CHAPTER 14

Epidemiology in Community Health Care

KEY TERMS

- Agent
- Analytic epidemiology
- Case-control studies
- Causality
- Cohort
- Cross-sectional studies
- Descriptive epidemiology
- Endemic
- Environment
- Epidemic
- Epidemiology
- Experimental epidemiology
- Experimental study
- Host
- Immunity
- Incidence
- Morbidity rate
- Mortality rate
- Natural history
- Pandemic
- Prevalence
- Prospective study
- Rates
- Retrospective study
- Risk

LEARNING OBJECTIVES

Upon mastery of this chapter, you should be able to:

- Explore the historical roots of epidemiology.
- Explain the host, agent, and environment model.
- Describe theories of causality in health and illness.
- Define *immunity* and compare passive, active, cross, and herd immunity.
- Explain how epidemiologists determine populations at risk.
- Identify the four stages of a disease or health condition.
- List the major sources of epidemiologic information.
- Distinguish between incidence and prevalence in health and illness states.
- Use epidemiologic methods to describe an aggregate's health.
- Distinguish between types of epidemiologic studies useful for researching aggregate health.
- Use the seven-step research process when conducting an epidemiologic study.

Epidemiology is the study of the determinants and distribution of health, disease, and injuries in human populations. It is a specialized form of scientific research that can provide health care workers, including community health nurses, with a body of knowledge on which to base their practice and methods for studying new and existing problems. The term is derived from the Greek words *epi* (upon), *demos* (the people), and *logos* (knowledge), thus meaning the knowledge or study of what happens to people. Epidemiologists ask such questions as, What is the occurrence of health and disease in a population? Is there an increase or decrease in a health state over the years? Does one geographic area have a higher frequency of disease than another? What characteristics of people with a particular condition distinguish them from those without the condition? Is one treatment or program more effective than another in changing the health of affected people? Why do some people recover from a disease when others do not? The ultimate goal of epidemiology is to determine the scale and nature of human health problems, identify solutions to prevent disease, and improve the health of the entire population (Beaglehole & Bonita, 1997).

Epidemiology offers community health nurses a specific methodology for assessing the health of aggregates. Furthermore, it provides a frame of reference for investigating and improving clinical practice in any setting. For example, if a community health nursing goal is to lower the incidence of sexually transmitted diseases (STDs) in a given community, such a prevention plan requires information about population groups. How many STD cases have been reported in this community in the past year? What is the expected number of STD

cases (the morbidity rate)? What members of the community are at highest risk of contracting STDs? Any program of screening, treatment, or health promotion regarding STDs must be based on this kind of information about population groups in order to be effective. Whether the community health nurse's goals are to improve a population's nutrition, to control the spread of human immunodeficiency virus (HIV), to deal with health problems created by a flood, or to protect and promote the health of battered women, epidemiologic data are essential.

HISTORICAL ROOTS OF EPIDEMIOLOGY

The roots of epidemiology can be traced to Hippocrates, a Greek physician who lived from about 460 to 375 BC and is sometimes referred to as the first epidemiologist. Hippocrates and other members of the Hippocratic School believed that disease not only affects individuals but is a mass phenomenon. This was one of the earliest associations of the occurrence of disease with lifestyle and environmental factors (Beaglehole & Bonita, 1997). However, it was not until the late 19th century that modern epidemiology actually came into existence.

Although they are among history's greatest disasters, epidemic diseases clearly prompted the development of epidemiology as a science. An **epidemic** refers to a disease occurrence that clearly exceeds normal or expected frequency in a community or region. In past centuries, epidemics of cholera, bubonic plague, and smallpox swept through community after community, killing thousands of people, changing the community structure, and altering the lifestyle of masses of people. When an epidemic, such as the plague or acquired immunodeficiency syndrome (AIDS), is worldwide in distribution, it is called a **pandemic.**

Epidemiology became a distinct branch of medical science through its concern with epidemics and pandemics of infectious diseases. In 1348, the Black Death (bubonic plague, pneumonic plague, or referred to as the plague and caused by the bacillus *Yersinia pestis*) swept through continental Europe and England, killing millions of people and lowering the life expectancy to 20 years from 30 to 35 years (Display 14–1). In England alone, approximately one fourth of the population died from the plague. The plague continued in Europe, but with less force, for three centuries and then waned, only to reappear in an epidemic in Hong Kong in 1896. Kitasato, a Japanese bacteriologist, discovered the plague bacillus during this Hong Kong epidemic; within 10 years, epidemiologists had traced its life cycle from rats to their infected fleas that bit humans. Now intervention was possible, and public health officials declared war on rats, seeking to make ships and wharf buildings rat-proof. The first major campaign against rats that took place in California after an outbreak of plague in 1900 was successful. However, wild rodents, especially ground squirrels, remain a natural reservoir of the plague bacillus, as well as rabbits and domestic cats. Cases still occur occasionally in the western half of the United States with periodic outbreaks in large areas of South America; north-central, eastern, and southern Africa; and central and Southeast Asia (Chin, 1999). The continuing presence of a disease or infectious agent in a given geographic area, such as plague in Vietnam and malaria in the tropics of Brazil and Indonesia, means the disease is **endemic** to that area.

DISPLAY 14-1. **Impact of the Plague**

"It was the appearance of the plague in the fourteenth century, and its periodic return throughout the next two centuries, that crystallized the interest in public health that had begun with the isolation of lepers in the thirteenth century. Some cities complied 'books of the dead,' which were comprehensive mortality records used to identify epidemics and follow their course. Mortality rates in the early epidemics were staggering, with up to half of the population dying in cities during the plague pandemic. In response to the first plague pandemic, Northern Italian city-states instituted a series of public health measures designed to protect the health of the elite. For example, the authorities isolated ships suspected of carrying disease; the quarantine lasted for 40 days" (Beaglehole & Bonita, 1997, p. 87).

As the threat of the great epidemic diseases declined, epidemiologists began to focus on other infectious diseases such as diphtheria, infant diarrhea, typhoid, tuberculosis, and syphilis. They also studied diseases linked to occupations, such as scurvy among sailors and scrotal cancer among chimney sweeps. In recent years, epidemiologists have turned to the study of major causes of death and disability, such as cancer, cardiovascular disorders, AIDS, violence, mental illness, accidents, arthritis, and congenital defects.

Nursing's epidemiologic roots can be traced back to Florence Nightingale (1820–1910) (Cohen, 1984). Miss Nightingale often obtained advice on issues related to hospital statistics and disease classification from her close friend William Farr, who established the field of medical statistics as chief statistician of England's General Register Office for health and vital statistics. Her detailed records, morbidity (sickness) statistics, and careful description of the health conditions among the military in the Crimean War represent one of the first systematic descriptive studies of the distribution and patterns of disease in a population. She used wedge-shaped graphs, circles, and squares that were shaded and in colors to illustrate preventable deaths of the hospitalized Crimean soldiers as compared with hospitalized soldiers in England at the time. Changes made according to her suggestions brought dramatic proof of the authenticity of her observations and knowledge. Forty out of every 100 British troops (40%) were dying in the Crimea before Miss Nightingale instituted environmental and nutritional changes in the hospital and field.

When her work in the Crimea was finished, the mortality (death) rate was only 2%.

Florence Nightingale's use of statistical data along with her commitment to environmental reform strongly influenced nursing's evolution into a profession whose service addressed public health problems as well as hospital care (Kopf, 1978). As nursing has evolved, community health nurses have been increasingly challenged to intervene at the aggregate level, using epidemiologic approaches to address the needs of high-risk groups and populations.

CONCEPTS BASIC TO EPIDEMIOLOGY

The science of epidemiology draws on certain basic concepts and principles to analyze and understand patterns of occurrence among aggregate health conditions.

Host, Agent, and Environment Model

Through their early study of infectious diseases, epidemiologists began to consider disease states generally in terms of the epidemiologic triad, or the *host, agent, and environment model*. Interactions among these three elements explained infectious and other disease patterns.

HOST

The **host** is a susceptible human or animal who harbors and nourishes a disease-causing agent. Many physical, psychological, and lifestyle factors influence the host's susceptibility and response to an agent. Physical factors include such things as age, sex, race, and genetic influences on the host's vulnerability or resistance. Psychological factors, such as people's outlook and response to stress, can strongly influence host susceptibility. Lifestyle factors also play a major role. Diet, exercise, sleep patterns, healthy or unhealthy habits all contribute to either increased or decreased vulnerability to the disease-causing agent.

The concept of resistance is important for community health nursing practice. People sometimes have an ability to resist pathogens, which is called *inherent resistance*. Typically, these people have inherited or acquired characteristics, such as the various factors mentioned above, which make them less vulnerable. For instance, people who maintain a healthful lifestyle may be exposed to the flu virus but do not contract the disease. Resistance can be promoted through preventive interventions (see Levels of Prevention).

AGENT

An **agent** is a factor that causes or contributes to a health problem or condition. Causative agents can be factors that are present, such as the presence of the bacteria that causes tuberculosis, or factors that are lacking, such as a lack of iron in the body, which causes anemia.

Agents vary considerably and include five types: biologic, chemical, nutrient, physical, and psychological. Biologic agents include bacteria, viruses, fungi, protozoa, worms, and insects. Some biologic agents are infectious, such as influenza virus or HIV. Chemical agents may be in the form of liquids, solids, gases, dusts, or fumes. Examples are poisonous sprays used on garden pests and industrial chemical wastes. The degree of toxicity of the chemical agent influences its impact on health. Nutrient agents include essential dietary components, which, if deficient or taken in excess, can produce illness conditions. For example, a deficiency of niacin can cause pellagra, and too much vitamin A can be toxic. Physical agents include anything mechanical (a chainsaw or an automobile), material (rockslide), atmospheric (ultraviolet radiation); geologic (earthquake), or genetically transmitted that causes injury to humans. The shape, size, and force of physical agents influence the degree of harm to the host. Psychological agents are events producing stress that lead to health problems.

Agents may also be classified as either infectious or noninfectious. Infectious agents cause diseases, such as AIDS or tuberculosis, that are communicable—that is, the disease can be spread from one person to another. Certain characteristics of infectious agents are important for community health nurses to understand. Extent of exposure to the agent, the agent's pathogenicity (disease-causing ability), infectivity (invasive ability), virulence (severity of disease), and the infectious agent's structure and chemical composition all influence its effects on the host. (Chapter 15 examines the subject of communicable disease in greater depth.) Noninfectious agents have similar characteristics in that their relative abilities to harm the host vary with type of agent and intensity, and duration of exposure.

