PART 3
Conceptual Frameworks Applied to Nursing Practice in the Community

CHAPTER
9

Epidemiological Applications

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OBJECTIVES
After reading this chapter, the student should be able to:
1. Define epidemiology and describe how it has developed over time.
2. Describe the essential elements of epidemiology and an epidemiological approach.
3. Discuss the steps in the epidemiological process.
4. Explain the basic epidemiological concepts of population at risk, natural history of disease, levels of prevention, host-agent-environment relationships, and the web-of-causation model.
5. Differentiate between descriptive and analytic epidemiology.
6. Explain how nurses use epidemiology in community health practice.

CHAPTER OUTLINE
Definitions
History
How Nurses Use Epidemiology
Basic Concepts in Epidemiology
  Measures of Morbidity and Mortality
  Epidemiologic Triangle: Agent, Host, and Environment
  Levels of Preventive Interventions
Screening
  Reliability and Validity
Basic Methods in Epidemiology
  Sources of Data
  Rate Adjustment
  Comparison Groups
Descriptive Epidemiology
  Person
  Place
  Time

Analytic Epidemiology
  Cohort Studies
  Prospective Cohort Studies
  Case-Control Studies
  Cross-Sectional Studies
  Ecological Studies
Experimental Studies
  Clinical Trials
  Community Trials
Causality
  Statistical Associations
  Bias
  Assessing for Causality
Applications of Epidemiology in Nursing

KEY TERMS
agent, 160
analytic epidemiology, 151
attack rate, 158
bias, 170
case-control study, 168
case fatality rate (CFR), 159
The term epidemiology comes from the Greek terms *logos* ("study"), *demos* ("people"), and *epi* ("upon"). Literally this would be "the study of what is upon the people." Epidemiology is the study of the distribution and determinants of disease in populations. For example, you would use epidemiology to see if a disease is more common among men or women or if the disease is seen more in older versus younger people. The term originally referred to the spread of infectious epidemics such as cholera or tuberculosis (TB). Now the term is more inclusive and involves infectious diseases and chronic diseases, such as cancer and cardiovascular disease, as well as mental health and other health-related events, such as intentional injuries (accidents), violence, occupational and environmental exposures and their effects, and positive health states. The public health science of epidemiology has made major contributions to (1) the understanding of factors that contribute to health and disease, (2) the development of health promotion and disease-prevention measures, (3) the detection and characterization of emerging infectious agents, (4) the evaluation of health services and policies, and (5) the practice of nursing in public health.

**DEFINITIONS**

Epidemiology investigates the distribution or the patterns of health events in populations and the determinants or the factors that influence those patterns. When using descriptive epidemiology, health outcomes are considered in terms of what, who, where, and when. That is: What is the outcome? Who is affected? Where are they? When do events occur? Descriptive epidemiology discusses a disease in terms of person, place, and time. The how and why, or determinants of health events, are those factors, exposures, characteristics, behaviors, and contexts that determine (or influence) the patterns: How does it occur? Why are some people affected more than others? Determinants may be individual, relational or social, communal, or environmental. This focus on investigation of causes and associations is called analytic epidemiology.

Epidemiology, like both the research process and nursing process, consists of a set of steps. The first step is to answer the "what" question by defining the outcome. The health outcome can be a disease, or it can refer to injuries, accidents, or even wellness (Koepsell and Weiss, 2003). The aim in epidemiology is to describe the distribution (i.e., determine how, where, and when the disease occurs) and to look for factors that explain the pattern of the disease or the risk for occurrence (i.e., answer the questions of why and how the disease occurs).

