition accompanies the demographic transition. The demographic transition, however, is not without its own set of consequences: Both industrialization and urbanization have led to environmental contamination, concentration of social and health problems in the urban core areas of the United States, and out-migration of inner city residents to the suburbs.

Health of the Community

One of the important applications in epidemiology is to provide methodologies used to describe the overall health of a particular community. The resulting description may then provide a key to the types of problems that require attention and also accentuate the need for specific health services. A complete epidemiologic description would include indices of health as well as indicators of the psychosocial milieu of the community. A representative list of variables that might be covered in a description of the health of the community is given in Exhibit 2–2.

Demographic and social variables

Age and sex distribution: Referring to **Exhibit 2–2**, note that the first set of variables shown are demographic and social variables. Consider the example of

EXHIBIT 2–2

Descriptive Variables for the Health of the Community

Demographic and social variables:

1. Age and sex distribution
2. Socioeconomic status
3. Family structure, including marital status and number of single-parent families
4. Racial, ethnic, and religious composition

Variables related to community infrastructure:

1. Availability of social and health services including hospitals and emergency rooms
2. Quality of housing stock including presence of lead-based paint and asbestos
3. Social stability (residential mobility)
4. Community policing
5. Employment opportunities

Health-related outcome variables:

1. Homicide and suicide rates
2. Infant mortality rate
3. Mortality from selected conditions (cause specific)
4. Scope of chronic and infectious diseases
5. Alcoholism and substance abuse rates
6. Teenage pregnancy rates
7. Occurrence of sexually transmitted diseases
8. Birth rate

Environmental variables:

1. Air pollution from stationary and mobile sources
2. Access to parks/recreational facilities
3. Availability of clean water
4. Availability of markets that supply healthful groceries
5. Number of liquor stores and fast-food outlets
6. Nutritional quality of foods and beverages vended to schoolchildren
7. Soil levels of radon

the relationship between the age and sex composition of the population and typical health problems. In a community that consists primarily of senior citizens (as in a retirement community), health problems related to aging would tend to predominate. Chronic diseases (e.g., cancer, heart disease, and stroke) increase in prevalence among the elderly. Because of the longer life expectancy of women, an older population would tend to have a majority of elderly women, who might have unique health needs such as screening and interventions for osteoporosis, risk of falling, and other conditions associated with aging.

In contrast, a younger community would also have a distinctive morbidity and mortality profile. If there are many young children and teenagers, health officials might be particularly concerned with providing immunizations against vaccine-preventable infectious diseases. Another topic would be the prevention of sexually transmitted diseases (e.g., HIV/AIDS) and health education programs for avoidance of substance use and smoking. Finally, attention would need to be directed to the control of unintentional injuries and deaths, which are the leading cause of mortality among younger persons, particularly young males.

Socioeconomic status (SES): SES, which comprises income level, educational attainment, and type of occupation, is a major determinant of the community's health. Often, persons who have inadequate income and employment opportunities lack health insurance and access to health care. By definition, an aspect of low SES is low education levels. Individuals who have low education levels in comparison with more highly educated persons may be less aware of dietary and exercise practices that promote good health. Service employment in comparison with professional occupations usually does not does not carry a full range of health benefits.

Racial, ethnic, and religious composition: The racial and ethnic composition of the community is related to its health profile. Some health outcomes are more common in one racial or ethnic group than in another, for example, sickle cell anemia among African Americans or diabetes mellitus among Latinos. Tay-Sachs disease tends to be more common among persons of Eastern European Jewish extraction than among other groups.

A community may demonstrate characteristic health patterns associated with members of a religious denomination if that group has settled in the community. Adherents of some religious denominations may adopt lifestyle and dietary practices that may affect the community health profile. For example, members of some religious groups may abstain from alcohol consumption and smoking or avoid certain foods that are high in saturated fats or increase cancer risks. Consequently, such communities would be expected to have lower frequencies of adverse health outcomes related to alcohol consumption, tobacco use, and diet. Thus, the health of the community may be determined to some extent by racial, ethnic, and religious factors.

Variables related to community infrastructure

Availability of health and social services: The socioeconomic characteristics of the community relate in part to the availability of health and social services and ability to pay for healthcare services. Wealthy communities, because of greater tax resources, have the capacity to provide a greater range of social and health-related services, which may be more up-to-date and conveniently located than in less affluent areas. Low-income residents may utilize, as their primary source of medical care, public health services, which may be overcrowded and inaccessible by public transportation. Often, when state and federal funding are curtailed, wealthy communities have the means to back fill lost revenue with local funding resources, whereas poorer locales do not have this option.

Quality of housing stock: Safe and clean housing is essential to the health of the community. The presence of toxic lead, dangerous asbestos, and vermin in older housing detract from the quality of housing stock and contribute to adverse health outcomes. The U.S. Census Bureau operates the American Housing Survey, which provides statistical information on the quality of housing in the United States.[6] **Figure 2–7** presents data for 2007 and 2009. In both years, slightly more than 5% of housing units were classified as inadequate and 23% as unhealthy, meaning that housing had rodent infestations, absence of smoke alarms, leaks, and peeling paint.

Social stability: Some of the newer communities, such as those in the Sunbelt of the southern United States, have highly mobile residents. The constant shifting of residents contributes to a sense of social instability, alienation, and lack of social connectedness. In turn, social pathology and adverse mental health problems may result. Less affluent urban communities of some parts of the United States have high unemployment levels that encourage out-migration of younger residents who are seeking better economic prospects, leaving behind a majority of older and indigent individuals.

Community policing programs reinforce social stability by reducing violent crime. Communities that form partnerships with the police force (e.g., through neighborhood watch programs) often are more successful at policing the community and maintaining lower crime rates than in communities where such partnerships do not exist.

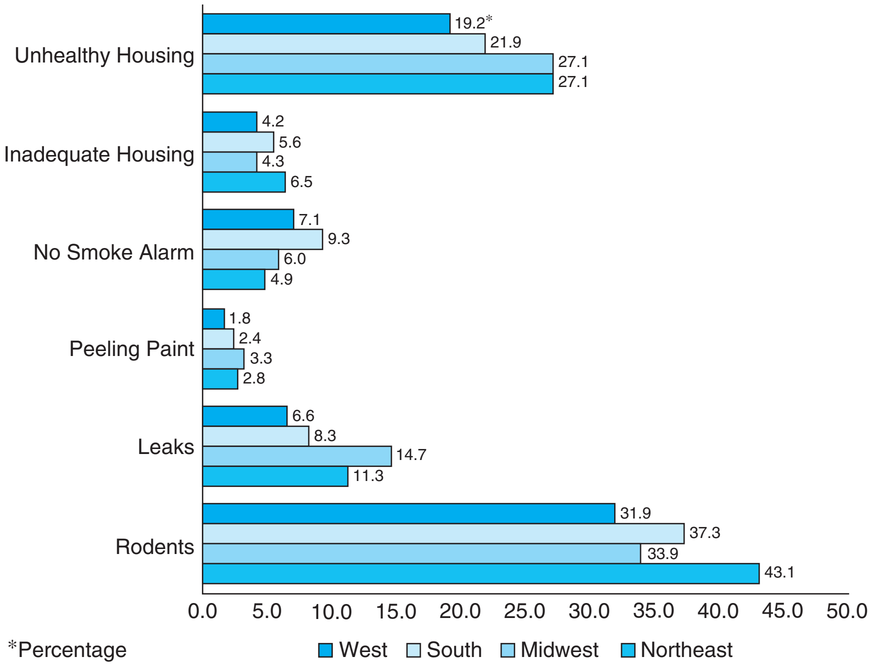


FIGURE 2–7 The quality of housing in the United States. *Source:* Data from Raymond J, Wheeler W, Brown MJ. Inadequate and Unhealthy Housing, 2007 and 2009. MMWR. 2011;60:22, 23, 25, 26.

Health-related outcome variables: Measures of health outcomes shown in the exhibit are a barometer of community health status and suggest needed social and health-related services.

- **Infant mortality rate**: An elevated infant mortality rate may reflect inadequate prenatal care, inadequate maternal diet, or a deficit of relevant social and health services.
- **Suicide rates**: Depression, social isolation, and alienation within the community may contribute to increased suicide rates and also elevated rates of alcoholism and substance abuse.
- **Chronic and infectious diseases**: Often, chronic conditions (e.g., obesity and type 2 diabetes) reflect poor dietary choices and the existence of "food deserts" in the community. A resurgence of preventable infectious diseases, such as measles and tuberculosis, may reflect the failure of immunization and community infectious disease surveillance programs.

- **Teenage pregnancy rates/sexually transmitted diseases**: Increases in the occurrence of pregnancies, births, and sexually transmitted diseases among teenagers within specific communities suggest the need for appropriate education and counseling services targeted to this age group.
- **Homicide rates**: High firearm death rates and homicide rates are indicators of the adverse conditions within the community. **Figure 2–8** portrays motor vehicle, homicide, and firearm death rates for the South Atlantic states (plus Washington, D.C.) in the United States during 2003. According to data reported for 2003, Washington, D.C., led all the other areas in mortality caused by assault and firearms, with age-adjusted death rates of 31.5 and 26.9, respectively, per 100,000 population.

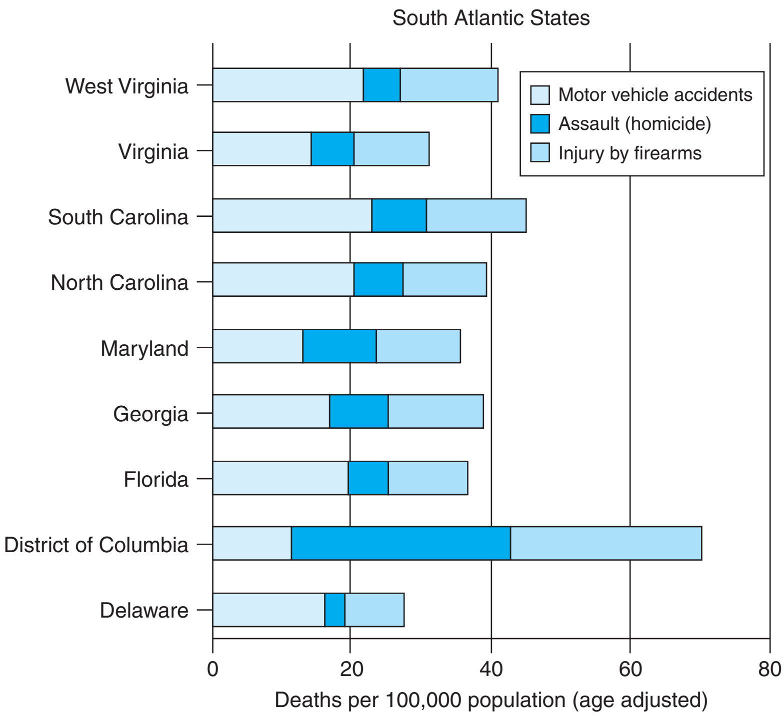


FIGURE 2–8 Motor vehicle, assault, and firearm injury death rates (age adjusted), South Atlantic States, United States, 2003. *Source:* Data from Hoyert DL, Heron MP, Murphy SL, Kung H. Deaths: Final data for 2003, National Vital Statistics Reports. Vol. 46, No 13, p. 5. Hyattsville, MD: National Center for Health Statistics, 2006.