ENVIRONMENT

The **environment** refers to all the external factors surrounding the host that might influence vulnerability or resistance. The physical environment includes factors like geography, climate, weather, safety of buildings, and water and food supply, presence of animals, plants, insects, and microorganisms, which have the capacity to serve as reservoirs (storage sites for disease-causing agents) or vectors (carriers) for transmitting disease. The psychosocial environment refers to social, cultural, economic, and psychological influences and conditions that affect health, such as access to health care, cultural health practices, poverty, and work stressors, which can all contribute to disease or health.

Host, agent, and environment interact with each other to cause a disease or health condition. For example, the agent responsible for Lyme disease is the spirochete *Borrelia burgdorferi;* humans of all ages are susceptible hosts, along with dogs, cattle, and horses. Ticks that feed on wild rodents and deer transfer the spirochete to human hosts after feeding on them for several hours. Environmental factors, such as working or playing in tick-infested areas, influence host vulnerability. The host, agent, and environment model, shown in Figure 14–1, offered the epidemiologists who first studied

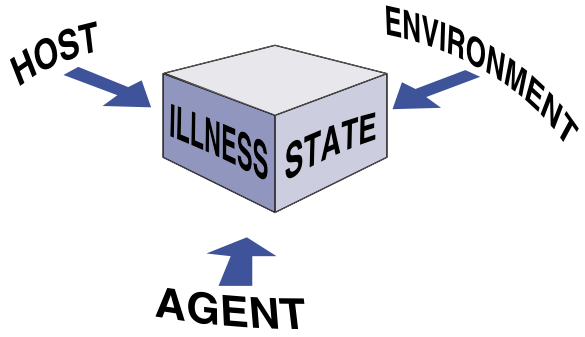

FIGURE 14–1. Epidemiologic triad. Epidemiologists study the causal agent, the susceptible host, and environmental factors that contribute to an illness state (or a wellness state). Intervention may focus on any of these three to prevent the spread of illness or to improve health in a population.

Lyme disease in 1982 a plan for intervention. As soon as the agent was identified, measures could be taken to keep the spirochete from infecting human hosts, such as wearing protective clothing or tick repellent in tick-infested areas and promptly removing surface or attached ticks (Chin, 1999).

Causality

The concept of **causality** refers to the relationship between a cause and its effect. A purpose of epidemiologic study has been to discover causal relationships in order to understand why conditions develop and offer effective prevention and protection. Over the years, as scientific knowledge of health and disease has expanded, epidemiology has changed its view of causality.

ERAS IN THE EVOLUTION OF MODERN EPIDEMIOLOGY

Modern epidemiology can be described as having three distinct eras, each based on causal thinking. They are sanitary statistics, infectious-disease epidemiology, and chronic-disease epidemiology. Eco-epidemiology, a fourth era, is emerging (Susser & Susser, 1996a).

Early causal thinking was dominated by the *miasma theory,* which had its origins in the work of the Hippocratic School and was formally developed in the early 1700s. The miasma theory held that miasma was "composed of malodorous and poisonous particles generated by the decomposition of organic matter" (Beaglehole & Bonita, 1997, p. 87) and was the cause of disease. Prevention based on this theory attempted to eliminate the sources of the miasma or polluted vapors. Despite its faulty reasoning, this type of prevention has had positive consequences in our awareness that decaying organic matter can be a source of infectious diseases. This theory dominated until the first half of the 19th century.

The era of infectious-disease epidemiology was dominated by the *contagion theory* of disease, which had developed by the mid-18th century. Prompted by the development of increasingly sophisticated microscopes, this theory attempted to identify the microorganisms that cause diseases as a first step in prevention. It inspired various theories of immunity and even some initial attempts at vaccination against smallpox. Additionally, once an agent had been identified, measures were taken to contain its spread. Fumigating ships to kill rats, protecting wharf buildings and human habitations against rats, and removing rat food supplies from easy access were all measures taken to protect the public by further preventing the spread of plague bacilli. Following the work of Jacob Henle, Louis Pasteur, and Robert Koch (Dever, 1991), the contagion theory was refined and best known as the germ theory of disease and became predominant in the late 19th century through the first half of the 20th century (Susser & Susser, 1996a).

In the era of infectious disease epidemiology, scientists viewed disease in terms of a simple cause-and-effect relationship. Finding a single cause (plague bacilli) and attacking it (eliminating rats) seemed the solution for preventing many diseases. In the case of bubonic plague, this approach appeared quite effective. However, scientific research eventually revealed that disease causation was much more complex than was first suspected. For example, although most members of a group might be exposed to the plague, many did not contract the disease. With bubonic plague, as with many other infectious diseases, the characteristics of the host can determine the spread of the disease. Not everyone in a population is at risk; it is now known that untreated bubonic plague has a case-fatality rate of only about 50% to 60%. Furthermore, the agent and course of transmission can be quite complex. Although a flea carries the bacilli from rat to human in bubonic plague, many infectious diseases spread directly from one human being to another. Finally, the environment must be considered as part of the cause of disease. Considering the plague again, evidence suggests that it originated in the high steppes of Asia and spread to other parts of the world. However, questions remain as to whether the bacillus spread from rats to ground squirrels or whether it had always been part of the squirrels' ecology.

After World War II, the causative agents of major infectious diseases were identified, methods of prevention recognized, and antibiotics and chemotherapy added to the arsenal to fight communicable diseases. The focus then became to "understand and control the new chronic disease epidemics" (Susser & Susser, 1996a, p. 670). The key figures of R. Doll, A. B. Hill, J. Morris, and T. McKeown completed case-control and cohort studies linking the causative factors of cholesterol levels and smoking with coronary heart disease and tied smoking with lung cancer. The general metaphor of a *black box* (a self-contained unit whose inner processes are hidden from view) is the associated paradigm with this era; it relates exposure to outcome without obligation to interpolate intervening factors or pathogenesis. Just as in earlier

TABLE 14–1. Eras in the Evolution of Modern Epidemiology

Era	Paradigm	Analytic Approach	Prevention Approach
Sanitary statistics (1800–1850)	Miasma: poisoning from foul emanations	Clustering of morbidity and mortality	Drainage, sewage, sanitation
Infectious disease epidemiology (1850–1950)	Germ theory: single agent related to specific disease	Laboratory isolation and culture from disease sites and reproduce lesions	Interrupt transmission (vaccines, isolation, and antibiotics)
Chronic disease epidemiology (1950–2000)	Black box: exposure related to outcome	Risk ratio of exposure to outcome at individual level in populations	Control risk factors by modifying lifestyle (diet), agent (guns), or environment (pollution)
Eco-epidemiology (emerging)	Chinese boxes: relations within and between localized structures organized in a hierarchy of levels	Analysis of determinants and outcomes at different levels of organization using new information systems and biomedical techniques	Apply both information and biomedical technology to find leverage at efficacious levels

Adapted from Susser, M., & Susser, E. (1996). Choosing a future for epidemiology: 1. Eras and paradigms. *American Journal of Public Health, 86* [5], 668–673; and Susser, M., & Susser, E. [1996b]. Choosing a future for epidemiology: II. From black box to Chinese boxes and eco-epidemiology. *American Journal of Public Health, 86* [5], 674–677.)

eras, epidemiologists are faced once more with major mortal diseases of completely unknown origin.

We are entering a new era of eco-epidemiology distinguished by the inclusion of systems at different levels and inclusion of the two factors of transforming global health patterns and technological advances (Susser & Susser, 1996b). This paradigm is called *Chinese boxes*. First, there is a transformation in global health patterns. The HIV epidemic is a good example.

The causative organism as well as the critical risk factors are known, yet we are failing to control the disease because of our lack of understanding of transmission and illness in the social context. We know which social behaviors need to change, but we know little about how to change them, even when entire societies are at stake (Susser & Susser, 1996a).

This is true for many current chronic diseases. How many nurses smoke? Do you exercise as you know you should? What are we missing to effectively change social behaviors?

The second factor is technology. Developments in technology will drive research primarily in biology and biomedical techniques and in the information system capabilities. For example, possibilities now exist through DNA studies to recognize both viral and genetic components in insulin-dependent diabetes (Solimena & De Camilli, 1995); track HIV, tuberculosis, and other infections from person to person through molecular specificity of the organisms (Alland et al., 1994); and track and mark the first breast cancer gene (Hall et al., 1990). The possibilities of learning through technology have just begun as we enter this fourth epidemiologic era. Table 14–1 summarizes the four eras in the evolution of modern epidemiology.

CHAIN OF CAUSATION

As the scientific community's thinking about disease causation has grown more complex around the tripartite model of host, agent, and environment, epidemiologists have used the idea of a chain of causation (Fig. 14–2). The chain begins by identifying the reservoir (ie, where the causal agent can live and multiply). With plague, that reservoir may be other humans, rats, squirrels, and a few other animals. With malaria, infected humans are the major reservoir for the parasitic agents, although certain nonhuman primates also act as reservoirs (Chin, 1999). Next, the agent must have a portal of exit from the reservoir as well as some mode of transmission. For example, the bite of an *Anopheles* mosquito provides a portal of exit for the parasites, which spend part of their life cycle in the mosquito's body, which thus acts as a mode of transmission. The next link in the chain of causation is the agent itself. Malaria, for instance, actually consists of four distinct diseases caused by four kinds of microscopic protozoa. The next link is the portal of entry. In the case of malaria, the mosquito bite provides a portal of exit as well as a portal of entry into the human host.