Like nursing, epidemiology builds on and draws from other disciplines and methods, including clinical medicine and laboratory sciences, social sciences, quantitative methods (especially biostatistics), and public health policy and goals. Epidemiology focuses on populations, whereas clinical medicine focuses on the diagnosis and treatment of disease in individuals. Epidemiology studies populations to determine the causes of health and disease in communities and to investigate and evaluate interventions that will prevent disease and maintain health. Epidemiological methods are used extensively to determine to what extent the goals of *Healthy People 2020* (U.S. Department of Health and Human Services, 2010) have been met and to monitor the progress of those objectives not fully met at present. Epidemiology is true detective work. For example, consider a man who visits a country other than where he lived. Within 3 days, he was experiencing nausea and diarrhea. The epidemiological process could help determine what action should be taken. Specifically, what did he eat or drink? Did others eat or drink the same things? Are other people with him experiencing the same symptoms? After a thorough review of the "what, who, where, and when," he realizes that the only thing he did differently from others with him was use water from the bathroom faucet to brush his teeth. Others in his group had used bottled water. Although he knew that people often react negatively to
HEALTHY PEOPLE 2020

Examples of Epidemiologic Objectives in Healthy People 2020

- **AH-2**: Increase the percentage of adolescents who participate in extracurricular and out-of-school activities.
- **AOCBC-4**: Reduce the proportion of adults with doctor-diagnosed arthritis who find it "very difficult" to perform specific joint-related activities.
- **D-16**: Increase prevention behaviors in persons at high risk for diabetes with prediabetes.
- **HAI-2**: Reduce invasive methicillin-resistant *Staphylococcus aureus* (MRSA) infections.


In the eighteenth and nineteenth centuries, comparison groups began to be used to measure change or the effects of some action or treatment on an experimental group. Also at this time, quantitative methods (i.e., numeric measurements or counts) were beginning to be used. One of the most famous studies using a comparison group is the mid-nineteenth century

### TABLE 9-1 SELECTED SIGNIFICANT MILESTONES IN THE HISTORY OF EPIDEMIOLOGY

<table>
<thead>
<tr>
<th>DATE</th>
<th>INVESTIGATOR</th>
<th>CONTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1662</td>
<td>John Graunt</td>
<td>Used Bills of Mortality (forerunner of modern vital records) to study patterns of death in various populations in England. Published early form of life table analysis.</td>
</tr>
<tr>
<td>1798</td>
<td>Edward Jenner</td>
<td>Demonstrated the effectiveness of smallpox vaccination. Marine Hospital Service was opened; forerunner of the U.S. Public Health Service (1912).</td>
</tr>
<tr>
<td>1840s</td>
<td>William Farr</td>
<td>Developed the forerunner of a modern vital records system in the Registrar-General’s Office in England. Study of mortality in Liverpool led to significant public health reform. Pioneered mortality surveillance and anticipated many of the basic concepts in epidemiology. His data provided much of the basis for Snow’s work on cholera.</td>
</tr>
<tr>
<td>1850</td>
<td>Lemuel Shattuck</td>
<td>Reported on sanitation and public health in Massachusetts. The London Epidemiological Society was founded. Known for influential reports on smallpox vaccination and studies of cholera.</td>
</tr>
<tr>
<td>1850s</td>
<td>John Snow</td>
<td>Conducted epidemiologic research on transmission of cholera. Used mapping and natural experiment, comparing rates in groups exposed to different water supplies.</td>
</tr>
<tr>
<td>1870-1880s</td>
<td>Robert Koch</td>
<td>Discovered causal agents for anthrax, tuberculosis, and cholera; development of causal criteria.</td>
</tr>
<tr>
<td>1887</td>
<td>Joseph Kinyoun</td>
<td>Founded the “Laboratory of Hygiene,” forerunner of the National Institutes of Health (1930). The United States Public Health Service (USPHS) assumed the work previously done by the Marine Hospital Service.</td>
</tr>
<tr>
<td>1921</td>
<td>Wade Hampton Frost</td>
<td>Founded the first U.S. academic program in epidemiology at Johns Hopkins. The National Institutes of Health (NIH) was created.</td>
</tr>
<tr>
<td>1942</td>
<td></td>
<td>The Office of Malaria Control in War Areas was established; it became the Communicable Disease Center (CDC) in 1946; then the Centers for Disease Control (1973); now the Centers for Disease Control and Prevention.</td>
</tr>
<tr>
<td>1948</td>
<td></td>
<td>Framingham Heart Study began.</td>
</tr>
<tr>
<td>1944</td>
<td></td>
<td>The Surgeon General’s report on smoking and health was released.</td>
</tr>
<tr>
<td>1980</td>
<td></td>
<td>American Psychiatric Association Diagnostic and Statistical Manual of Mental Disorders, ed 3 (DSM-III) was published, which for the first time provided consistent, reliable, and generally accepted criteria for the diagnosis of psychiatric disorders that could be used in epidemiologic research as well as clinical practice. Led to the development of assessment instruments that could be used in epidemiologic studies. Followed by DSM-III-R (revised, 1987), DSM IV (1994), and DSM-IV-TR (text revision, 2000).</td>
</tr>
<tr>
<td>1981</td>
<td></td>
<td>The CDC’s Morbidity and Mortality Weekly Report (MMWR) ran an article on <em>Pneumocystis</em> pneumonia that announced the new disease of acquired immunodeficiency syndrome (AIDS).</td>
</tr>
<tr>
<td>1983</td>
<td></td>
<td>The Public Health Service (PHS) published its first guidelines on AIDS prevention, recommending that people refrain from donating blood and modify their sexual practices.</td>
</tr>
<tr>
<td>1988</td>
<td></td>
<td>The Institute of Medicine published <em>The Future of Public Health</em>. This report says that the core public health functions are assessment, policy development, and assurance. Epidemiology and statistics are established as the basis for the assessment function.</td>
</tr>
</tbody>
</table>