Environmental variables

Numerous adverse environmental factors are implicated in the health of the community. Members of some economically disadvantaged communities have high levels of exposure to air pollution that emanate from diesel trucks and other vehicles on freeways that traverse the community. Other sources of air pollution include nearby industrial and power plants as well as port facilities where ships are off-loaded. Access to playgrounds and public parks may be limited as may be access to nutritious and healthful foods, particularly meals supplied to schoolchildren. In some communities, the dominant food source may be snacks from liquor stores, the fare sold by fast-food outlets, and sugar-laden beverages sold in vending machines. Some low socioeconomic status communities are overcrowded and more likely to have associated unsanitary conditions, which can be linked to ill-health and transmission of infectious diseases.

Health disparities

Using epidemiology to describe the health of the community relates to Goal 2, "Eliminate Health Disparities," of *Healthy People 2010*. Goal 2 strives ". . . to eliminate health disparities among segments of the population, including differences that occur by gender, race or ethnicity, education or income, disability, geographic location, or sexual orientation."[8(p 11)] A later document, *Healthy People 2020*, continues to express this goal. One of the four overarching goals of *Healthy People 2020* is to "[a]chieve health equity, eliminate disparities, and improve the health of all groups."[9]

Health disparities have been defined as, ". . . differences in health outcomes that are closely linked with social, economic, and environmental disadvantage."[10(p 1)] Six areas are the focus of the U.S. Department of Health and Human Services: infant mortality, cancer screening and management, cardiovascular disease, diabetes, human immunodeficiency virus infection/AIDS, and immunizations. In a 2011 report, the CDC noted that "increasingly, the research, policy, and public health practice literature report substantial disparities in life expectancy, morbidity, risk factors, and quality of life, as well does persistence of these disparities among segments of the population . . ." [11(p 3)] As the U.S. population ages and becomes more ethnically and socioeconomically diverse, health disparities are likely to increase in the future.

For example, consider infant mortality, which as noted previously is an indicator of the health of the community. While the infant mortality rate in the United States has trended downward, it is 27th (based on 2006 data) in comparison with other developed nations. Within the United States, African-American infants have approximately 2.45 times the mortality rate of white infants

(14.01 per 1,000 versus 6.85 per 1,000 in 2003).[12] When epidemiology is used to study the health of the community, this discipline can identify geographic areas that have elevated rates of infant mortality (as well as other adverse health conditions) and assist in identifying risk factors for these elevated rates.

Income inequality is one of the factors associated with health disparities. A common measure of income inequality is known as the Gini index, which is a number that ranges from 0 to 1. The closer the index is to one, the greater is the level of inequality. For example, a value of zero indicates total equality and a value of one total inequality. Income inequality is highest among advanced developed economies; in 2007 the Gini index for the United States was 0.46.[11] In order to portray the effects of income inequality, statisticians report associations between the Gini index and health outcomes such as inequality in the number of healthy days. **Figure 2–9** shows the state-specific index of inequality in the number of healthy days and the average number of healthy days in the United States for 2007. The lowest levels of health inequality and highest mean number of healthy days occurred in Utah, Connecticut, and North Dakota, the three states that had the lowest Gini scores. At the bottom of the list were Tennessee, Kentucky, and West Virginia, which had the three highest Gini scores and, consequently, the highest health inequality and lowest average number of healthy days.

Policy evaluation

Regarding the health of the community, epidemiology is not only a descriptive tool but also plays a role in policy evaluation. As Ibrahim has pointed out, "Health planning and policy formulation in the ideal sense should apply to total communities and employ a centralized process, which facilitates an overview of the whole rather than selected health problems."[13(p 4)] Samet and Lee wrote: "The findings of epidemiologic research figure prominently in nearly all aspects of developing policies to safeguard the public's health. Epidemiologic evidence receives consideration at the national and even global levels, while also directly and indirectly influencing individual decisions concerning lifestyle, work, and family."[14(p S1)]

Legislators and government officials are charged with the responsibility of enacting laws, enforcing them, and creating policies, many of which have substantial impacts on public health. Numerous examples that have occurred in distant and recent history come to mind, including fluoridation of water, helmet protection for motorcycle riders, mandatory seat belt use in motor vehicles, and requiring automobile manufacturers to install air bags in vehicles. Other examples of laws that impact health are shown in **Table 2–1**. The remainder of this section will advocate for an increasing role of epidemiologists in informing the policy-making process.

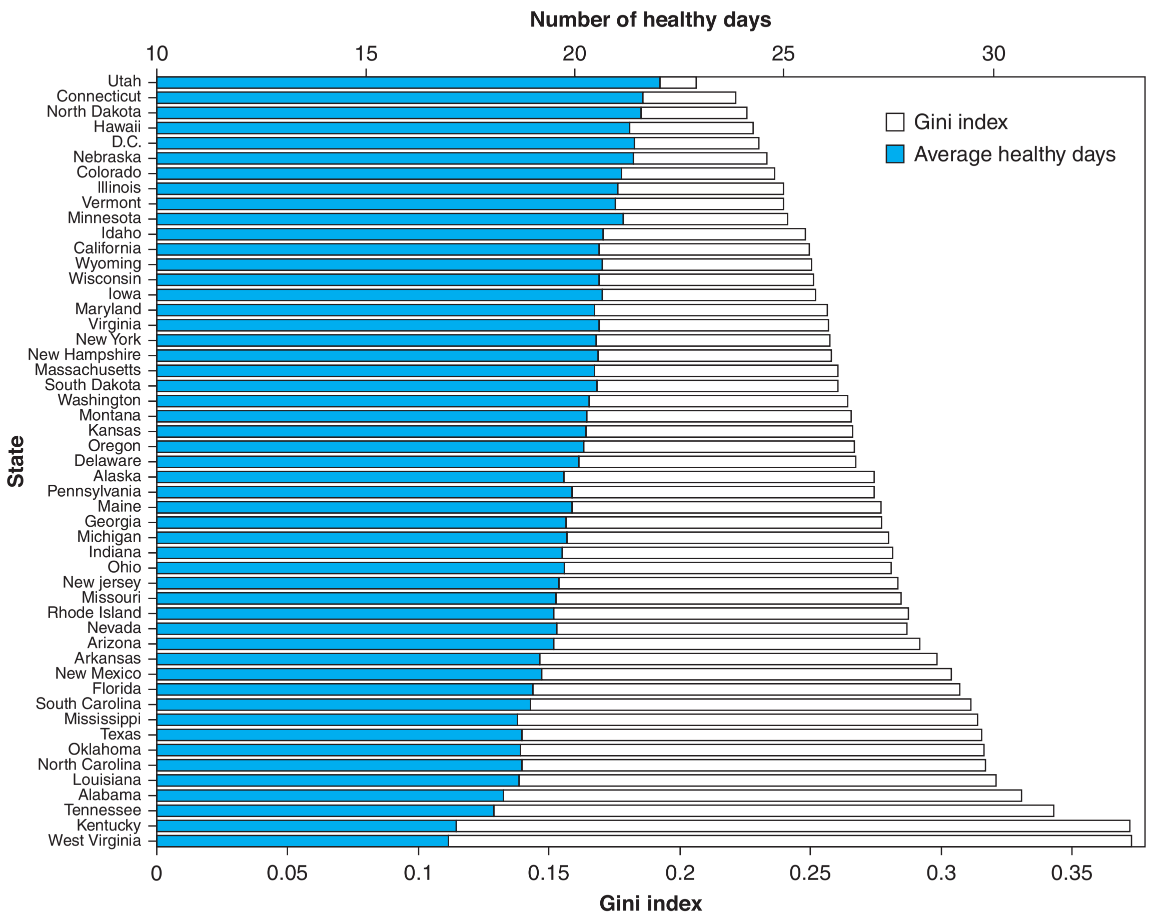


FIGURE 2–9 State-specific Gini index of inequality in number of healthy days and average number of healthy days–United States, 2007. *Source:* Reproduced from Centers for Disease and Control and Prevention. MMWR. 2011;60 (supplement):7.

Table 2–1 Examples of Laws and Ordinances That Affect Public Health

Tobacco control policies
- Smoke-free bar, restaurant, and worksite laws in the United States (as of 2012, 29 U.S. states ban smoking in restaurants and bars and 23 states ban smoking in restaurants and bars and nonhospitality worksites)
- Prohibition of smoking in commercial aircraft
- Prohibition of smoking in airports (United States, Germany, England, Spain, and other countries)
- Prohibition of smoking in shopping malls
- Prohibition of smoking in outdoor areas (e.g., public parks and beaches, outdoor stadiums)
- Prohibition of smoking in automobiles when children are present

Drug treatment systems for nonprescription drugs, such as cocaine and heroin

Needle distribution programs for prevention of needle sharing among intravenous drug users

Laws to regulate amount of particulate matter emitted from automobiles

Ban on plastic bags in some communities (or local ordinances that provide for recycling of plastic bags)

Removal of high fat and high sugar content foods from vending machines in schools

Printing nutritional information on restaurant menus

Prohibition of drivers' use of cells phones unless the devices are hands-free; texting generally not permitted

The question arises as to whether enacted policies merely satisfy public whim, appease well-meaning interest groups, or in fact do have an established scientific rationale and documented efficacy. The term evidence-based decisions, as applied to public health policies, implies the enactment of laws that have empirical support for their need as well as for their effectiveness.

Support for the involvement of epidemiologists in public health policy-making has been advocated strongly.[15] Epidemiologists have an important role to play in the development of evidence-based decisions because of their expertise in studying about risks associated with certain exposures and their familiarity with findings based on human subjects.[16] A clear illustration of epidemiologists' involvement in risk assessment arises in the determination of health effects associated with varying levels of exposure to potentially toxic agents in environmental health studies.