The box surrounding this chain of causation in Figure 14–2 represents the environment, which can have a profound influence at almost any point along the chain. Consider the impact of environmental factors in the malaria epidemic of Ceylon in the Indian Ocean off southern India in 1934 to 1935. Historically, malaria occurred frequently in the dry northern area where sparse vegetation allowed pools of water to be exposed to the sun, providing excellent breeding grounds for the *Anopheles* mosquito. In contrast, the more populous southwestern area usually had heavy monsoon rains and was relatively free from malaria. In 1934, however, a severe drought changed this environment drastically;

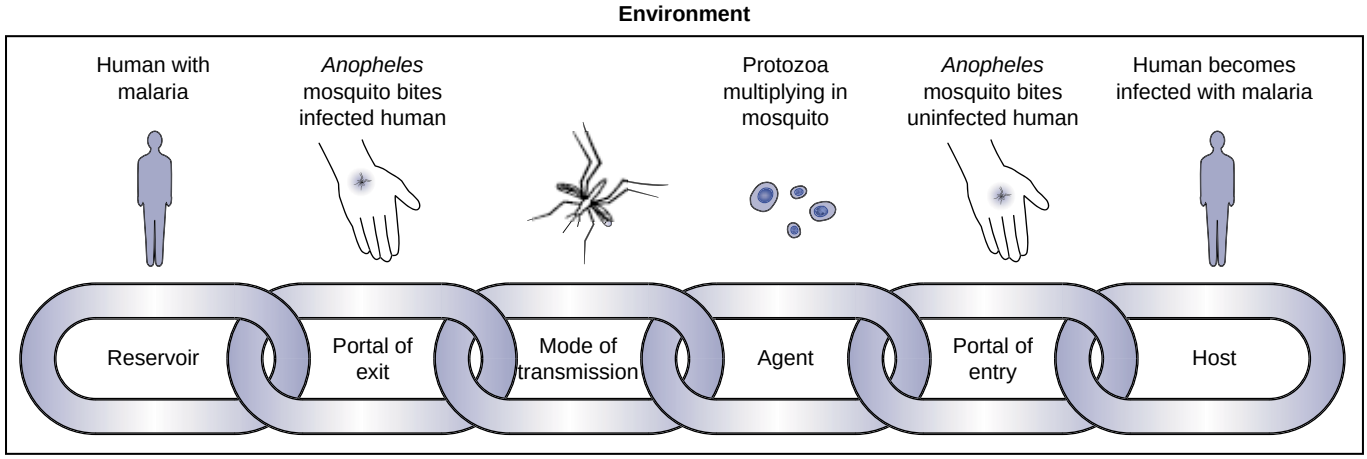

FIGURE 14–2. Chain of causation in infectious disease.

throughout Ceylon, rivers almost dried up, leaving stagnant pools of water for mosquito breeding. Widespread crop failure caused the population to become badly undernourished, which added to the conditions that would foster a malaria epidemic. The epidemic hit in October 1934, affecting 2 to 3 million people and causing 80,000 deaths. The environment must certainly be seen as a major part of this causal chain (Burnet, 1962). A similar tragedy occurred in the African country of Rwanda in July of 1994. Civil war caused a large percentage of the population to flee an unfriendly regime. Hundreds of thousands of people filled refugee camps to overflowing. Conditions of squalor and poor sanitation led to contaminated water and resulted in a large-scale epidemic of cholera, a severe form of bacterial dysentery. Relief workers had limited supplies of intravenous or oral rehydration solutions and could do little to help. Uncounted thousands lost their lives. The unstable political environment, unsanitary conditions, and malnourishment were all part of the causal chain.

MULTIPLE CAUSATION

A more advanced concept of multiple causation has emerged to explain the existence of health and illness states and to provide guiding principles for epidemiologic practice (Dever, 1991). Sometimes discussed as a "web of causation," this model attempts to identify all the possible influences on the health and illness processes (Friedman, 1994). Figure 14–3 shows the web of causation for myocardial infarction; such a health problem cannot be explained in single causal terms, even if that cause represents part of a larger chain. Recognition of multiple causes provides many points of intervention for prevention, health promotion, and treatment. For example, examination of Figure 14–3 suggests interventions such as directly attacking significant coronary atherosclerosis (bypass surgery), reducing the incidence of obesity, helping people stop smoking, developing an exercise program, and making dietary modifications. Figure 14–4 depicts the web of causation for infant mortality. Data from birth and death certificates were used to identify the complex interactions among multicausal factors that produced a negative health condition leading to infant mortality.

A concept helpful in determining multiple causality is *association*. Events are associated when they appear together more often than they would appear by chance alone. These events may include risk factors or other characteristics affecting disease or health states. Examples are the frequent association of cigarette smoking with lung cancer, obesity with heart disease, or severe prematurity with infant mortality. Thus, study of frequently appearing associated factors suggests possible causality and points for intervention. Contemporary epidemiologists continue to explore new and more comprehensive ways of viewing health and illness. Lifestyle, behavior, environment, and stress of all kinds affect health states.

In the model of host, agent, and environment, one can note a shifting emphasis over time. Early epidemiologists worked to identify and manage the causative agent; the focus of concern was disease states. The emphasis then shifted to the host. Who was susceptible? What characteristics led to susceptibility? Through immunization and health promotion, efforts were made to improve hosts' resistance. Increasingly, however, community health workers have come to realize the limitations imposed on individual control of health. Even those in the best of health cannot withstand toxic agents in the workplace, nuclear wastes in the atmosphere from power plant accidents, or other debilitating conditions created by modern society. More and more, public health professionals are turning to a study of the environment and looking for methods to change environmental conditions that contribute to illness.

Immunity

The concept of **immunity** refers to the host's ability to resist a particular infectious disease-causing agent. This occurs when the body forms antibodies and lymphocytes that react with the foreign antigenic molecules and render them harm-

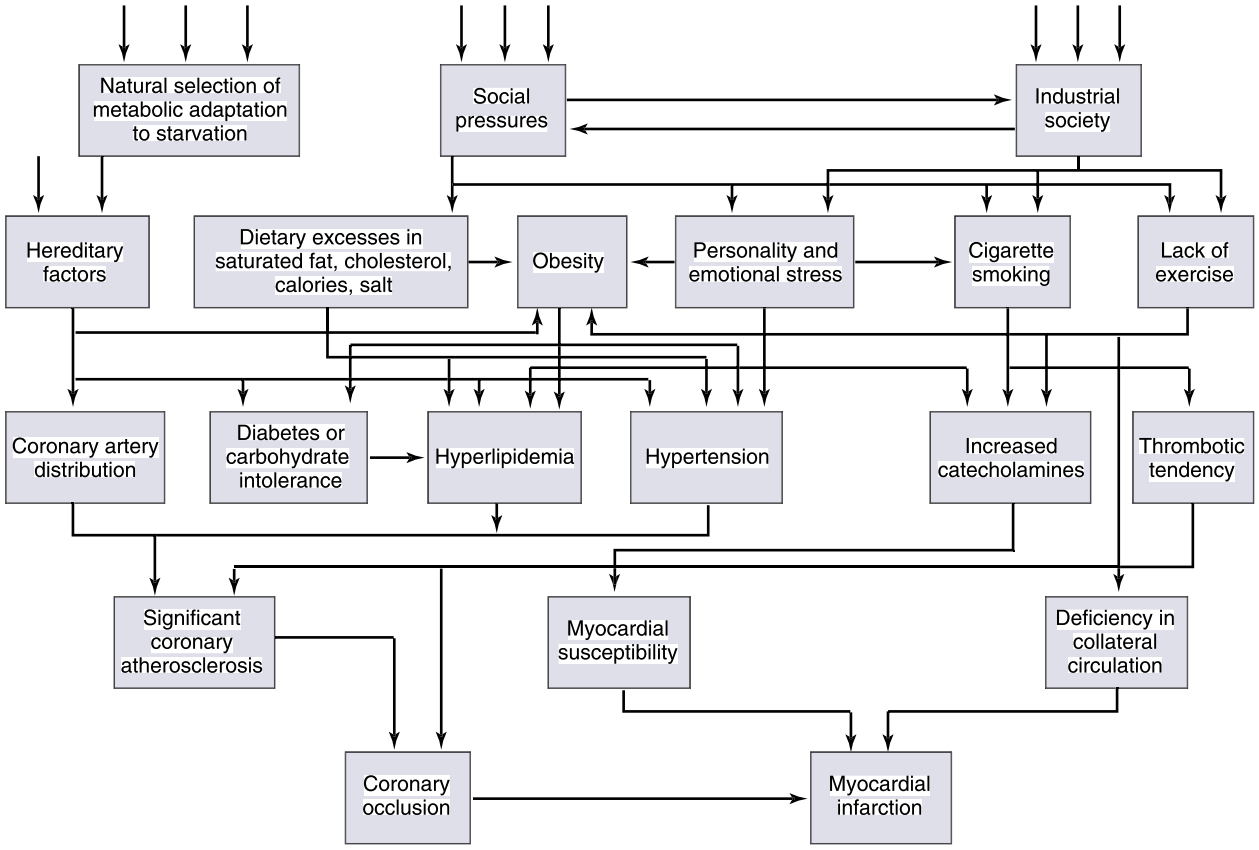

FIGURE 14–3. Web of causation for myocardial infarction. (Adapted from Friedman, G. D. [1987]. *Primer of epidemiology.* New York: McGraw-Hill. Reprinted by permission.)

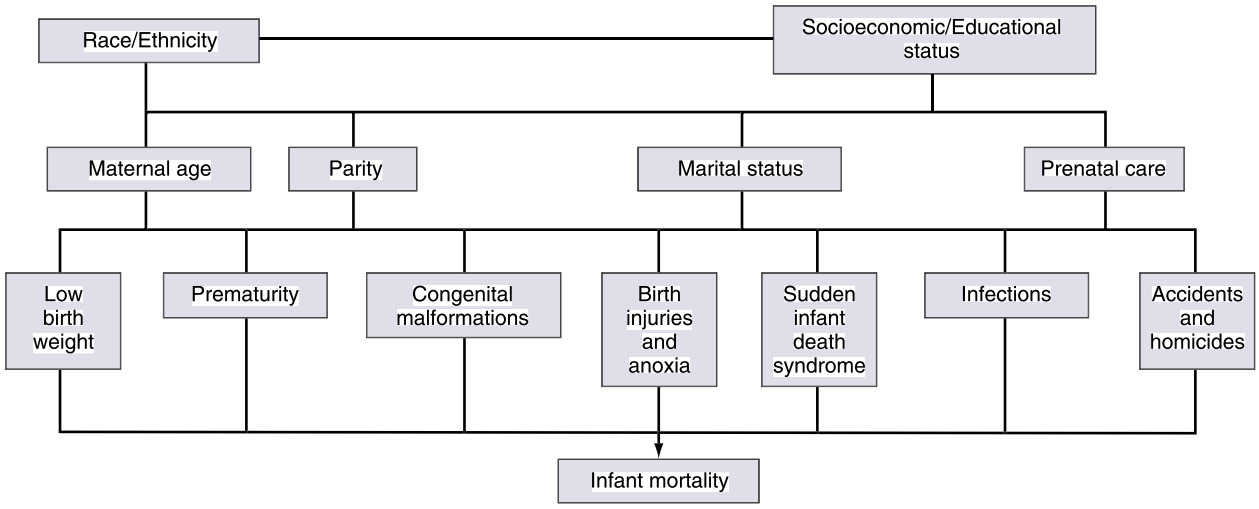

FIGURE 14–4. A web of causation for infant mortality, based on information available from birth and death certificates. (From Anderson, C. T., & McFarlane, J. [2000]. *Community as partner.* [3rd ed.]. Philadelphia: Lippincott Williams & Wilkins.)

less. For community health nursing, this concept has significance in determining which individuals and groups are protected against disease and which may be vulnerable. Four types of immunity are important in community health. They are passive, active, cross, and herd immunity.

PASSIVE IMMUNITY

Passive immunity refers to short-term resistance that is acquired either naturally or artificially. Newborns, through maternal antibody transfer, have natural passive immunity lasting about 6 months. Artificial passive immunity is attained

through inoculation with a vaccine that gives temporary resistance. Such immunizations must be repeated periodically to maintain immunity levels.