Hippocrates, in the fourth century BCE, was one of the first people to use the ideas that are now part of epidemiology (Merrill and Timmreck, 2006). He examined health and disease in a community by looking at geography, climate, the seasons of the year, the food and water consumed, and the habits and behaviors of the people. His approach, like descriptive epidemiology, looked at how health is influenced by personal characteristics, place, and time. Notable events in the history of epidemiology are shown in Table 9-1.

In the eighteenth and nineteenth centuries, comparison groups began to be used to measure change or the effects of some action or treatment on an experimental group. Also at this time, quantitative methods (i.e., numeric measurements or counts) were beginning to be used. One of the most famous studies using a comparison group is the mid-nineteenth century
investigation of cholera by John Snow, whom some call the “father of epidemiology” (Merrill and Timmreck, 2006). By mapping cases that clustered around one public water pump during a London cholera outbreak, Snow was able to show how the water supply and cholera were associated. He observed that cholera rates were higher among households supplied by water companies whose water came from downstream than among households whose water came from farther upstream, where it was subject to less contamination. Snow conducted a “natural experiment,” as seen in Table 9-2 and documented that foul water was the vehicle for transmission of the agent that caused cholera (Rothman, 2002).

In nursing, Florence Nightingale contributed to the development of epidemiology in her work with British soldiers during the Crimean War (1854 to 1856). At this time, sick soldiers were cared for in cramped quarters that had poor sanitation, were overrun with lice and rats, and had insufficient food and medical supplies. She looked at the relationship between the conditions of the environment and the recovery of the soldiers. Using simple epidemiological measures of rates of illness per 1000 soldiers, she was able to show that improving environmental conditions and adding nursing care decreased the mortality rates of the soldiers (Cohen, 1984; Palmer, 1983). These same principles can be applied today in the many countries that experience war leading to poor food, water, and sanitary conditions. That is, if the environment could be improved and better care provided, the rate of illnesses and death would be reduced.