Further, in their traditional activities, epidemiologists participate in policy-making related to education, research, and publication of manuscripts.[15] Expertise in these areas can be applied readily to other policy arenas. Matanoski pointed out that ". . . epidemiologists can predict future risks based on current trends and knowledge of changing risk factors in the population. Planning for future needs and setting goals to meet these needs will require population-based thinking, for which epidemiologists are well trained."[16(p 541)]

The extremely complex issue of public health policy development encompasses five phases known as the policy cycle. These phases include examination of population health, assessment of potential interventions, alternative policy choices, policy implementation, and policy evaluation[17] (see **Figure 2–10** for a diagram of factors that influence policy decision-making). As you can see from Figure 2–10, an epidemiologist might be able to provide input into a number of phases of decision-making, for example, those phases that pertain to scientific fact (human health), interpretation of science, cost/benefit analysis, and risk assessment. Refer to the case study (**Exhibit 2–3**) in which we describe an applied epidemiologic study (conducted by Robert Friis and Julia Lee) to evaluate responses to the Smoke free Bars Law in California.

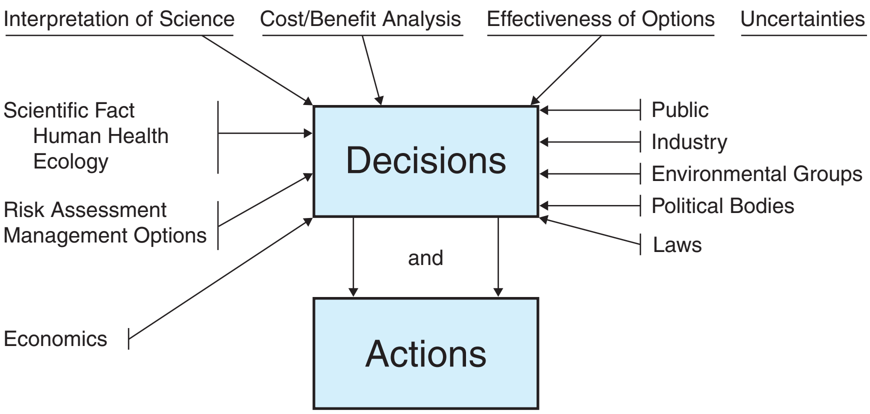


FIGURE 2–10 Factors influencing policy decision-making.
Source: Reproduced from Matanoski GM. Conflicts between two cultures: implications for epidemiologic researchers in communicating with policy-makers. Am J Epidemiol. 2001:154(Suppl 12):S37. Reprinted by permission of Oxford University Press.

EXHIBIT 2–3

Case Study: Using Epidemiologic Methods to Conduct a Policy Evaluation of the Smokefree Bars Law

This research project investigated a community's response to the California Smokefree Bars (SFB) Law, a change in tobacco control policy that was implemented as Assembly Bill (AB) 3037 on January 1, 1998. The SFB Law removed the exemption for bars, taverns, and lounges that had been included in AB 13, the 1995 Workplace Safety Law. AB13/3037 banned smoking in all bars throughout the state (with some exemptions for bars with no employees). For our epidemiologic research, the SFB Law was viewed as a natural experiment, with its scope and timing under the control of the California State Legislature.

continues

EXHIBIT 2–3 *continued*

Tobacco control policy in the form of laws and local ordinances is occurring with increasing frequency as part of the antitobacco efforts to reduce the deleterious first- and secondhand health effects of cigarette smoke. Evidence suggests that secondhand smoke has harmful health consequences from which customers and workers in alcohol-serving establishments need protection. These adverse effects include cancer, emphysema and other lung disorders, and heart disease. Policies to reduce exposure to secondhand smoke need to be investigated to understand their potential to effect health-related changes in population groups and to suggest recommendations regarding their efficacy.

Our policy analysis of the response to the SFB Law was conducted within Long Beach, which is the fifth-largest city (population, 460,000) in the state of California and the second largest in Los Angeles County, the county in which Long Beach is located. Noteworthy is the fact that Long Beach has a distinguished record of local tobacco control. In September 1994, Long Beach was one of 22 cities in the state recognized for protecting the health of its residents through strong tobacco control policies. The Long Beach Smoking Ordinance, enacted in 1991, prohibited smoking in all enclosed workplaces and public places. In 1993, the Long Beach City Council strengthened the ordinance by prohibiting smoking in all restaurants and restaurant/bar combinations. Additionally, Long Beach is one of the few cities in the state with its own health department, a key factor for the positive community response to both local and statewide tobacco control. Over the years, a very active Tobacco Education Program within the city's health department has worked closely with the city to educate the citizens regarding antitobacco concerns and also to implement various tobacco control policies.

In order to determine the response to the California SFB Law, we directed our efforts to gathering data from five different perspectives: bar personnel, residents, economic data from the restaurant business, compliance at the bars, and print media. The study was conducted over a 4-year period (July 1998–June 2002). Trained interviewers were sent to a sample of alcohol-serving establishments, such as restaurant bars and stand-alone bars.

Observations of compliance at Long Beach bars showed a continuing decrease in the proportion of bars with inside ashtrays; no restaurant bars

continues

EXHIBIT 2–3 ***continued***

in the sample had ashtrays during fall 2000 or spring 2001. Inside smoking increased only for stand-alone bars during fall 2000, and then decreased in spring 2001. No inside smoking was observed in any restaurant bars in either fall 2000 or spring 2001. Outside smoking continued to increase during the third year. The extent of the smell of smoke was significantly higher in stand-alone bars than in restaurant-bars, whether measured during daytime or early evening hours during fall 2000 and spring 2001. Based upon the odor of smoke, we concluded that compliance with the law was higher within restaurant-bars than stand-alone bars, although smoking continued in some restaurant-bars.

In year 1 (with a follow-up in year 3), a telephone survey of a cross-sectional sample of Long Beach residents was conducted with over 1,500 respondents. A key result was that approval for the SFB Law increased from 66% in year 1 to 73% in year 3. Other results demonstrated that 68% approved a ban on smoking on a nearby, wooden ocean pier; 75% approved of a cigarette tax to fund early childhood development programs; and 83% approved of smokefree zones in parks frequented by children. In conclusion, this case study demonstrated how epidemiologic methods (e.g., cross-sectional surveys and other analyses of population-based data) could be used in public health policy evaluation.

Supported by Grant 7RT-0185, University of California Tobacco-Related Disease Research Program.

Working of Health Services: Operations Research and Program Evaluation

The term *operations research* (operational research) is defined as "[t]he systematic study, by observations and experiment, of the working of a system (e.g., health services), with a view to improvement."[18] Epidemiology applied to operations research refers to the study of the placement of health services in a community and the optimum utilization of such services. "The usual epidemiologic approaches—descriptive, analytic, and experimental—are all used in health services research and, in addition, methods of evaluation have been expanded through their application to problems in health services."[19(p 140)] A major contribution of epidemiology to operations research is the development of research designs, analytic techniques, and measurement procedures. Operations research strives to answer the following kinds of questions, among others:

- What health services are not being supplied by an agency in the community?
- Is a particular health service unnecessarily duplicated in the community?
- What segments of the community are the primary utilizers of a service, and which segments are being underserved?
- What is the most efficient organizational and staff power configuration?
- What characteristics of the community, providers, and patients affect service delivery and outcome?
- What procedures could be used to assess, match, and refer patients to service facilities?

The perspective of operations research reveals the extent to which health services are harmonized. Coordination and integration of services helps to optimize use of available funds and services. Uncoordinated programs result in wasted resources, fragmentation, low efficiency, duplication, service gaps, lack of service continuity, and delays in securing services. Usually a single agency or program is unable to provide a full spectrum of needed health services, especially to individuals who are afflicted with severe health problems such as multiple sclerosis or mental disorders. One agency may specialize in diagnosis, evaluation, and treatment of the client's physical problems, whereas another may emphasize mental health issues. Because the mental and physical dimensions of the person are intertwined, the holistic medical concept argues that there should be greater coordination among various healthcare agencies that specialize in a particular component of health services. Operations research facilitates such coordination.

During the 1970s, Robert Friis directed a project to improve the coordination of health services to severely developmentally disabled children in the Bronx, New York. Some of the goals of the project were to identify unmet needs for services, to identify overlapping services, and to assist the referral of clients from one agency to another. In brief, for every severely developmentally disabled youngster in the Bronx (individuals with an IQ lower than 50) who was under the age of 21, the following representative items of information were collected:

- the facility from which medical treatment or follow-up was received
- drugs or medications that the person received
- diagnostic tests received in the past
- enrollment in educational, recreational, and other specified programs
- specific conditions and disabilities presented

The project aimed to quantify the characteristics of service utilization. Examples were clients' diagnoses, the number of separate agencies that each client visited, and the types of medical and other services. By linking these types of information, the project would inform health about the numbers and kinds of services needed in the community and make projections for funding of health services. Although this description is a simplification of the goals of the project, it illustrates how the epidemiologic approach may be utilized for operations research purposes.

Two additional examples of the application of epidemiologic methods to operations research are quantification of methods of payment of healthcare services and description of the residents of residential care facilities. The National Ambulatory Medical Care Survey (NAMCS) is a "survey of the private office-based, non-Federal physicians practicing in the United States."[20(p 1)] **Figure 2–11** (part A) presents NAMCS data for the percent distribution of office visits by primary expected source of payment (e.g., Medicare, Medicaid, private medical insurance, and self-pay) according to patient's age. Among persons aged 18–64 years, more than 60% were funded by private medical insurance; the majority of persons aged 65 years and older were funded by Medicare.

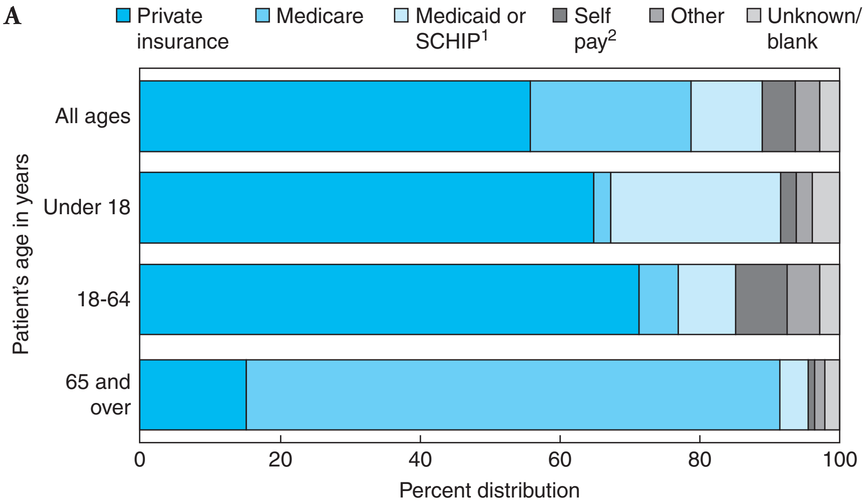
Figure 2–11 (part B) shows the age and sex of residents of residential care facilities. The majority of residents were non-Hispanic whites, females, and persons aged 85 years and older. Quantitative information such as the characteristics of residential care patients and the method of payment for medical care contributes to improvement of access to health care in the United States.