ACTIVE IMMUNITY

Active immunity is long-term and sometimes lifelong resistance that is acquired either naturally or artificially. Naturally acquired active immunity comes through host infection. That is, a person who contracts a disease often develops long-lasting antibodies that provide immunity against future exposure. Artificially acquired active immunity is attained through vaccine inoculation. Such vaccines are prepared from killed, living-attenuated, or living-virulent organisms administered to artificially produce or increase immunity to a particular disease. The concept of active immunity underlies public health immunization programs that have successfully kept polio, diphtheria, smallpox, and other major diseases under control worldwide.

CROSS IMMUNITY

Cross immunity refers to a situation in which a person's immunity to one agent provides that person with immunity to another related agent. The immunity can be either passive or active. Sometimes, infection with one disease, such as cowpox, gives immunity to a related disease, such as smallpox. The concept of cross immunity has also been useful in the development and administration of vaccines. Inoculation using a vaccine made from one disease organism can provide immunity to a related disease-causing organism. Field trials in Uganda and Papua, New Guinea, and a study in India are exploring the administration of bacille Calmette-Guérin (BCG) vaccine, used to prevent tuberculosis, to people who have been exposed to Hansen's disease (leprosy). This appears to provide them with a degree of cross immunity to the related infectious agent, *Mycobacterium leprae,* and prevents their contracting the disease (Chin, 1999).

HERD IMMUNITY

Herd immunity describes the immunity level present in a population group (Chin, 1999). A population with low herd immunity is one that has few immune members and is consequently more susceptible to the disease. Nonimmune people are more likely to contract the disease and spread it throughout the group, placing the entire population at greater risk. Conversely, high herd immunity means that the immune people in the group outnumber the susceptible people, thus reducing the incidence of disease. High herd immunity (80% or more) provides the population with greater overall protection because nonimmune people are at less risk of disease exposure. Mandatory preschool immunizations and required travel vaccinations are applications of the herd immunity concept.

Risk

To determine the chances that a disease or health problem will occur, epidemiologists are concerned with **risk** or the probability that a disease or other unfavorable health condition will develop. For any given group of people, risk of developing a health problem is directly influenced by their biology, environment, lifestyle, and the system of health care. Situations or factors in these four areas can negatively affect health and increase the likelihood that a health problem will occur. These negative influences are called *risk factors*. For example, low-birth-weight babies (health status) tend to be at greater risk for health problems, and people whose lifestyles are very stressful are more prone to illness. The degree of risk is directly linked to people's susceptibility or vulnerability to a given health problem.

Epidemiologists study populations at risk. A population at risk means a collection of people among whom a health problem has the possibility of developing because certain influencing factors are either present (such as exposure to HIV) or absent (such as lack of childhood immunizations). A population at risk has a greater probability of developing a given health problem than other groups. Epidemiologists measure this difference using relative risk ratio, which statistically compares the disease occurrence in the population at risk with the occurrence of the same disease in people without that risk factor.

$$\text{Relative Risk Ratio} = \frac{\text{Incidence in Exposed Group}}{\text{Incidence in Unexposed Group}}$$

The risk is the same for both groups if the relative risk ratio is 1:1. When the ratio is greater than 1:0, the exposed group is at greater risk. An example is the difference between the incidence of heart disease among smokers (risk factor) as compared with the incidence of heart disease among nonsmokers. Relative risk ratio assists in determining the most effective points for community health intervention with health problems.

Natural History of Disease or Health Condition

Any disease or health condition follows a progression known as its **natural history;** this refers to events preceding its development, during its course, and during its conclusion. This process involves the interaction among host, agent, and environment. The natural progression of a disease occurs in four stages as they affect a population. They are susceptibility, exposure, onset, and culmination (Fig. 14–5).

1. In the *susceptibility stage,* also called the *stage of prepathogenesis,* the disease is not present nor have individuals been exposed. However, host and environment factors could very likely influence people's susceptibility to a causative agent and lead to development of the disease. For example, in 1994 the overcrowded conditions and poor sanitation of Rwandan refugee camps in Africa (described earlier), as well as refugees' stress, fatigue, and malnutrition, made them extremely vulnerable to contracting cholera and other diseases. However, in a later tragedy in Kosovo (1999), the thousands of refugees

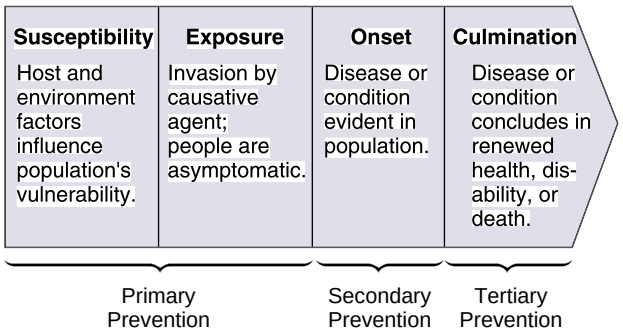

FIGURE 14–5. Natural history stages of a disease or health condition.

fleeing for their lives from Yugoslavian Serbs were housed in refugee border camps with adequate supplies and services, and many found temporary or permanent refuge in other countries, including the United States. They entered a shorter period of stress and fatigue with better nutrition than for those in Rwanda; thus, malnutrition was not as rampant. Because improved conditions in refugee camps eliminated major outbreaks of cholera and other diseases, susceptibility to disease as a group was reduced. Nevertheless, the psychological trauma from the attempts at "ethnic cleansing" of the people in Kosovo remains an existing health problem.

2. The *exposure stage* occurs when individuals have been exposed but are asymptomatic. This stage has also been called *early pathogenesis* because the disease is present in an early form and has begun its work. Vulnerable children who have been exposed to chickenpox (varicella) but do not yet display signs of fever or lesions are an example.
3. During the *onset stage,* signs and symptoms of the disease or condition develop. In the early phase of this period, the signs may only be evident through laboratory tests, such as tubercular lesions on x-ray or premalignant cervical changes evident on Pap smears. Later in this stage, acute symptoms are clearly visible, as in the case of widespread enterocolitis in a salmonellosis (food poisoning) outbreak. Other names for this stage are the *clinical stage* or *early discernible lesions stage* because evidence of the disease or condition is now present.
4. In the *culmination stage,* the disease or health condition is fully advanced and concludes either in a return to health, a residual or chronic form with some disabling limitations, or death. This is also called the *advanced disease stage* because the disease or condition has completed its course. Community health nurses can intervene at any point during these four stages to delay, arrest, or prevent the progress of the disease or condition. Primary, secondary, and tertiary prevention can be applied to the stages (see Levels of Prevention).

Epidemiology of Wellness

The public health science of epidemiology has traditionally studied the occurrence of disease and health problems. Because of their devastating effect on the health of populations, infectious diseases like plague, cholera, and AIDS as well as chronic illnesses like heart disease and cancer and fatal or debilitating injuries all require a continued epidemiologic focus. Nonetheless, the need to examine the epidemiology of wellness grows increasingly urgent.

Epidemiology has moved from concentrating only on illness to examining how host, agent, and environment are involved in wellness at various levels. In response to an escalating need for improved methods for health planning and health policy analysis, epidemiology has developed more holistic models of health. These newer epidemiologic models are organized around four attributes that influence health: (1) the physical, social, and psychological environment, (2) lifestyle with its self-created risks, (3) human biology and genetic influences, and (4) the system of health care organization (Blum, 1981; Dever, 1991). In the United States, establishment of health objectives for the year 2010 (U.S. Department of Health and Human Services, 2000) and greater recognition of the importance and cost-effectiveness of illness prevention and health promotion are driving new efforts at developing policy and research initiatives for public health.

Wellness models that at first focused on individual behavior now include approaches that encompass aggregates. Such a model was used by nurse researchers to study the substance-abuse pandemic (Talashek, Gerace & Starr, 1994). Societal changes, such as the growing elderly population, communication revolution, global economy, environmental threats, technology development, holism and wellness movements, are driving these new approaches.

The natural history stages of disease can apply to one's understanding of any health condition, including wellness states. In stage one, susceptibility, people can become amenable to healthier practices and improved health system organization. In stage two, exposure, a community can learn about these health-promoting behaviors. Stage three, onset, could be a period of trying out the beneficial policies and activities, and stage four, culmination, could be full adoption and a higher level of well-being for the community. This fact has important implications for community health nursing preventive and health promotive practice.

Community health nursing can play a primary role in the investigation and identification of factors that not only prevent illness but also promote health. This means sharpening skills in epidemiologic research to uncover the factors that contribute to a full measure of healthful living. The time for an epidemiology of wellness has come.

Causal Relationships

One of the main challenges to epidemiology is to identify causal relationships in disease and health conditions in

LEVELS OF PREVENTION

PREVENTION DURING NATURAL HISTORY STAGES OF DISEASE

GOAL

Because the events leading to a disease or health condition generally develop over time, there are a number of instances where preventive measures can alter or stop their progress. Community health nurses have a prime opportunity to apply the three levels of prevention—primary, secondary, and tertiary—discussed in Chapter 1—to the natural history progression of a health condition

PRIMARY PREVENTION

Primary prevention, which keeps a health problem from ever occurring, can be applied in both the susceptibility and exposure stages. Susceptible and exposed people are at risk. The number and type of risk factors can be eradicated or reduced through health promotion and protection measures. Health promotion measures might include nutritional counseling, sex education, and smoking cessation. Protective measures might address such areas as improved housing and sanitation, immunizations, and removal of environmental hazards.

Public health efforts using primary prevention have been very successful in reducing disease occurrence with its associated mortality and morbidity. This can be attributed, in particular, to mandatory immunization programs and environmental management.

SECONDARY PREVENTION

Secondary prevention seeks to find and treat existing health problems as early as possible. Secondary prevention measures are used to address the third stage in the natural history of disease, the onset stage, through early detection, diagnosis, and timely treatment. When an illness exists, screening programs can detect such conditions as breast and testicular cancer, hypertension, hearing problems, tuberculosis, and diabetes. Screening tests and early case-finding provide opportunities to diagnose and treat conditions in the early stage of the disease or illness condition's progress. The aim of secondary prevention is to remove the health problem, cure the disease, or at least arrest its progression and prevent associated disability.

TERTIARY PREVENTION

Tertiary prevention seeks to reduce the extent and severity of a health problem in order to minimize disability and restore or preserve function. This level addresses the culmination stage of the natural history of disease process. At this stage, the health condition is advanced; thus, tertiary preventive measures include treatment to arrest further progression of the disease and rehabilitative efforts to limit disability. At the aggregate level, an example of tertiary prevention is providing food, shelter, health services, and training for employment with a homeless population. Another example is group treatment and rehabilitation for adolescent drug users.

Community health nurses apply all three levels of prevention but concentrate their efforts especially on the primary and secondary levels.

populations. As has been suggested in previous sections, the assessment of causality in human health is difficult at best; no single study is adequate to establish causality. Causal inference is based on consistent results obtained from many studies. Frequently, the accumulation of evidence begins with a clinical observation or an educated guess that a certain factor may be causally related to a health problem. A **cross-sectional study** (exploring a health condition's relationship to other variables in a specified population at a certain point in time) can show that the factor and problem coexist. An example is a study of never smokers, former smokers, and current smokers to examine the association of smoking with facial wrinkling (Ernster, Grady, Miike, Black, Selby & Kerlikowske, 1995). Results of the study showed that risk of facial wrinkling was greater in cigarette smokers than in never smokers. A **retrospective study** (looking backward in time to find a causal relationship) allows a fairly quick assessment of whether an association exists. Nonepidemiologic animal studies may suggest a biologic mechanism whereby the factor could cause the disease or condition. At this point, a **prospective study** (looking forward in time to find a causal relationship) is crucial to ensure that the presumed causal factor actually antedates the onset of the health problem. The prospective approach is concerned with current information and provides a direct measure of the variables in question. Finally, if ethically possible, an **experimental study** (in which the investigator controls or changes factors suspected of causing the condition and observes results) is used to confirm the associations obtained from the observational studies. Thus, it often requires many years to accumulate enough evidence to suggest a causal relationship.

Epidemiologically, one can accept that a causal relationship may exist when two major conditions are met: (1) the factor of interest (causal agent) is shown to increase the probability of occurrence of the disease or condition as observed in many studies in different populations, and (2) there is evidence that a reduction in the factor decreases the frequency of the given disease. The synthesis of data begins by selecting as many as possible of all the various types of epidemiologic studies on the problem. After discarding those studies that are not methodologically sound, the studies are reviewed. The better the data meet the following six criteria, the more likely the factor of interest will be one of several causes of the disease:

1. Temporal relationship: Exposure to the suspected factor must precede the onset of disease.
2. Strength of the association: This refers to the ratio of disease rates in those with and without the suspected causal factor. A strong association would be noted when disease rates are much higher in the group with the factor than in the group without it.
3. Dose–response relationship: This relationship is demonstrated if, with increasing levels of exposure to the factor, there is a corresponding increase in occurrence of disease.

4. Consistency: Association is demonstrated in varying types of studies among diverse study groups.
5. Biologic plausibility and coherence of the evidence: The hypothesized cause makes sense based on current biologic knowledge.
6. Lowering of disease risk: Interventions that decrease the exposure or factor result in a lowering of disease risk (relative risk).

The goal of any epidemiologic investigation is to identify causal mechanisms that meet the above criteria and to develop measures for preventing illness and promoting health. The community health nurse may need to gather new data for this type of investigation but should thoroughly examine existing, pertinent data before doing so. This type of information can be obtained by the community health nurse from a variety of sources, discussed in the next section.

SOURCES OF INFORMATION FOR EPIDEMIOLOGIC STUDY

Epidemiologic investigators may draw data from three major sources or a combination of these sources. They are (1) existing data, (2) informal investigations, and (3) scientific studies. The community health nurse will find all three sources useful in efforts to improve the health of aggregates.

Existing Data

A variety of information is available nationally, by states, and by sections, such as counties, regions, or urbanized areas. This information includes vital statistics, census data, and morbidity statistics on certain communicable or infectious diseases. Local health departments often can provide these data on request. Community health nurses seeking information on nearby communities may find local health system agencies helpful. These agencies work to collect health information for groups of counties within states and interact with health planning authorities at the state level. They have access to many types of information and can give advice on specific problems raised by nurses.

VITAL STATISTICS

Vital statistics is a term used for the information gathered from ongoing registration of "vital" events relating to births, deaths, adoptions, divorces, and marriages. Certification of births, deaths, and fetal deaths are the vital statistics most useful in epidemiologic study. The community health nurse can obtain blank copies of a state's birth and death certificates to become familiar with the information contained in each. It will become apparent that much more information is recorded than the fact and cause of death on the death certificate. Birth certificates also can provide helpful information. For example, the weights of infants and the amount of prenatal care received by their mothers have been used to identify high-risk mothers and infants.

CENSUS DATA

Data from population censuses taken every 10 years in many countries are the main source of population statistics. This information can be a valuable assessment tool for the community health nurse taking part in health planning for aggregates. These population statistics can be analyzed by age, sex, race, ethnic background, type of occupation, income gradient, marital status, or educational level, as well as by other standards, such as housing. Analysis of population statistics can provide the community health nurse with a better understanding of the community and help identify specific areas that may warrant further epidemiologic investigation.

REPORTABLE DISEASES

Each state has developed laws or regulations that require health organizations and practitioners to report to their local health authority cases of certain communicable and infectious diseases that can be spread through the community (Chin, 1999). This reporting enables the health department to take the most appropriate and efficient action. All states require that the diseases subject to international quarantine regulations be reported immediately. These diseases (plague, cholera, yellow fever, and smallpox) are virtually unknown now in developed countries. The World Health Organization announced the global eradication of smallpox in 1980 after more than 10 years of international effort (The World Health Report, 1998). In addition, there are numerous diseases under surveillance by the World Health Organization (eg, louse-borne typhus fever and relapsing fever, paralytic poliomyelitis, malaria, and viral influenza), and these must be reported. The other reportable diseases (varying between 20 and 40 by state) are usually classified according to the speed with which the health department should be notified. Some should be reported by phone or electronic mail, others weekly by regular mail. They vary in potential severity from chickenpox to rabies and include AIDS, encephalitis, meningitis, syphilis, and toxic shock syndrome. Community health nurses should obtain the list of reportable diseases from their local or state health department offices. Following up on occurrences of these diseases is a task frequently assigned to community nursing services.

DISEASE REGISTRIES

In some areas or states, there are disease registries or rosters for conditions with major public health impact. Tuberculosis and rheumatic fever registries were more common in past years when these diseases occurred more frequently. Cancer registries provide useful incidence, prevalence, and survival data and assist the community health nurse in monitoring cancer patterns within a community.

ENVIRONMENTAL MONITORING

State governments, sometimes through health departments and sometimes through other agencies, now monitor health hazards found in the environment. Pesticides, industrial wastes, radioactive or nuclear materials, chemical additives in food, and medicinal drugs have joined the list of pollutants (see Chapter 16 for detailed discussion). Concerned community members and leaders view these as risk factors that affect health at both the community and individual levels. Community health nurses can also obtain data from federal agencies such as the Food and Drug Administration, the Consumer Product Safety Commission, and the Environmental Protection Agency.

NATIONAL CENTER FOR HEALTH STATISTICS HEALTH SURVEYS

On the national level (published data are frequently available also for regions), the National Center for Health Statistics (NCHS) furnishes valuable health prevalence data from surveys of Americans (Scutchfield & Keck, 1997). The Health Interview Survey includes interviews from approximately 40,000 households each year and provides information about the health status and needs of the entire country. The Health Examination Survey reports physical measurements on smaller samples of the population and augments the information provided by interviews. This survey provides prevalence information on injuries, diseases, and disabilities that appear frequently in the population. A third type of NCHS survey is of health records. This survey samples institutional records of hospitals and nursing homes, primarily. This survey provides information on those who are using services from these institutions along with diagnoses and other characteristics. Other NCHS surveys focus on fertility and family planning, follow back studies on vital statistics events, and characteristics of ambulatory patients in physicians' community practices.

Each of these nationally sponsored efforts suggests ways in which community health nurses can examine health problems or concerns affecting their communities. Interviews, physical examinations of samples of community members, and surveillance of institutions, clinics, and private physicians' practices can be carried out locally when needs are identified and funds made available. Other sources may be found in data kept routinely but not centrally on the health problems of workers in local industry or health problems of schoolchildren, a key issue to many community health nurses. Existing epidemiologic data can be used to plan parent education programs, health promotion among students, and almost any other type of service.

Informal Observational Studies

A second information source in epidemiologic study comes through informal observation and description. Almost any client group encountered by the community health nurse can trigger such a study. If, for example, the nurse encounters an abused child at a clinic, screening the clinic's records for possible further instances of child abuse and neglect could lead to more case finding. If several cases of diabetes come to the attention of a nurse serving on a Navajo reservation, a widespread problem might come to light through conducting informal inquiries about the incidence and age of onset of the disease among this Native American population. A nurse working with several elderly widows living alone learned by questioning them that being independent was secondary to staying in their own homes. Interview data revealed that these older widows had learned to accept their aloneness, exercised freedom and delegation in getting things done, practiced safety measures, and took good care of themselves, thus enabling them to continue to live at home (Porter, 1994). Collecting such information, complemented with existing data, could lead to improved understanding and service to the broader population of elderly widows living alone. Informal observational study often raises questions and suggests hypotheses that form the basis for designing larger-scale epidemiologic investigations.

Scientific Studies

The third source of information used in epidemiologic inquiry involves carefully designed scientific studies. Nursing, as a profession, has recognized the need to develop a systematic body of knowledge on which to base nursing practice. Already, systematic research is becoming an accepted part of the community health nurse's role. Findings from epidemiologic studies conducted by or involving nurses are appearing more frequently in the literature. For example, concern about a large number of infant injuries led a nurse and physician research team to study sociodemographic and psychosocial risk factors causing unintentional infant injuries in the home (Harris & Kotch, 1994). They learned that family conflict and maternal unemployment were among predictors for unintentional injury. They also learned that use of social support to alleviate maternal stress resulted in fewer unintentional infant injuries. In another study, conducted in Baltimore, Maryland, researchers examined whether interventions aimed at aggressive and disruptive classroom behavior and poor academic achievement would also reduce the incidence of smoking initiation (Kellam & Anthony, 1998). An epidemiologically based, universal randomized preventive study involved 2,311 boys in two classroom-based interventions or controls. Each intervention was directed at one of the aforementioned two antecedents over first and second grades in 19 urban Baltimore schools. Smoking initiation was reduced in both cohorts for boys at final assessment age of 14 who were assigned to the behavioral intervention. The researchers concluded that targeting early risk antecedents such as aggressive behavior appears to be an important smoking-prevention strategy. Systematic studies such as these, as well as informal studies and existing epidemiologic data, can provide the community

health nurse with valuable information that can be used to positively affect aggregate health.

METHODS IN THE EPIDEMIOLOGIC INVESTIGATIVE PROCESS

The goal of epidemiologic investigation is to identify the causal mechanisms of health and illness states and to develop measures for preventing illness and promoting health. Epidemiologists employ an investigative process that involves a sequence of three approaches that build on one another: descriptive, analytic, and experimental studies. All three approaches have relevance for community health nursing.