The foregoing examples illustrate the role of epidemiology in evaluation of healthcare utilization and needs assessment. A related application is program evaluation. Specifically, how well does a health program meet certain stated goals? To illustrate, if the goal of a national health insurance program is to provide equal access to health services, an evaluation of the program should include utilization by socioeconomic status variables. The program would be on target if the analysis revealed little discrepancy in service utilization by social class. Epidemiologic methods may be employed to answer this question by providing the following methodologic input:

- methods for selecting target populations to be included in the evaluation
- design of instruments for data collection
- delimitation of types of health-related data to collect
- methods for assessment of healthcare needs

Evaluation of a clinic program or other health service can make use of epidemiologic tools. An example of an issue to include in the evaluation is the extent

A



[1]SCHIP is State Children's Health Insurance Program.
[2]Includes no charge or charity.

B

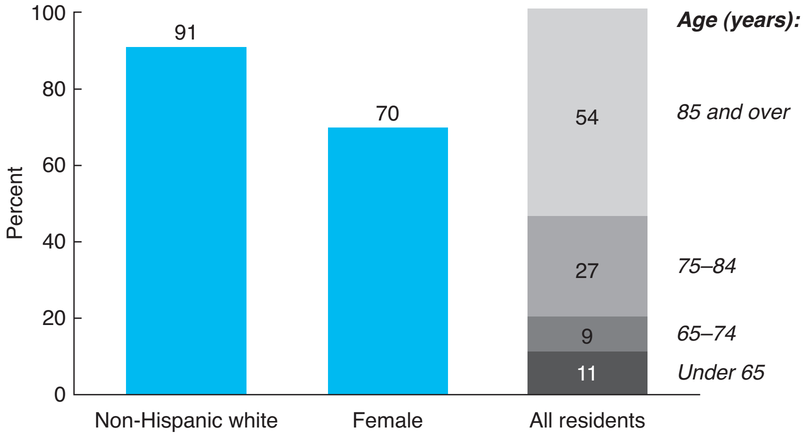


FIGURE 2–11 (A) Percent distribution of office visits by primary expected source of payment according to patient's age: United States, 2003; (B) Selected characteristics of residential care residents: United States, 2010. *Sources:* (A) Data from Hing E, Cherry DK, Woodwell DA. National Ambulatory Medical Care Survey: 2003 Summary. Advance data from Vital and Health Statistics: No. 385. Hyattsville, Maryland: National Center for Health Statistics, 2005. (B) Data from Caffrey C, Sengupta M, Park-Lee E, et al. Residents Living in Residential Care Facilities: United States, 2010. NCHS Data Brief. 2012;No. 91:1.

to which a program reaches minority individuals or socially and economically disadvantaged persons, the aged, or other targeted groups. An evaluation also might address the issue of changes or improvements in the overall health status of a target population. Other epidemiologic evaluations have studied patient satisfaction with medical care.

Demographic and socioeconomic indices may be employed in the epidemiologic evaluation of utilization of surgical operations. An example is the use of surgical interventions for benign prostatic hyperplasia (BHP), a common clinical diagnosis that is costly for the healthcare system.[21] BHP causes weak urine flow, urgency, and other urinary tract symptoms among some older men. Data from the Southern Community Cohort Study (n = 21,949 men) demonstrated that the diagnosis of BHP was twice as common among Caucasian men as among African-American men (4.1% versus 9.9%, respectively). However, surgery for persons who reported a BHP diagnosis was more prevalent among African-American men than among Caucasian men (12.9% versus 9.1%, respectively). Among study participants who had lower income, diagnosis with BHP was less common than among individuals with higher income. In summary, the researchers found that race and socioeconomic status were independently linked with BHP.

Another example of this use of epidemiology is in the evaluation of minority populations' access to health insurance coverage. In an analysis of epidemiologic data from the Hispanic Health and Nutrition Examination Survey, 1982–1984, researchers examined the percentages of health insurance coverage among three major subpopulations (Mexican, Puerto Rican, and Cuban) of adult Latinas. The findings demonstrated that Mexican-origin women had the lowest level of any health insurance coverage, about 64% in comparison to the two other groups (about 74% and 81%, respectively). The disparity was even more pronounced for older women, particularly those between 50 and 64 years of age.[22] A more recent study based on data from the Third National Health and Nutrition Examination Survey found that lack of health insurance at the time of interview was associated with 40% greater risk of death during follow-up.[23]

Applications Relevant to Disease Etiology

The second group of applications encompasses uses of epidemiology that are connected with disease etiology (e.g., determining the *causes* of infectious and chronic diseases such as tuberculosis and cancer as well as preventing them).

Under this general area, Morris[1] noted the search for causes, individual risks, and specific clinical concerns. (See Figure 2–1.)

Causality in Epidemiologic Research

As an observational science, epidemiology is frequently subject to criticism. The prestigious journal *Science* ran a special news report entitled, "Epidemiology Faces Its Limits."[24] The subtitle read: "The Search for Subtle Links between Diet, Life Style, or Environmental Factors and Disease Is an Unending Source of Fear—but Often Yields Little Certainty." A portion of the report follows:

> The news about health risks comes thick and fast these days, and it seems almost constitutionally contradictory. In January of last year [1994], for instance, a Swedish study found a significant association between residential radon exposure and lung cancer. A Canadian study did not. Three months later, it was pesticide residues. *The Journal of the National Cancer Institute* published a study in April reporting—contrary to previous, less powerful studies—that the presence of DDT metabolites in the bloodstream seemed to have no effect on the risk of breast cancer. In October, it was abortions and breast cancer. Maybe yes. Maybe no. In January of this year it was electromagnetic fields (EMF) from power lines . . .

These are not isolated examples of the conflicting nature of epidemiologic studies; they are just a few to hit the newspapers. Over the years, such studies have come up with a mind-numbing array of potential disease-causing agents, from hair dyes (lymphomas, myelomas, and leukemia), to coffee (pancreatic cancer and heart disease), to oral contraceptives and other hormone treatments (virtually every disorder known to women). The pendulum swings back and forth, subjecting the public to an "epidemic of anxiety," as Lewis Thomas wrote many years ago. Indeed, the *New England Journal of Medicine* published an editorial by editors Marcia Angell and Jerome Kassirer asking the pithy question, "What Should the Public Believe?" "Health-conscious Americans," they wrote, "increasingly find themselves beset by contradictory advice. No sooner do they learn the results of one research study than they hear of one with the opposite message."[24]

Part of the reason for the skepticism about epidemiologic research is the inability of the discipline to "prove" anything. The contributions of Koch are considered by some as a basis for this skepticism. His postulates, first developed by Henle, adapted in 1877, and further elaborated in 1882, also are referred to as the Henle–Koch postulates. They were instrumental in efforts to prove (or disprove) the causative involvement of a microorganism in the pathogenesis of an infectious disease. The postulates specified that the agent must be present in every case of the disease, must be isolated and grown in pure culture, must reproduce the disease when reintroduced into a healthy susceptible animal, and must be recovered and grown again in a pure culture. In addition, the agent should occur in no other disease: the one agent–one disease criterion. This classical Henle–Koch concept of causality, sometimes referred to as pure determinism, becomes problematic when one attempts to apply it to the chronic diseases prevalent in modern eras. Let us examine separately three of the four criteria that form part of Koch's concept of causality:

1. Agent present in every case of the disease. How well would this criterion apply to cardiovascular disease (CVD)? Decades of research have established that individuals who develop CVD tend to be overweight, physically inactive, cigarette smokers, and have high blood pressure and high total cholesterol. If we were to apply Koch's postulates strictly, then every case of CVD would have all these characteristics. Clearly not true.
2. One agent–one disease. How would this criterion hold up against cigarette smoking? We just pointed out that smokers are more likely to develop CVD than nonsmokers. Is CVD the only disease associated with smoking? No. In fact, smoking is associated with lung cancer, pancreatic cancer, oral cancer, nasopharyngeal cancer, cervical cancer, emphysema, chronic obstructive pulmonary disease, and stroke, to name just a few. Therefore, the one agent–one disease criterion is not particularly helpful, especially for diseases of noninfectious origin.
3. Exposure of healthy subjects to suspected agents. The ethical conduct of research on humans forbids exposure of subjects to risks that exceed potential benefits. Would it be reasonable to suspect the smoking–lung cancer association even if such an experiment was never conducted? As pointed out in the introduction to this chapter, there are simply some exposures that cannot be evaluated in the context of controlled experimental studies. Epidemiology must be relied upon to provide such information.

In addition to the three issues just discussed that are direct tests of Koch's postulates, there are others that must be considered. It is relatively straightforward to categorize individuals with respect to the presence or absence of an exposure when the exposure is an infectious agent; one is either exposed or not exposed. However, even this simplification ignores the complicating issue of biologically effective dose. What about something such as blood pressure? Individuals with "elevated" blood pressure are more likely to develop a stroke than individuals with "low" blood pressure. Where does one draw the line between elevated and normal (or low)? At what level should an individual be considered obese?

A more subtle concept to consider is the fact that, for diseases of unknown etiology, we are dealing with imperfect knowledge. For example, although we may know that smokers are 20 times more likely to develop lung cancer than nonsmokers, why is it that not all smokers develop the disease? There must be other factors (e.g., diet, alcohol intake, and host susceptibility) that are part of the total picture of causality. When not all the contributing factors are known, it is problematic indeed to know truly and accurately the complete cause of a given disease. The issue of causality and epidemiology has been the focus of debate for decades. Some of the early writings are still fascinating and relevant today. For example, refer to *Causal Thinking in the Health Sciences* by Mervyn Susser.[25] The work *Eras in Epidemiology* by Susser and coauthor Zena Stein presents information on the historical evolution of epidemiologic ideas.[26] This book illustrates how epidemiology relies on and contributes to carefully formulated concepts of cause whether derived experimentally or observationally in the laboratory or general environment, both physical and social.

To summarize, the doctrine of multiple causality (instead of single causal agents) is now accepted widely; current research indicates that a framework of multiple causes for chronic diseases such as heart disease, cancer, and diabetes mellitus is appropriate. Noted epidemiologist the late John Cassel was an articulate proponent of multifactorial causality for contemporary diseases. In the fourth Wade Hampton Frost Lecture, Cassel noted that early theories stated "disease occurred as a result of new exposure to a pathogenic agent." The single agent causal model was extended to "the well-known triad of host, agent and environment in epidemiologic thinking."[27(pp 107–108)] The formulation was satisfactory to explain diseases of importance during the late 19th and early 20th centuries, when agents of overwhelming pathogenicity and virulence produced conditions such as typhoid and smallpox. Cassel suggested that the triad of agent, host, and environment is no longer satisfactory because, "In a modern society the majority of citizens are protected from these overwhelming agents and most of the agents associated with current diseases are ubiquitous in our environment . . . [There may be] categories or classes of environmental factors that are capable of changing human resistance in important ways." One group of factors, Cassel argued, was the social environment ("presence of other members of the same species"), which might be capable of profoundly influencing host susceptibility to environmental disease agents, whether they are microbiologic or physiochemical.[27]

Risk Factors Defined

Because of the uncertainty of "causal" factors in epidemiologic research, it is customary to refer to an exposure that is associated with a disease as a *risk factor*. There are three requisite criteria for risk factors:

1. The frequency of the disease varies by category or value of the factor. Consider cigarette smoking and lung cancer. Light smokers are more likely to develop lung cancer than nonsmokers, and heavy smokers are more likely still to develop the disease.
2. The risk factor must precede the onset of disease. This criterion, known as temporality, applies to the smoking–lung cancer example. We now know that smoking causes lung cancer. Nevertheless, hypothetically speaking, if individuals with lung cancer began to smoke after the onset of disease, smoking would not be a likely cause of their condition. The issue of the temporal relationship between exposure and disease is particularly relevant to chronic diseases such as cancer. Epidemiologists may not be able to determine when exposure occurred in relationship to onset of the disease.
3. The observed association must not be due to any source of error. In illustration, researchers could introduce methodological errors at any of several points during an epidemiologic investigation. These errors might occur in the selection of study groups, measurement of exposure and disease, and data analysis.

Modern Concepts of Causality

The 1964 Surgeon General's Report

Causal inferences derived from epidemiologic research (especially in the realm of noninfectious diseases) gained increasing popularity as a topic of formal discussion as a result of findings (in the early 1950s) regarding the association between smoking and lung cancer.[28] The publication of *Smoking and Health, Report of the Advisory Committee to the Surgeon General of the Public Health Service* listed five criteria for the judgment of the causal significance of an association[29] and, based on these criteria, concluded that smoking was a cause of lung cancer among men. (**Exhibit 2–4** provides a description of the report.) These criteria were addressed subsequently in other writings by Susser,[30] Rothman,[7] and Hill.[31]

EXHIBIT 2–4

Case Study: Does Smoking Cause Lung Cancer?

The first Surgeon General's report on smoking and health was published in 1964. This report generated global reaction by stating that cigarette smoking is a cause of lung cancer in men and is linked to other disabling or fatal diseases. Five criteria were identified as necessary for the establishment of a causal relationship between smoking and lung cancer. The report's authors concluded that, to judge the causal significance of the association between cigarette smoking and lung cancer, several of these criteria would have to be taken into account in combination and no single criterion would, in itself, be "pathognomonic" (pathognomonic means characteristic or diagnostic). The criteria of judgment were strength of association, time sequence, consistency of relationship upon repetition, specificity of association, and coherence of explanation.

1. Strength of association: The report stated that the relative risk ratio is the most direct measure of the strength of association between smoking and lung cancer; several retrospective and prospective studies completed up to the time of the report demonstrated high relative risks for lung cancer among smokers and nonsmokers. Thus, it was concluded that the criterion of strength of association was supported.
2. Time sequence: The report argued that early exposure to tobacco smoke and late manifestation seems to meet the criterion of time sequence, at least superficially.
3. Consistency upon repetition: With regard to the causal relationship between smoking and health, the report asserted that this criterion was strongly confirmed for the relationship between smoking and lung cancer. Numerous retrospective and prospective studies demonstrated highly significant associations between smoking and lung cancer; it is unlikely that these findings would be obtained unless the associations were causal or else due to unknown factors.

continues

EXHIBIT 2–3 *continued*

4. Specificity: The hypothesis that smoking causes lung cancer has been attacked because of the lack of specificity of the relationship; smoking has been linked to a wide range of conditions, including cardiovascular disease (CVD), low birth weight, and bladder cancer. The report claimed, however, that rarely in the biologic realm does an agent always predict the occurrence of a disease; in addition, accumulating evidence about chronic diseases suggests that a given disease may have multiple causes.
5. Coherence of explanation: The report contended that the association between cigarette smoking and lung cancer was supported for this criterion. Evidence noted included the rise in lung cancer mortality with increases in per capita consumption of cigarettes and increases in lung cancer mortality as a function of age cohort patterns of smoking among men and women; the sex differential in mortality was consistent with sex differences in tobacco use. General smoking rates were higher among men than among women; the report noted that young women were increasing their rates of smoking, however. ■

Source: Data from U.S. Department of Health, Education and Welfare, Public Health Service. Smoking and Health, Report of the Advisory Committee to the Surgeon General of the Public Health Service. Public Health Service publication 1103. Washington, DC: Government Printing Office; 1964.

Sir Austin Bradford Hill

In 1965 Sir Austin Bradford Hill, Professor Emeritus of Medical Statistics at the University of London, published one of the seminal articles that elaborated on the five criteria for causality in epidemiologic research.[31] The article, which was his President's Address to the Section of Occupational Medicine of the Royal Society of Medicine, lists nine aspects of an empirical association to consider when one is trying to decide whether the association is consistent with cause and effect. Refer to **Table 2–2**. These were not intended to be interpreted as criteria of causality, but nonetheless they have been presented as such in several textbooks. The following is a quotation from his article:

> I have no wish, nor the skill, to embark upon a philosophical discussion of the meaning of "causation." The "cause" of illness may be immediate and direct, it

Table 2–2 Aspects of an Association That Suggest Causality

1. Strength	2. Consistency
3. Specificity	4. Temporality
5. Biological gradient	6. Plausibility
7. Coherence	8. Experiment
9. Analogy	

Source: Data from Hill AB. The environment and disease: association or causation? *Proceedings of the Royal Society of Medicine*. 1965; 58:295–300.

> may be remote and indirect, underlying the observed association. But with the aims of occupational, and almost synonymously preventive, medicine in mind, the decisive question is whether the frequency of the undesirable event B will be influenced by a change in the environmental feature A. [31(p 295)]

Further elaborating on his statement, Hill asserted that in some instances much research would be required to determine the existence of a causal association. In other cases, a smaller body of information would be adequate. Thus, making causal inferences depends upon the circumstances of an association. Hill's landmark article identified nine issues that are relevant to causality and epidemiologic research. (Refer to Table 2–2.)

1. Strength of association. One example cited by Hill was the observation of Percival Pott that chimney sweeps in comparison to other workers had an enormous increase in scrotal cancer; the mortality was more than 200 times that of workers not exposed to tar and mineral oils. A strong association is less likely to be the result of errors.
2. Consistency upon repetition. This term refers to whether the association between agent and putative health effects has been observed by different persons in different places, circumstances, and times. The Surgeon General's report of 1964 cited a total of 36 different studies that found an association between smoking and lung cancer.[29] Hill felt that consistency was especially important when the exposure was rare.
3. Specificity. With respect to occupational exposures, Hill noted that if "the association is limited to specific workers and to particular sites and types of disease and there is no association between the work and other modes of dying, then clearly that is a strong argument in favor of causation."[31(p 297)] He later went on to acknowledge that the criterion of specificity should be used as evidence in favor of causality; however, if evidence of a specific association cannot be obtained, this fact is not necessarily a refutation of a causal association.

4. Time sequence. In Hill's words, "Which is the cart and which is the horse?" For example, if one is trying to identify the role of diet in the pathogenesis of colon cancer, one has to be careful to sort out dietary preferences that lead to colon cancer versus dietary changes that result from early stages of the disease. There is some evidence that low intakes of calcium are associated with increased risk of colon cancer. If early stages of disease create problems with digestion of milk products (which are good sources of calcium), individuals may lower their intake of milk (and calcium) as a consequence of the disease. The shorter the duration between exposure to an agent and development of the disease (i.e., the latency period), the more certain one is regarding the hypothesized cause of the disease. For this reason, many of the acute infectious diseases or chemical poisonings are relatively easy to pinpoint as to cause. Diseases having longer latency periods (many forms of cancer, for example) are more difficult to relate to a causal agent; it is said that the onset of chronic diseases is insidious and that one is ignorant of the precise induction periods for chronic diseases. Many different causal factors could intervene during the latency period. This is why a great deal of detective work was needed to link early exposure to asbestos in shipyards to subsequent development of mesothelioma, a form of cancer of the lining of the abdominal cavity.
5. Biologic gradient. Evidence of a dose–response curve is another important criterion. Hill notes, "the fact that the death rate from lung cancer increases linearly with the number of cigarettes smoked daily adds a great deal to the simpler evidence that cigarette smokers have a higher death rate than non-smokers."[31(p 298)] MacMahon and Pugh state, "the existence of a dose-response relationship—that is, an increase in disease risk with increase in the amount of exposure—supports the view that an association is a causal one."[3(p 235)] **Figure 2–12** illustrates a dose–response relationship between number of cigarettes smoked per day and lung cancer mortality among male British physicians.
6. Plausibility. If an association is biologically plausible, it is credible on the basis of existing biomedical knowledge.[18] The weakness of this line of evidence is that it is necessarily dependent upon the biologic knowledge of the day.
7. Coherence of explanation. The association must not seriously conflict with what is already known about the natural history and biology of the disease. Data from laboratory experiments on animals may be most helpful. For example, the ability of tobacco extracts to cause skin cancer in

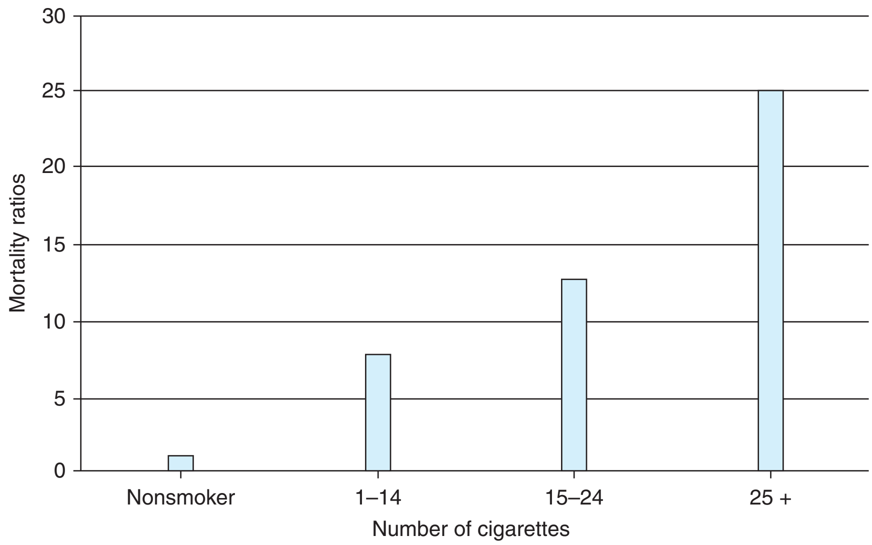


FIGURE 2–12 Dose–response relationships between smoking and lung cancer mortality among British physicians. *Source:* Data from R Doll, R Peto. Mortality in Relation to Smoking: 20 Year's Observation on Male British Doctors. British Medical Journal, vol 2 (6051), pp 1525–1536, BMJ Publishing Group, © 1976.

mice is coherent with the theory that consumption of tobacco products in humans causes lung cancer.