Descriptive Epidemiology

Descriptive epidemiology includes investigations that seek to observe and describe patterns of health-related conditions that naturally occur in a population. For example, a community health nurse might seek to learn how many children in a school district have been immunized for measles, how many home births occur each year in the county, or how many cases of STDs have occurred in the city in the past month. At this stage in the epidemiologic investigation, one seeks to establish the occurrence of a problem. Data from descriptive studies suggest hypotheses for further testing. Descriptive studies almost always involve some form of broad-based quantification and statistical analysis.

COUNTS

The simplest measure of description is a count. For example, an epidemiologic study of childhood drownings was conducted to provide data for prevention efforts in Harris County, Texas (Warneke & Cooper, 1994). One of the first steps in the research was to make a simple count of the number of child and adolescent (newborn through 19 years) drownings that occurred. The investigators gathered data from death certificates (1983 through 1989) and medical examiner data (1983 through 1990); most of the 196 unintentional drownings occurred in swimming pools, half of which were in apartment complexes and a third of which were in private homes (Fig. 14–6). Obtaining a count of this type always depends on the definition of what one counts. This count, for example, does not represent all drownings occurring in the county, but only those in this age group. As in most kinds of research, availability of data influences the count. Before making use of any statistics, whether from official state offices, the Census Bureau, or a health agency, it is necessary to determine what the information represents.

RATES

Rates are a statistical measure expressing the proportion of people with a given health problem among a population at risk. The total number of people in this group serves as the denominator for various types of rates. To express a count as a proportion, or rate, one must first decide on the population to be studied. If 196 drownings are considered in relation to the total number of children in Harris County, there will be one rate; if they are considered in relation to the total population of children in the state, there will be a different proportion.

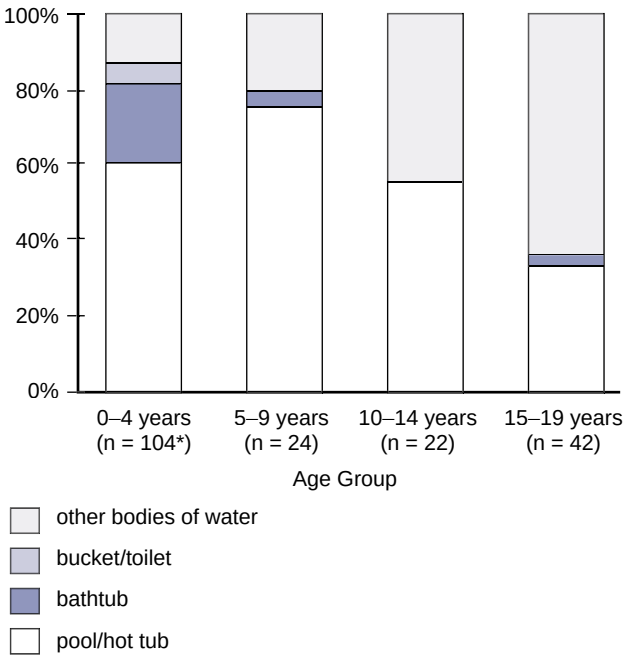

FIGURE 14–6. Percentage distribution for location of submersion, by age group, for unintentional drownings that, according to medical examiner files, occurred in Harris County, Texas, 1983 through 1990, among persons newborn through 19 years. (Warneke & Cooper, 1994, p. 595. Reprinted by permission.)

In epidemiology, the population represents the universe of people defined as the objects of one's study. Because it is often difficult, if not impossible, to study an entire population, most epidemiologic studies draw a sample to represent that group. For example, in the Baltimore study dealing with behavioral interventions that decrease smoking initiation, the investigators selected a random sample of 2,311 children in 19 classrooms to include as study subjects or controls out of a much larger urban school population (Kellam & Anthony, 1998). Sometimes, it is important to seek a random sample (when everyone in the population has an equal chance of selection for study and choice is made without bias); at other times, a sample of convenience (when study subjects are selected because of their availability) is sufficient. In many small epidemiologic studies, it may be possible to study nearly every person in the population, thus eliminating the need for a sample.

Several proportions have wide use in epidemiology. Those most important for the community health nurse to understand include prevalence rate, period prevalence rate, and incidence rate.

Prevalence refers to all people with a health condition existing in a given population at a given point in time. The prevalence rate describes a situation at one point in time (Friedman, 1994). If a nurse discovers 50 cases of measles in an elementary school, that is a simple count. If that number is divided by the number of students in the school, it describes the prevalence of measles. For instance, if the school has 500 students, the prevalence of measles on that day would be 10% (50 measles/500 population).

$$\text{Prevalence Rate} = \frac{\text{Number of Persons With a Characteristic}}{\text{Total Number in Population}}$$

In the study of reported drownings, on the other hand, the investigators had a count for a 7-year period, 1983 to 1990. Rather than portraying only one day, this number covered an extended period of time. Calculating the prevalence rate over a period of time is called a period prevalence rate.

$$\text{Period Prevalence Rate} = \frac{\text{Number of Persons With a Characteristic During a Period of Time}}{\text{Total Number in Population}}$$

Not everyone in a population is at risk for developing a disease, incurring an injury, or having some other health-illness characteristic. The incidence rate recognizes this fact. **Incidence** refers to all new cases of a disease or health condition appearing during a given time. Incidence rate describes a proportion in which the numerator is all new cases appearing during a given time and the denominator is the population at risk during the same period of time. For example, some childhood diseases give lifelong immunity. The children in a school who have had such diseases would be removed from the total number of children at risk in the school population. The incidence rate, after 3 weeks of a measles epidemic in a school, was

$$\frac{200}{1000} \text{ or } \frac{200 \text{ New Cases}}{1000 \text{ Persons at Risk}}$$

during the 3-week time period. The health literature is not always consistent in the use of the term *incidence;* sometimes, this word is used synonymously with *prevalence rates,* and the reader must take this into consideration.

$$\text{Incidence Rate} = \frac{\text{Number of Persons Developing a Disease}}{\text{Total Number at Risk per Unit of Time}}$$

Another rate describing incidence is called an attack rate. An *attack rate* describes the proportion of a group or population that develops a disease among all those exposed to a particular risk. This term is used frequently in investigations of outbreaks of infectious diseases such as influenza. When the attack rate changes, it may suggest an alteration in the population's immune status or that the disease-causing organism is present in a more or less virulent strain.

COMPUTING RATES

To make comparisons between populations, epidemiologists often use a common base population in computing rates. For example, instead of merely saying that the rate of an illness is 13% in one city and 25% in another, the comparison is made per 100,000 people in the population. This population base can vary for different purposes from 100 to 100,000. To describe the **morbidity rate,** which is the relative incidence of disease in a population, one would describe the ratio of the number of sick individuals to a total given population. The **mortality rate** refers to the relative death rate or the sum of deaths in a given population at a given time. Display 14–2 includes formulas for computing rates commonly used in community health.

The goal of descriptive studies is to identify the patterns of occurrence of any health-related condition. They can be retrospective (identify cases and controls, then go back to review existing data) or prospective (identify groups and exposure factors and follow them forward in time). In a descriptive study of child abuse, for example, the investigator would note the age, sex, race or ethnic group, and physical and emotional conditions of the children affected. In addition, data would be collected that described the economic status and occupation of parents, the location and setting of abusive behavior, and the time and season of the year when abuse occurred. In the study on reported drownings in Harris County, Texas (retrospective design), the investigators described the age, sex, and ethnic background of victims and other features such as location and time of drowning. Describing facets of these health conditions provided information for further study as well as suggested avenues for intervention or prevention.

Analytic Epidemiology

A second type of epidemiologic investigation is analytic. **Analytic epidemiology** goes beyond simple description or observation and seeks to identify associations between a particular human disease or health problem and its possible cause(s). Analytic studies tend to be more specific than descriptive studies in their focus. They test hypotheses or seek to answer specific questions and can be retrospective or prospective in design. For example, in a prospective analytic study, several nurses set out to address the question, are paper diapers more effective in controlling fecal contamination than cloth diapers in a day care environment? The nurses studied children and providers in four licensed day care centers in Davidson County, Tennessee (Holaday et al., 1995). A total of 104 children and 25 caregivers participated in the study over a period of 8 weeks. The centers were supplied with cloth and paper diapers, and two centers used cloth diapers for the first 4-week period while the other two used paper, each then switching to the other diaper type for the second 4-week period. The investigators monitored selected rooms twice weekly in each center for the presence of fecal bacteria by sampling of play/sleep area, diaper changing

DISPLAY 14-2. **Common Epidemiologic Rates**

General Mortality Rates

Crude Morality Rate =
$$\frac{\text{Number of Reported Deaths During 1 Year}}{\text{Estimated Population as of July 1 of Same Year}} \times 100{,}000$$

Cause-Specific Mortality Rate =
$$\frac{\text{Number of Deaths From a Stated Cause During 1 Year}}{\text{Estimated Population as of July 1 of Same Year}} \times 100{,}000$$

Case Fatality Rate =
$$\frac{\text{Number of Deaths From a Particular Disease}}{\text{Total Number With the Same Disease}} \times 100$$

Proportional Mortality Ratio =
$$\frac{\text{Number of Deaths From a Specific Cause Within a Given TIme Period}}{\text{Total Deaths in the Same Time Period}} \times 100$$

Age-Specific Mortality Rate =
$$\frac{\text{Number of Persons in a Specific Age Group Dying During 1 Year}}{\text{Estimated Population of the Specific Age Group as of July 1 of Same Year}} \times 100{,}000$$

Specific Rates for Maternal and Infant Populations

Crude Birth Rate =
$$\frac{\text{Number of Live Births During 1 Year}}{\text{Estimated Population as of July 1 of Same Year}} \times 1{,}000$$

General Fertility Rate =
$$\frac{\text{Number of Live Births During 1 Year}}{\text{Number of Females Aged 15–44 as of July 1 of Same Year}} \times 1{,}000$$

Maternal Mortality Rate =
$$\frac{\text{Number of Deaths From Puerperal Causes During 1 Year}}{\text{Number of Live Births During Same Year}} \times 100{,}000$$

Infant Mortality Rate =
$$\frac{\text{Number of Deaths Under 1 Year of Age for Given Year}}{\text{Number of Live Births Reported for Same Year}} \times 1{,}000$$

Perinatal Mortality Rate =
$$\frac{\text{Number of Fetal Deaths Plus Infant Deaths Under 7 Days of Age During 1 Year}}{\text{Number of Live Births Plus Fetal Deaths During Same Year}} \times 1{,}000$$

area, and caregivers' and children's hands (Fig. 14–7). No significant differences were found between cloth and paper diapers in the frequency or intensity of fecal contamination. However, the study revealed that sink faucets and caregivers' and children's hands were often contaminated, suggesting the need for further study of handwashing and diapering techniques, use of disinfectant hand creams, and altering the environment by installing automatic, faucet-free handwashing sinks. Like many analytical studies, this one gathered a great deal of descriptive data as well.