8. Experiment. In some instances there may be "natural experiments" that shed important light on a topic. The observation that communities with naturally fluoridated water had fewer dental caries among their citizens than communities without fluoridated water is one example.
9. Analogy. The examples Hill cites are thalidomide and rubella. Thalidomide, administered in the early 1960s as an antinausea drug for use during pregnancy, was associated subsequently with severe birth defects. Rubella (German measles), if contracted during pregnancy, has been linked to birth defects, stillbirths, and miscarriages. Given that such associations have already been demonstrated, "we would surely be ready to accept slighter but similar evidence with another drug or another viral disease in pregnancy."[31(p 299)]

Although it is not critical that all these lines of evidence be substantiated to uphold a causal association, the more that are supported, the more the case of causality is strengthened. More important, careful consideration of these concepts is helpful in trying to decide at what point one needs to take action. One of Hill's concluding remarks was particularly apropos: "All scientific work is incomplete, whether it be observational or experimental. All scientific work is liable to be upset or modified by advancing knowledge. That does not confer upon us a freedom to ignore the knowledge we already have, or to postpone the action that it appears to demand at a given time."[31(p 300)] Evans,[32] in a compelling discussion of causality, drew an analogy between ascertainment of causality and establishment of guilt in a criminal trial. Evans' detailed arguments are found in **Exhibit 2–5**.

Frequently, the processes of causal inference and statistical inference overlap yet represent different principles. According to Susser, "Formal statistical tests are framed to give mathematical answers to structured questions leading to judgments, whereas in any field practitioners must give answers to unstructured questions leading from judgment to decision and implementation."[30(p 1)]

Study of Risks to Individuals

In many instances, epidemiologic research on disease etiology involves collection of data on a number of individual members of different study groups or study populations. Epidemiologists use two main types of observational studies for research on disease etiology: case-control and cohort studies. A case-control design compares a group of individuals who have a disease of interest (the cases) with a group who does not have the disease (the controls). The two groups are compared with respect to a variety of hypothesized exposures (e.g., diet, exercise habits, or use of sunscreens). Differences in exposure that are observed between the two groups may suggest why one group has the disease and the other does not. Another research method is the cohort study. In this approach, a study group free from disease is assembled and measured with respect to a variety of exposures that are hypothesized to increase (or decrease) the chance of getting the disease. One then follows the group over time for the development of disease, comparing the frequency with which disease develops in the group exposed to the factor and the group not exposed to the factor. Either type of study may demonstrate that a disease or other outcome is more likely to occur in those with a particular exposure.

The issue of whether the results of an epidemiologic study influence clinical decision-making is in part determined by the criteria of causality covered in the previous section. How large is the effect? How consistent is the finding with previous research? Is there biologic plausibility? All these issues are important,

EXHIBIT 2–5

Rules of Evidence: Criminality and Causality

Mayhem or murder and criminal law	Morbidity, mortality, and causality
1. Criminal present at scene of crime.	1. Agent present in lesion of the disease.
2. Premeditation.	2. Causal events precede onset of disease.
3. Accessories involved in the crime.	3. Cofactors and/or multiple causalities involved.
4. Severity or death related to state of victim.	4. Susceptibility and host response determine severity.
5. Motivation: The crime must make sense in terms of gain to the criminal.	5. The role of the agent in the disease must make biologic and common sense.
6. No other suspect could have committed.	6. No other agent could have caused the disease under the circumstances given.
7. The proof of the guilt must be established beyond a reasonable doubt.	7. The proof of causation must be established beyond reasonable doubt or role of chance.

In criminal law, the presence of the criminal at the scene of the crime would be equivalent to the presence of the agent in a lesion of the disease. Premeditation would be similar to the requirement that the causal exposure should precede the onset of the disease. The presence of accessories at the scene of the crime might be compared to the presence of cofactors and/or multiple causes for human diseases. The severity of the crime or the consequence of death might be loosely equivalent to susceptibility and the host responses, which determine the severity of the illness. The motivation involved in a crime should make sense in terms of reward to the criminal, just as the role of the causal agent should make biologic sense. The absence of other suspects and their elimination in a criminal trial would be similar to that of the exclusion of other putative causes in human illness. Finally, need that the proof of guilt must be established beyond a reasonable doubt would be true for both criminal justice and for disease causation.

Source: Adapted from Evans AS. Causation and disease: A chronological journey, *American Journal of Epidemiology*, 108(4):254–255; with permission of the Johns Hopkins University, School of Hygiene and Public Health. © 1978.

but a major issue for the clinician is the relevance to each particular patient. Epidemiologic studies employ groups of individuals; the studies provide evidence that groups with particular exposures or lifestyle characteristics are more or less likely to develop disease than groups of individuals without the exposures. Extrapolation to the individual from findings based on observations of groups should be made with caution. The observation that cigarette smokers are 20 times more likely to develop lung cancer than nonsmokers does not necessarily entitle someone to tell a smoker, "You are 20 times more likely to get lung cancer than a nonsmoker." The problem is that there are a number of other factors that may be important contributors to the cause of lung cancer. A more accurate statement would be, "Collectively, groups of individuals who smoke are 20 times more likely to develop lung cancer than nonsmokers." The difference is subtle, yet important.

Another issue for the clinician is the size of the risk; an example is the slight risk of mortality from CVD associated with a high serum cholesterol level. If the risk is small, a person may reasonably not wish to change his or her lifestyle.[33] The 1990 editorial in the *New England Journal of Medicine* is particularly illustrative.[2] Suppose that the 10-year risk of death is 1.7% in middle-aged men with cholesterol levels below 200 mg/dL but 4.9% if the cholesterol level is above 240 mg/dL.[34] This difference in risk of approximately 3.0% may not be sufficient to induce an otherwise healthy man to try to lower his cholesterol level. Conversely, even if the risk factor is strong, it may still be unimportant to individual patients if the disease is rare.

Thus, the extrapolation of epidemiologic research to individuals is complicated. Another aspect of risk concerns public health implications. A risk factor that may be relatively unimportant for individuals may be important indeed when the effect is multiplied over the population as a whole, especially if the disease is common.

Another example of this application of epidemiology is predicting the individual's prognosis and likelihood of survival if afflicted by a serious medical condition. Clinicians can use such information to aid the patient in decision-making about whether to undergo invasive surgical procedures or debilitating treatments for cancer. Information about prognosis helps demonstrate the efficacy of medical interventions (e.g., coronary bypass surgery) by showing whether the practice yields an increase in long-term survival for the population. Some additional illustrations of the use of epidemiology to study risks to the individual are making predictions of mortality from cancer and other serious chronic illnesses and developing assessments of morbidity and mortality from infectious diseases.

Epidemiologic research indicates that there is an important contribution to mortality from common infectious diseases, such as influenza and colds. Sometimes mortality results from complications that can occur in high risk groups such as neonates, elderly persons, and immunocompromised individuals. Without population-based data, mortality from these "minor" diseases might not be obvious. In 2008, influenza was responsible for 0.6 deaths per 100,000 individuals in the United States.[12]

Epidemiologic data may be used to predict cancer prognosis and mortality. Both vary by site of the tumor, type, and a number of social variables, such as socioeconomic status, race, and sex. **Figure 2–13** presents the 5-year relative survival rate for selected forms of cancer by race from 2002 to 2008. Differences in survival are evident by both cancer type and race. Among African-Americans in comparison with whites, the 5-year survival rates for all cancer sites were 59.9% and 68.9%, respectively. Survival rates for cancer of the pancreas and lung (6.0% and 16.9%, respectively) were lower than the rates for prostate cancer (99.9%) and breast cancer (90.2%) [35]

Another illustration of the study of risks to the individual involves prognosis of survival from coronary bypass surgery. The Veterans Administration Cooperative Study[36] traced the survival of 596 patients treated by medication or by surgery

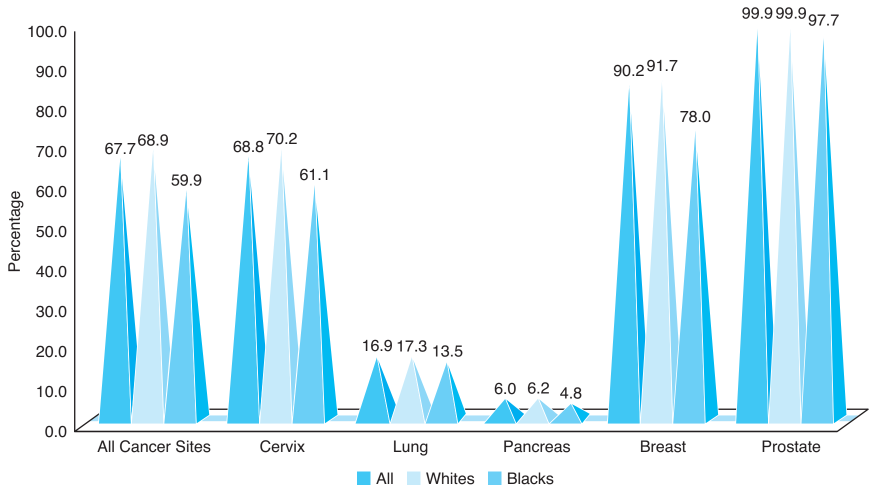


FIGURE 2–13 Five-year relative and period survival (%) from invasive cancer by race and sex in the United States, 2002–2008. *Source:* Data from Howlander N, Noone AM, Krapcho, et al. SEER Cancer Statistics Review, 1975–2009 (Vintage 2009 Populations), National Cancer Institute. Bethesda, MD, updated April 30, 2012.

for chronic stable angina in a large-scale prospective, randomized study. Findings indicated no differences in survival at 21 and 36 months between surgery patients and medically treated patients. Thus, the factors of mortality from surgery itself and expense of the operation need to be weighed against increases in life expectancy and improvement in the quality of life due to improved arterial circulation. This is an epidemiologic question that may be raised about risks associated with other types of surgical procedures as well.