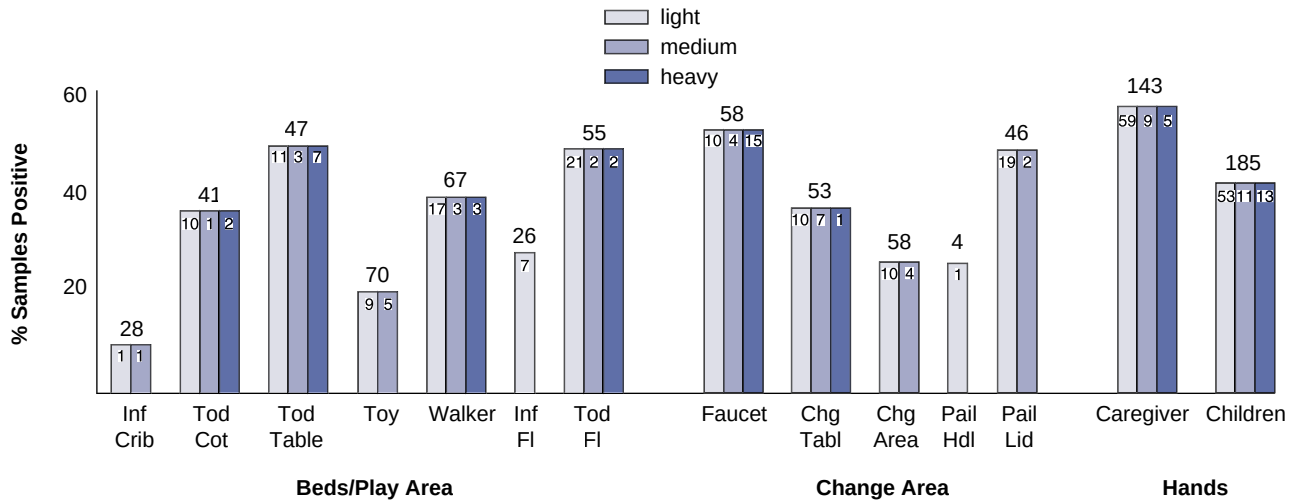

FIGURE 14–7. Cloth vs. paper diaper study. Total fecal cultures by collection site and location: percentage of positive samples from all four centers in both time periods (Holaday, et al, 1995, p. 31). Reprinted by permission. Note: Above each bar is the total number of specimens collected at each site. Within each bar is the number of positive samples that are classified as light, medium, or heavy growth. Inf crib = infant crib; tod cot = toddler cot; tod table = toddler table; inf fl = infant floor; tod fl = toddler floor; chg tabl = diaper change table; chg area = diaper change area; hdl = diaper pail handle; pail lid = diaper pail lid.

Analytic studies fall into three types: prevalence studies, case-control studies, and cohort studies.

PREVALENCE STUDIES

When one examines prevalence, it is helpful to remember that the health condition may be new or may have affected some people for many years. Prevalence studies describe patterns of occurrence, as in the study of reported drownings in Texas and in the study described in Research: Bridge to Practice. They may examine causal factors, but these are always from the same point in time and the same population. Hypothesized causal factors are based on inferences from a single examination and most likely need further testing for validation.

CASE-CONTROL STUDIES

Case-control studies make a comparison between people with a health-illness condition (cases) and those who lack this condition (controls). These studies begin with disease (case) and look back over time for presence or absence of the suspected causal factor in both cases and controls. In the study of early antecedents to prevent smoking initiation, 1,604 students remained in the Baltimore City public schools. Of that number, 700 had participated as study subjects (cases); the 904 other children not experiencing the interventions were the controls. This study then reviewed the history of cases and controls for the presence of aggressive or disruptive behavior among the 1,604 students remaining in the school system. In a case-control study, both groups should share as many characteristics as possible in order to isolate possible causes; randomly selecting first- and second-grade classrooms helps to ensure this. Comparison between one group of children in first grade with another group in their late teens would have invalidated the conclusion in a study on the effects of behavioral interventions.

COHORT STUDIES

A **cohort** is a group of people who share a common experience in a specific time period. Examples are a group of elders or the employees of an industry. In epidemiology, a cohort of people often becomes a focus of study. Cohort studies, rather than measuring the relationship of variables in existing conditions, study the development of a condition over time. A cohort study begins by selecting a group of people who display certain defined characteristics before the onset of the condition being investigated. In studying a disease, the cohort might include individuals initially free of the disease but known to have been exposed to a particular factor. They would be followed over time to evaluate what variables were associated with the development or nondevelopment of the disease. An example is the prospective study of unintentional infant injuries, mentioned earlier (Harris & Kotch, 1994). The subjects, a cohort of 367 mothers, were interviewed 6 to 8 weeks after the newborns' hospital discharge and then again approximately 1 year later. Investigators were able to identify injury predictors (family conflict and maternal unemployment) and also interventions (social support) for reducing the number of injuries.

In actual practice, the various types of studies just discussed are frequently mixed. A case-control study may include description and analysis with a retrospective focus; a cohort study may be conducted prospectively or retrospectively. The study of early antecedents to prevent tobacco smoking (Kellam & Anthony, 1998) was a case-control study, a cohort study, and an experimental study (see below). Flexibility is essential to allow the investigator as much freedom as possible in choosing the most useful methodology.

RESEARCH Bridge to Practice

Safety Belt Use After California's Primary Law

Lange, J.E. & Voas, R.B. (1998). Nighttime observations of safety belt use: An evaluation of California's primary law. *American Journal of Public Health, 88*(11), 1718–1720.

In 1993, California was the first state in the country to modify an existing safety belt law from a secondary to a primary enforcement law, meaning that not wearing a safety belt can be the only reason one is stopped by the police. Before this change, if drivers were stopped for another reason, they could also be cited for not wearing a safety belt. This study analyzed what effect this change had on safety belt use among nighttime weekend drivers. Observations were made in two California communities during voluntary roadside surveys conducted every other Friday and Saturday night from 9 PM to 2 AM for 4 years from 1991 to 1995. Over 18,4000 drivers were surveyed. Data collected over the 4 years show that rates of safety belt use rose from 73.0% to 95.6%. High-risk drivers, such as those with a blood alcohol concentration of 0.10 or higher, had rates rise from 53.4% to 92.1%. "Because substantial improvement in safety belt use was seen even in a group of high-risk drivers, the injury reduction benefits of this law may be high" (p. 1718).

Experimental Epidemiology

Experimental epidemiology follows and builds on information gathered from descriptive and analytic approaches. It is used to study epidemics, the etiology of human disease, the value of preventive and therapeutic measures, and the evaluation of health services (Timmreck, 1998). In an experimental study, the investigator actually controls or changes the factors suspected of causing the health condition under study and observes what happens to the health state. In human populations, experimental studies should focus on disease prevention or health promotion rather than testing the causes of disease, which is done primarily on animals.

Experimental studies are carried out under carefully controlled conditions. The investigator uses an experimental group and exposes them to some factor thought to cause disease, improve health, prevent disease, or influence health in some way. Simultaneously, the investigator uses a control group that is similar in characteristics to the experimental group but without the exposure factor. An example is a study

conducted by several nurses to examine the influence of case management approaches on client use of preventive child health services (Erkel, Morgan, Staples, Assey & Michel, 1994). An experimental group of infants received continuity of care provided by a single public health nurse who integrated case management and preventive services. The control group of infants received the customary pattern of services, which were fragmented and delivered by multiple public health nurses. Findings showed that continuous, integrated public health nursing case management was significantly more effective in achieving client use of preventive child health services and was also one fifth the cost of the control group's fragmented services.

The community health nurse should be alert for opportunities to conduct experimental studies in the course of working with groups. The study need not be elaborate and can provide important data for future nursing practice. For example, a study conducted in Albuquerque, New Mexico, compared 17 schoolboys with violent behavior with a control group of 27 carefully matched students (second through fifth grades) who were not overtly violent at school (Sheline, Skipper & Broadhead, 1994). Data were gathered through questionnaires completed by all students and in-home interviews with parents or guardians. Findings showed that boys from families with absent fathers, divorced parents, or numerous siblings were at higher risk for violent behavior. Lack of parental affection and expression of pride and use of spanking as discipline were parenting practices most strongly associated with violent behavior. The findings suggested the need for programs in parental education and encouragement to show affection and to use other methods of discipline. Similar experimental studies could be done with almost any small group within the community health nurse's practice.

An expanding area of experimental epidemiology involves the use of computers to simulate epidemics. With mathematical models, it is possible to determine the probability of various aspects of disease occurrence. This approach is making an increased contribution to epidemiologists' knowledge of etiology and prevention.

At present, there is a national longitudinal experimental study involving thousands of nurses called the Brigham and Women's Hospital/Harvard Medical School Women's Health Study. It consists of a randomized trial evaluating the balance of benefits and risks of low-dose aspirin and vitamin E in the prevention of cancer and cardiovascular disease. Depending on the random assignment of the nurses, participants are taking 100 mg of aspirin or placebo and 600 IU of vitamin E or placebo. Early in the study, 50 mg of beta carotene or placebo was included in the study, but findings in other studies associated additional beta carotene with a higher risk of lung cancer. It was removed from the study in the mid-1990s. This is a double-blind study (neither the participants or researchers know which subjects are taking the study drugs or placebos). Nurses were selected for this major study because, as an aggregate, they are accessible through RN registry, and it was assumed that nurses, who know the value of research, would have a higher rate of follow-through in taking the test drugs routinely than the general public. Data on the health status of the participants is gathered every 6 months, and the study is presently funded through 2001.

Occasionally, an experiment occurs naturally in which conditions offer the researcher the chance to make important discoveries. John Snow discovered such a "natural experiment" in London in 1854 (Turnock, 1997). In his seminal study of an epidemic of cholera, he observed one group that contracted the disease and another that did not. Closer inspection revealed that the major difference between these groups was their water supply. Eventually, the spread of cholera was traced to the water supply of the group with the high morbidity rate.

A *community trial* is a type of experimental study done at the community level (Timmreck, 1998). In this type of study, geographic communities are assigned to intervention (experimental) or nonintervention (control) groups and compared to determine whether the intervention produces a positive change in the community. Community trials can be extremely expensive and are not undertaken unless there is substantial evidence that the intervention will make a difference at the aggregate level.