Enlargement of the Clinical Picture of Disease

When a new disease first gains the attention of health authorities, usually the most dramatic cases are the ones observed initially. One may conclude incorrectly that the new disease is an extremely acute or fatal condition; later epidemiologic studies may reveal that the most common form of the new disease is a mild, subclinical illness that occurs widely in the population. To develop a full clinical picture of the disease, thorough studies are necessary to find out about the subacute cases; an adequate study may require a survey of a complete population.

One example of this use of epidemiology was the investigation of the 1976 Legionnaires' disease outbreak, which at first seemed to be a highly virulent and new condition. The outbreak of a mysterious illness that ravaged participants at the American Legion's July 1976 convention in Philadelphia riveted public attention. Concerned officials appealed to local and federal epidemiologists to investigate the outbreak. Disease detectives ascertained that Legionnaires' disease was associated with a previously unidentified bacterium, *Legionella pneumophila*. Although the Philadelphia outbreak suggested initially that Legionnaires' disease was highly fatal, subsequent research found a much lower case fatality rate; about 15% of the people who developed the disease died from it. The previously unrecognized disease had probably occurred sporadically in other areas of the country before 1976.

Prevention of Disease

One of the potential applications of research on disease etiology is to identify where, in the disease's natural history, effective intervention might be implemented. The natural history of disease refers to the course of disease from its beginning to its final clinical end points. **Figure 2–14** illustrates the natural history of any disease in humans. As the figure demonstrates, the natural history signifies the progression of disease over time.

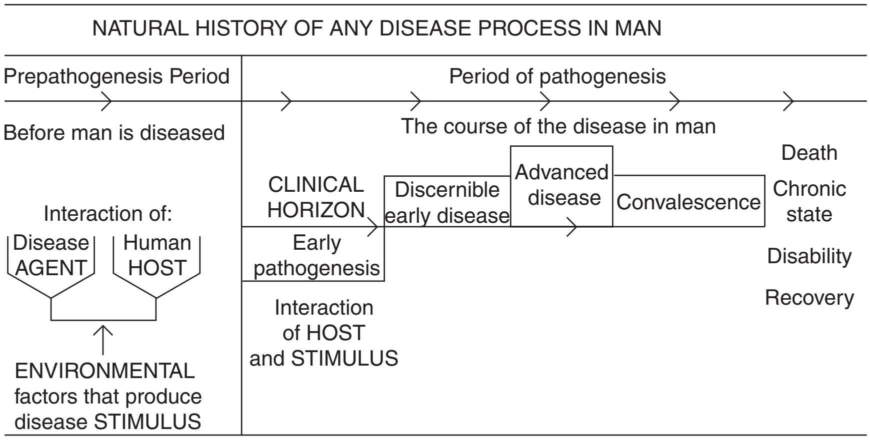


FIGURE 2–14 Prepathogenesis and pathogenesis periods of natural history. *Source:* Modified with permission from Leavell HR, Clark EG. *Preventive Medicine for the Doctor in His Community: An Epidemiologic Approach*, 3rd ed. New York: McGraw-Hill Book Company; 1965, p. 18.

The period of *prepathogenesis* occurs before the precursors of disease (e.g., the bacterium that causes Legionnaires' disease) have interacted with the host (the person who gets the disease). The period of *pathogenesis* occurs after the precursors have interacted with the host, an event that is marked by initial appearance of disease (the presymptomatic stage) and is characterized by tissue and physiologic changes. Later stages of the natural history include development of active signs and symptoms, and eventually recovery, disability, or death (all examples of clinical end points).

According to the model that Leavell and Clark[36] advanced, three strategies for disease prevention—primary, secondary, and tertiary—coincide with the periods of prepathogenesis and pathogenesis. **Figure 2–15** demonstrates these three levels of prevention, which are described in more detail in the following sections.

Primary Prevention

Primary prevention occurs during the period of prepathogenesis. As shown in Figure 2–15, primary prevention includes health promotion and specific protection against diseases. The former is analogous to a type of prevention known as primordial prevention. The term *primordial prevention* denotes ". . . conditions, actions and measures that minimize hazards to health and that hence inhibit the emergence and establishment of processes and factors (environmental,

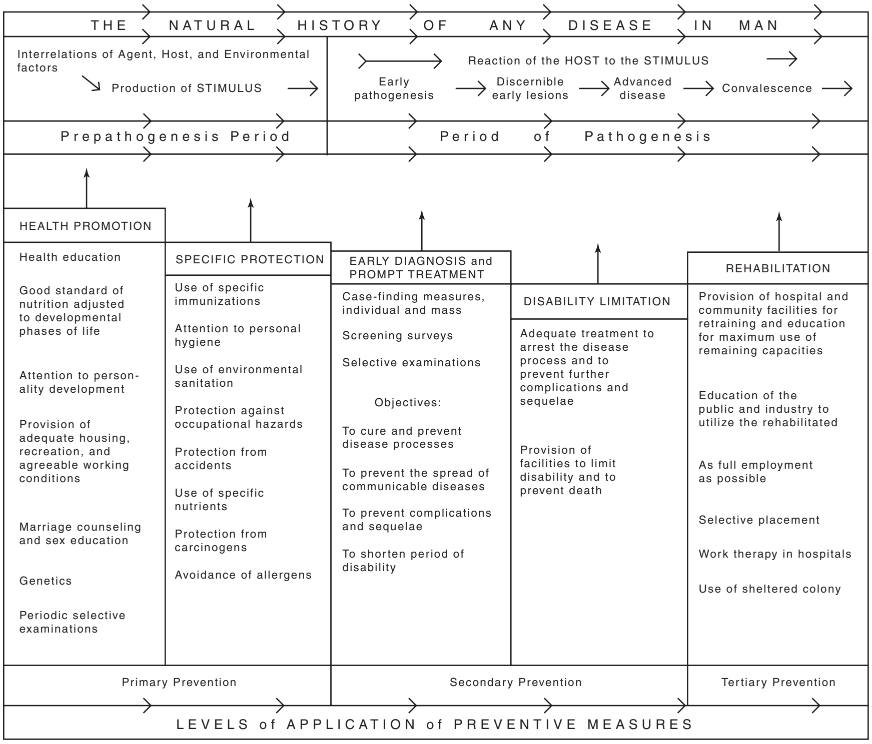


FIGURE 2–15 Levels of application of preventive measures in the natural history of disease. *Source:* Modified with permission from Leavell HR, Clark EG. *Preventive Medicine for the Doctor in His Community: An Epidemiologic Approach*, 3rd ed. New York: McGraw-Hill Book Company; 1965, p. 18.

economic, social, behavioral, cultural) known to increase the risk of disease."[18] Primordial prevention is concerned with minimizing health hazards in general, whereas primary prevention seeks to lower the occurrence of disease. Primordial prevention is achieved in part through health promotion, which includes health education programs in general, marriage counseling, sex education, and provision of adequate housing.

Examples of primary prevention that involve specific protection against disease-causing hazards are wearing protective devices to prevent occupational injuries, utilization of specific dietary supplements to prevent nutritional deficiency diseases, immunizations against specific infectious diseases, and education about the hazards of starting smoking. Interventions to reduce the number of alcohol-related traffic accidents similarly may focus on education, media campaigns, and warning labels on alcohol-containing beverages.

Primary prevention may be either active or passive. Active prevention necessitates behavior change on the part of the subject. Wearing protective devices and obtaining vaccinations require involvement of the individual to receive the benefit. Passive interventions, on the other hand, do not require any behavior change. Fluoridation of public water supplies and vitamin fortification of milk and bread products achieve their desired effects without any voluntary effort of the recipients.

Secondary Prevention

Secondary prevention, which takes place during the pathogenesis phase of the natural history of disease, encompasses early diagnosis and prompt treatment as well as disability limitation. One example of secondary prevention is early diagnosis and prompt treatment linked to cancer screening programs, which are efforts to detect cancer in its early stages (when it is treated more successfully) among apparently healthy individuals. One should note that in the instance of a positive screening result confirmed by a diagnostic workup, cancer is already present; however, detection of the tumor before the onset of clinical symptoms reduces the likelihood of progression to death. Most cancer screening programs are forms of secondary prevention. However, screening for colorectal cancer can be considered also as primary prevention: Because most colorectal cancers arise through a precancerous lesion (adenomatous polyp), screening that detects and removes polyps can prevent cancer, rather than merely detect cancer early.

Later in the natural history of disease (when discernible lesions or advanced disease have appeared), there occurs a type of secondary prevention called disability limitation, which is designed to limit and shorten the period of disability and prevent death from a disease. Another goal of disability limitation is to prevent the side effects and complications that may be associated with a disease.

Tertiary Prevention

Tertiary prevention takes place during late pathogenesis (advanced disease and convalescence stages). Thus, disease already has occurred and has been treated clinically, but rehabilitation is needed to restore the patient to an optimal functional level. Examples include physical therapy for stroke victims, halfway houses for persons recovering from alcohol abuse, sheltered homes for the developmentally disabled, and fitness programs for heart attack patients. This category of prevention seeks to achieve maximum use of the capacities of persons who have disabilities and help them regain full employment.

Conclusion

This chapter identified seven uses of epidemiology. The historical use of epidemiology traced changes in rates of disease from early in this century to the present. Dramatic changes in morbidity and mortality rates were noted. Predictions of future trends in health status incorporate population dynamics or shifts in the demographic composition of populations. Operations research and program evaluation are examples of using epidemiologic methods to improve healthcare services. Public health practitioners and researchers employ epidemiologic methods for describing the health of the community, identifying causes of disease, and studying risks to individuals. One of the most important epidemiologic applications is the study of the causality of disease; a detailed account of causality was provided. The chapter concluded with a review of primary, secondary, and tertiary prevention of diseases.

Study Questions and Exercises

1. Define in your own words the following terms:
    a. secular changes
    b. operations research
    c. risk factor
    d. the natural history of disease
    e. demographic transition
    f. epidemiologic transition
    g. disorders: disappearing, residual, persisting, epidemic
    h. population pyramid
2. Name three approaches for prevention (primary, secondary, and tertiary) of each of the following health problems/conditions:
    a. motor vehicle accidents
    b. obesity
    c. hepatitis A
    d. hepatitis B and C
    e. foodborne illness on cruise ships
    f. mortality due to gang violence

3. Apply the seven uses of epidemiology (as formulated by Morris[1]) to a public health issue (e.g., reduction of health disparities). For example, use of number two, "Diagnose the health of the community," might involve identification of groups in the community that are at high risk for sexually transmitted diseases. Similarly, the remaining six uses could be applied to other aspects of health disparities. Are the uses of epidemiology defined in the chapter distinct or overlapping? Can you think of other uses of epidemiology not identified in the chapter? Do all of the uses belong exclusively to the domain of epidemiology?
4. Describe a role for epidemiology in the field of policy evaluation. Consider how the field of epidemiology might inform policy evaluation of laws that regulate tobacco consumption in public places.
5. How are the rules of evidence for criminality similar or different from the rules of evidence for disease causality? (Refer to Exhibit 2–5 to help with your answer.)
6. Clinicians and epidemiologists differ in their assessment of the importance of risks. State how the clinical and epidemiologic approaches differ. Give an example by using a disease or condition that is important for society.
7. Describe how it is possible for an infectious disease, when it first comes to the attention of public health authorities, to be considered an extremely acute or fatal condition, and then later is found to be mild or benign in its most common form. Give an example of such a disease.
8. This chapter stated how epidemiology may be applied to the study of the causality of disease. Suggest other examples of how epidemiology might be applied to study the causality of disease.
9. The following questions refer to **Table 2A–1**.
   a. Calculate the percentage decline in the death rate for all causes. What generalizations can be made about changes in disease rates that have occurred between 1900 and the present?
   b. Contrast the changes in death rates due to cancer, heart disease, and cerebrovascular diseases. What additional information would be useful to specify better the changes in these conditions?
   c. Note the decline in mortality for the four communicable diseases (1, 2, 3, and 10) since 1900. With the exception of pneumonia and influenza, these are no longer among the 10 leading causes of death. Can you speculate regarding how much of each is due to environmental improvements and how much to specific preventive and curative practices?

Table 2A–1 Leading Causes of Death and Rates for Those Causes in 1900 and 2009, United States

Rank 1900	Cause of Death*	Rate per 100,000 Population 1900	2009[1]
	All causes	1,719.1	793.7
1	Influenza and pneumonia, except pneumonia of newborn	202.2	17.5
2	Tuberculosis, all forms	194.4	NA†
3	Diarrhea and enteritis	139.9	NA†
4	Disease of heart	137.4	195.0
5	Cerebrovascular diseases	106.9	41.9
6	Chronic nephritis	81.0	15.9
7	Accidents and adverse effects[2]	72.3	38.2
8	Malignant neoplasms	64.0	185.2
9	Senility	50.2	NA†
10	Diphtheria	40.3	NA†

* Some categories may not be strictly comparable because of change in classification.

† NA: These are no longer listed among the top 10 causes of death.

[1] Crude death rate

[2] Accidents (unintentional injuries)

Sources: U.S. Bureau of the Census. Statistical Abstract of the United States: 1957. Washington, D.C: U.S. Bureau of the Census; 1957: 69; U.S. Public Health Service. Vital Statistics Rates in the United States, 1900–1940. Washington, D. C.: U.S. Government Printing Office: 1947; Kochanek KD, Xu JQ, Murphy SL, et al. Deaths: Preliminary data for 2009. National vital statistics reports; 59(4):5. Hyattsville, MD: National Center for Health Statistics: 2011.

d. Among the 10 leading causes of death in 2009 were chronic lower respiratory diseases (44.7 per 100,000—rank 3), diabetes (22.3 per 100,000—rank 7), Alzheimer's disease (25.7 per 100,000—rank 6), and suicide (11.9 per 100,000—rank 10). (Note: Data are not shown in Table 2A–1.) In 1900, these were not among the 10 leading causes of death. How do you account for these changes?

10. The following questions refer to Figure 2–3.
    a. List and describe the trends in death rates by the five leading causes of death.
    b. Describe the trend for hypertension and Parkinson's disease. Can you suggest an explanation for the trends in hypertension and Parkinson's disease deaths?
    c. Does the curve for accidental deaths correspond to our expectations from various publicity reports?
    d. What is the trend for Alzheimer's disease? Can you offer an explanation?

References

1. Morris JN. *Uses of Epidemiology*, 3rd ed. Edinburgh, UK: Churchill Livingstone; 1975.
2. Angell M. The interpretation of epidemiologic studies. Editorial. *N Engl J Med*. 1990;323:823–825.
3. MacMahon B, Pugh TF. *Epidemiology Principles and Methods*. Boston, MA: Little, Brown; 1970.
4. Susser MW, Watson W, Hopper K. *Sociology in Medicine*, 3rd ed. New York, NY: Oxford University Press; 1985.
5. Mausner JS, Kramer S. *Epidemiology: An Introductory Text*, 2nd ed. Philadelphia: Saunders; 1985.
6. Raymond J, Wheeler W, Brown MJ. Inadequate and unhealthy housing, 2007 and 2009. *MMWR*. 2011;60 (supplement):21–27.
7. Rothman KJ. *Modern Epidemiology*. Boston, MA: Little, Brown; 1986.
8. U.S. Department of Health and Human Services. *Healthy People 2010: Understanding and Improving Health*, 2nd ed. Washington, DC: U.S. Government Printing Office, November 2000.
9. US Department of Health and Human Services. Office of Disease Prevention and Health Promotion. ODPHP Publication No. B0132 November 2010. www.healthypeople.gov.
10. US Department of Health and Human Services. *HHS Action Plan to Reduce Racial and Ethnic Health Disparities: A Nation Free of Disparities in Health and Health Care*. Washington, D.C.: US Department of Health and Human Services, April 2011.
11. Truman BI, Smith CK, Roy K, et al. Rationale for regular reporting on health disparities and inequalities–United States. *MMWR*. 2011;60(supplement):3–10.
12. Miniño AM, Murphy SL, Xu JQ, Kochanek KD. Deaths: Final data for 2008. *National Vital Statistics Reports*. 2011;59(10). Hyattsville, MD: National Center for Health Statistics. 2011.
13. Ibrahim MA. *Epidemiology and Health Policy*. Gaithersburg, MD: Aspen Publishers; 1985.
14. Samet JM, Lee NL. Bridging the gap: Perspectives on translating epidemiologic evidence into policy. *Am J Epidemiol*. 2001;154(12 Suppl):S1–S3.
15. Weed DL, Mink PJ. Roles and responsibilities of epidemiologists. *Ann Epidemiol*. 2002;12:67–72.
16. Matanoski GM. Conflicts between two cultures: Implications for epidemiologic researchers in communicating with policy-makers. *Am J Epidemiol*. 2001;154(12 Suppl):S36–S42.
17. Spasoff RA. *Epidemiologic Methods for Health Policy*. New York, NY: Oxford University Press; 1999.
18. Porta M. *A Dictionary of Epidemiology*, 5th ed. New York: Oxford University Press; 2008.
19. Hulka BS. Epidemiological applications to health services research. *J Community Health*. 1978;4:140–149.
20. Woodwell DA. *Office Visits to General Surgeons 1989–90, National Ambulatory Medical Care Survey*. Advance Data from Vital and Health Statistics. Report 228. Hyattsville, MD: National Center for Health Statistics; December 22, 1993.

21. Fowke JH, Murff, HJ, Senorello LB, at all. Race and socioeconomic status are independently associated with benign prostatic hyperplasia (BPH). *J Urol*. 2008;180(5):2091–2096.
22. de la Torre A, Friis R, Hunter HR, Garcia L. The health insurance of U.S. Latino women: A profile from the 1982–1984 HHANES. *Am J Public Health*. 1996;86: 533–537.
23. Wilper AP, Woolhandler S, Lasser KE, et al. Health insurance and mortality in US adults. *Am J Public Health*. 2009;99:2289–95.
24. Epidemiology faces its limits. *Science*. 1995;269:164–169.
25. Susser M. *Causal Thinking in the Health Sciences*. New York, NY: Oxford University Press; 1973.
26. Susser M and Stein Z. *Eras in Epidemiology*. New York, NY: Oxford University Press; 2009.
27. Cassel J. The contribution of the social environment to host resistance. *Am J Epidemiol*. 1976;104:107–123.
28. Winkelstein W Jr. Invited commentary on "Judgment and causal inference: criteria in epidemiologic studies." *Am J Epidemiol*. 1995;141:699–700.
29. U.S. Department of Health, Education and Welfare, Public Health Service. *Smoking and Health, Report of the Advisory Committee to the Surgeon General of the Public Health Service*. Public Health Service publication 1103. Washington, DC: Government Printing Office; 1964.
30. Susser M. Judgment and causal inference: Criteria in epidemiologic studies. *Am J Epidemiol*. 1977;105:1–15.
31. Hill AB. The environment and disease: Association or causation? *Proc R Soc Med*. 1965;58:295–300.
32. Evans AS. Causation and disease: A chronological journey. *Am J Epidemiol*. 1978;108:254–255.
33. Brett AS. Treating hypercholesterolemia: How should practicing physicians interpret the published data for patients? *N Engl J Med*. 1989;321:676–680.
34. Pekkanen J, Linn S, Heiss G, et al. Ten-year mortality from cardiovascular disease in relation to cholesterol level among men with and without preexisting cardiovascular disease. *N Engl J Med*. 1990;322:1700–1707.
35. Howlader N, Noone AM, Krapcho M, et al. (eds). *SEER Cancer Statistics Review, 1975–2009 (Vintage 2009 Populations)*, National Cancer Institute. Bethesda, MD.
36. Murphy M, Hultgren HN, Detre K, et al. Treatment of chronic stable angina: A preliminary report of survival data of the randomized Veterans Administration Cooperative Study. *N Engl J Med*. 1977;297:621–627.
37. Leavell HR, Clark EG. *Preventive Medicine for the Doctor in His Community: An Epidemiologic Approach*, 3rd ed. New York: McGraw-Hill Book Company; 1965.