The Minnesota Heart Health Program was one such community trial conducted in the Minneapolis/St. Paul area (Mittlemark et al., 1989). This study compared three sets of paired communities in the Upper Midwest. Each pair had one community in the intervention group and one in the nonintervention group. The intervention communities received multiple intervention techniques such as dietary instruction, smoking cessation intervention, and risk factor instruction. Myocardial infarction, stroke, and mortality rates along with other measurements were done at regular intervals to evaluate whether the interventions were improving the health in the communities that received them. Another classic example was the Kingston/Newburgh, New York, study, conducted in the 1950s in which two towns on opposite sides of a river, one whose water system was fluoridated and the other was not, compared dental records and learned that there was an association between fluoridated water and reduced dental caries. One consequence of this study was the development of fluoridated toothpaste.

CONDUCTING EPIDEMIOLOGIC RESEARCH

The community health nurse who engages in an epidemiologic investigation becomes a detective. First, there is a problem to solve, a puzzle to unravel, or a question to answer. Then, one begins to search for basic information, clues that might help answer the question. Information is never self-explanatory, and, like a detective, one must analyze and interpret every additional clue. Slowly, there is a narrowing of possible suspects until the causes of a disease, the consequences of a prevention

plan, or the results of treatment are identified. On the basis of this investigation, one can then draw further conclusions and make new applications to improve health services.

As discussed previously, epidemiologic studies are a form of research. The steps outlined below are similar to those discussed in Chapter 11. Epidemiologic research involves seven steps. Both an informal study in the course of nursing practice and the most comprehensive epidemiologic research project can be undertaken with these steps:

1. Identify the problem.
2. Review the literature.
3. Design the study.
4. Collect the data.
5. Analyze the findings.
6. Develop conclusions and applications.
7. Disseminate the findings.

Each of these steps will be considered in the context of a single nursing study examining the untoward effects of in-utero drug exposure for a group of infants and children.

Identify the Problem

Community health nurses are constantly confronted with threats to the health and well-being of the community. Almost daily, questions are raised, puzzles presented, and problems identified. Pregnant women who smoke or use cocaine threaten the health of their unborn children; what can be done to reduce this behavior? Rape is increasing; what can be done to prevent such violence or to bring aid to victims? Children are injured and die from bicycle accidents; why do these occur and how can they be prevented? Many farm workers have been killed or injured in farm equipment accidents; what can be done to prevent them? Any threat to the health of a group offers fertile ground for epidemiologic investigation.

One team of nurse researchers was concerned with the untoward effects of in-utero drug exposure (IUDE) on cognitive development and health problems in infants and children (Butz et al., 1998). Intensive home-based interventions provided by registered nurses proved an effective method to improve cognitive development and reduce health problems in these high-risk infants and children, supporting the view that home visiting should be incorporated into the discharge planning of any IUDE infant.

Review the Literature

All too often, after identifying a problem, health professionals rush to take immediate action without reviewing solutions that have been tried previously. Every epidemiologic investigation should begin with a review of the literature. Even discovering that little research has been done on the problem can be valuable information. Conversely, if many studies have already been conducted on the area, this information can help narrow the study to areas not previously investigated or allow researchers to replicate earlier studies to confirm findings in a different setting. One of the most valuable sources in the literature is the review article, which essentially summarizes all the research that has been conducted on a subject.

A review of the literature often suggests hypotheses from discoveries made in other studies. In the home intervention program for IUDE infants, a review of the literature did provide helpful background information; however, "home intervention studies specifically examining IUDE infants are sparse" (Butz et al., 1998, p. 308). The literature review also revealed that, when interventions were provided, they proved to be an effective method in many other settings with different populations. This assisted the researchers with this study.

Design the Study

The first step in designing a study is to formulate a specific question(s) to answer or perhaps a hypothesis to test. Sometimes, this question or hypothesis may emerge from the review of literature; at other times, it will have to be developed through the researcher's own analysis and hunches. It is a good idea to write out one or more hypotheses to test or questions to answer. The researchers in the IUDE infants study formulated several research questions, which led to a conceptual model for the study that used "a home-based nurse intervention focused on the mother and infant and aimed to reduce infant morbidity" (Butz et al., 1998, p. 308).

The next step is to plan what type or combination of study types will best suit the goals of the research (descriptive, analytic, or experimental) and how the study will be conducted. Will the data be collected retrospectively from existing records, or will new data be collected? Who will conduct interviews? What kinds of data will be needed to measure the outcomes of intervention?

The IUDE infants study was part of a larger, randomized clinical trial, which included 204 mother–infant dyads. This study reported analysis of home visit data for the first 20 enrolled infants and their mothers, and they received a total of 229 home visits.

Collect the Data

Data in the IUDE study were collected from existing records by analyzing the mean length of the home visits, mean scores on the type of educational material provided, the reception of the information by the mother/caregiver, and the quality of the nurse–mother/caregiver relationship. In addition, "clinical follow-up data (immunization status, number of developmental referrals) was collected at 6 months of age and analyzed by frequency distributions" (Butz et al., 1998, p. 310).

It is useful to perform a pilot study that pretests an interview guide or questionnaire. If one wishes to interview women about battering during pregnancy, it might be useful to prepare a guide and interview one or two people, then re-

vise the guide on the basis of one's experience. If developing a questionnaire to assess the nutritional needs of elderly people living alone, it would be helpful to test the survey on some volunteers to determine its clarity and relevance.

In community health nursing, data collection often can occur as part of ongoing practice. Unless the study has been carefully designed, however, one may collect data for months or years, only to discover that important questions have been omitted.

Analyze the Findings

In most epidemiologic studies, data analysis will consist of summarizing the findings, computing rates and ratios, and displaying the findings in tables and graphs. It is at this stage that the data are used to address the original questions or test the original hypothesis. Was the hypothesis supported or not supported by the data? Summarized data can also generate more questions or indicate areas that warrant further investigation. For example, one of the pieces of data accumulated in the IUDE study that was not a main focus of the study was that, on 25 home visits, during 10 of the visits (40%), there was evidence of rats/mice/cockroaches in the home, and, in 4 (16%) of the home visits, there was dust/garbage/clutter/dirt in the home. This leads to additional questions. What housing options are available to these mothers? Who is monitoring the landlord or homeowner responsibilities? Where is the priority of house cleaning among these mothers or other household members? Are there additional services (social, broader based teaching, environmental health referrals, and so forth) nurses provide when making these IUDE home visits?

Develop Conclusions and Applications

Stating conclusions is an outcome of analysis and interpretation. The investigators summarize the results and their meaning for the purpose of making it useful to other health services providers. Many times, the research will have direct practical application for improving health services, continuing or discontinuing services, and conducting future research. It is also important to describe mistakes made and lessons learned about study design and other aspects of the research to assist future investigators.

The researchers' conclusions from the IUDE study were that these 20 mother–infant dyads experienced health (30%) and social (80%) problems, supporting "the suggestion that nurse home visiting programs, if adequately designed and implemented, can expand office and clinic based efforts for high risk infants including IUDE infants" (Butz et al., 1998, p. 313).

Disseminate the Findings

Finally, research findings should be shared. Information gained from epidemiologic study must be disseminated throughout the professional community to strengthen the knowledge base for improved practice and to promote future research. The IUDE study was published in *Public Health Nursing* in October of 1998 and describes a portion of the work of David Olds and others over 15 years of a major ongoing study on the outcomes of intensive nurse home visiting among high-risk infants and children (Olds, 1992; Olds, Henderson & Kitzman, 1994; Olds et al., 1997).

SUMMARY

Epidemiology is the study of the distribution and determinants of health, health conditions, and disease in human population groups. It shares with community health nursing the common focus of the health of populations. It is a specialized form of scientific research that can provide public health professionals with a body of knowledge on which to base their practice and methods for studying new and existing problems. To understand epidemiology, one must first understand some basic epidemiologic concepts: the host, agent, and environment model; causality; immunity; the natural history of disease or health conditions; risk; and prevention strategies.

Community health nurses can use three sources of information when conducting epidemiologic investigations: existing epidemiologic data, informal investigations, and carefully designed scientific studies.

Epidemiology employs three investigative approaches: descriptive studies, analytic studies, and experimental studies. Although studies can be either retrospective or prospective, some merely describe existing conditions (descriptive studies), whereas others seek to explain causes (analytic studies). Experimental studies seek to confirm causal relationships identified in descriptive and analytic studies. Analytic studies can be of three types: prevalence, case-control, or cohort. In practice, all these types of studies often become combined in various ways. They also make use of quantitative concepts such as count, prevalence rate, incidence rate, mortality rate, and various types of morbidity (sickness) rates.

Epidemiologic research includes seven steps:

1. Identify the problem, which is usually some threat to the health of a population.
2. Review the literature to determine what other studies have found.
3. Carefully design the study.
4. Collect the data.
5. Analyze the findings.
6. Develop conclusions and applications.
7. Disseminate the findings.

Thinking epidemiologically can significantly enhance community health nursing practice. Epidemiology provides both the body of knowledge—information on the distribution and determinants of health conditions—and methods for investigating health problems and evaluating services.

ACTIVITIES TO PROMOTE CRITICAL THINKING

1. Identify an aggregate-level health problem in your community. Using the host, agent, and environment model, explain who is the host, what is the causative agent(s), and what environmental factors have promoted or delayed the development of the problem.
2. Select an aggregate health (wellness) condition, such as preschoolers' normal growth and development or elders' healthy aging, and list all the causal factors that might contribute to this healthy state. Now, plot these schematically in a diagram (such as Fig. 14–3) to show the web of causation for this condition.
3. Using the same health condition that you selected in the previous exercise, describe the natural history of this condition, outlining its four stages. Identify three preventive nursing interventions, one for each level of prevention, that could apply to this condition.
4. Select an article that reports an epidemiologic study from a recent nursing or public health journal, and record your responses to the following questions:
   a. What prompted the study, and what was its purpose?
   b. Was it descriptive, analytic, or experimental research?
   c. Was the study design retrospective or prospective?
   d. Why did the investigators choose this design?
   e. What existing sources of epidemiologic data did this study use? List all sources specifically, such as *Morbidity and Mortality Weekly Report* or incomes by household in census data.
   f. What were the study findings? Identify the population group that will benefit from this research.
5. Interview one or more practicing public health nurses in your community, and identify an aggregate-level problem that needs epidemiologic investigation. Propose a rough draft study design to research this problem.
6. A major portion of the end of this chapter was devoted to the steps of the epidemiologic process using as an example a portion of the major work of Dr. David Olds. Search the Internet for new data from this ongoing study. It is being replicated by health departments in many other states, and community health nurses may be publishing their data. Look for articles using the key terms Olds Model, home visiting, high-risk infants, and home visit assessment.

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