During the twentieth century, several changes in society influenced the further development of epidemiology. Some of these were the Great Depression of the 1920s in the United States; World War II; a rising standard of living for many but poverty for others; improved nutrition; better sanitation; the development of antibiotics, vaccines, and cancer chemotherapies; decreased birth rates in some countries; and decreases in infant and child mortality in many nations. People began to live longer, and the rates of several chronic diseases such as coronary heart disease (CHD), stroke, cancer, and senile dementia increased. In 1900 the leading causes of death were (1) pneumonia and influenza, followed by (2) tuberculosis and (3) gastritis, enteritis, and colitis; then came (4) heart diseases, (5) symptoms

### Table 9-1

<table>
<thead>
<tr>
<th>DATE</th>
<th>INVESTIGATOR</th>
<th>CONTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>Completion of the Human Genome Project, which provided breakthroughs in information that will aid in predicting the potential for disease, prevention, and treatment.</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>Publication of the “Essential Nursing Competencies and Curricula Guidelines for Genetics and Genomics” by the American Nurses Association, Silver Spring, Md.</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Publication of Healthy People 2020.</td>
<td></td>
</tr>
</tbody>
</table>


### Table 9-2

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>NUMBER OF HOUSES</th>
<th>DEATHS FROM CHOLERA</th>
<th>DEATHS PER 10,000 HOUSEHOLDES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southwark and Vauxhall</td>
<td>40,046</td>
<td>1263</td>
<td>315</td>
</tr>
<tr>
<td>Lambeth</td>
<td>26,107</td>
<td>98</td>
<td>37</td>
</tr>
<tr>
<td>Rest of London</td>
<td>256,423</td>
<td>1422</td>
<td>59</td>
</tr>
</tbody>
</table>


In nursing, Florence Nightingale contributed to the development of epidemiology in her work with British soldiers during the Crimean War (1854 to 1856). At this time, sick soldiers were cared for in cramped quarters that had poor sanitation, were overrun with lice and rats, and had insufficient food and medical supplies. She looked at the relationship between the conditions of the environment and the recovery of the soldiers. Using simple epidemiological measures of rates of illness per 1000 soldiers, she was able to show that improving environmental conditions and adding nursing care decreased the mortality rates of the soldiers (Cohen, 1984; Palmer, 1983). These same principles can be applied today in the many countries that experience war leading to poor food, water, and sanitary conditions. That is, if the environment could be improved and better care provided, the rate of illnesses and death would be reduced.

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of senility, (6) vascular lesions affecting the CNS, (7) chronic nephritis and renal sclerosis, (8) unintentional injuries, (9) malignant neoplasms, and (10) diphtheria. That contrasts with the changes in patterns that were seen in the 1950s and continue today with the following leading causes of death in 2010:

1. Diseases of the heart
2. Malignant neoplasms
3. Chronic lower respiratory diseases
4. Cerebrovascular disease (stroke)
5. Accidents (unintentional injuries)
6. Alzheimer’s disease
7. Diabetes mellitus
8. Nephritis, nephrotic syndrome, and nephrosis
9. Influenza and pneumonia
10. Intentional self-harm (suicide)

These were followed by septicemia; chronic liver disease and cirrhosis; essential hypertension and hypertensive renal disease; Parkinson’s disease; and pneumonitis due to solids and liquids (Murphy, Xu, Kochanek, 2012).

During the twentieth century a shift occurred from looking for single agents, such as the infectious agent that causes cholera, to determining the multifactorial etiology or the many factors or combinations of factors that contribute to disease. An example of multifactorial etiology can be found in the complex number and type of factors that cause cardiovascular disease. People began to realize that not all of the diseases of older people were the result of the degenerative processes of aging. Rather, it became clear that many behavioral and environmental factors supported or encouraged the development of diseases. This information led to the belief that some diseases could be prevented and other diseases could at least be delayed (Susser, 1985).

In addition, the development of genetic and molecular techniques increased the ability of the epidemiologist to classify persons in terms of exposures or inherent susceptibility to disease. Examples included the identification of genetic traits that indicated an increased risk for breast cancer and markers that identified exposures to environmental toxins such as lead or pesticides. These developments are of particular interest to nurses who work with people in their living and work environments and understand the interaction of the environment(s) on health and well-being. Furthermore, nurses in the community can assess a broad range of health outcomes, as well as factors that contribute to wellness and illness.

Unfortunately, in recent years new infectious diseases (e.g., Lyme disease, methicillin-resistant Staphylococcus aureus [MRSA], the H1N1 and H3N2 viruses, new forms of old diseases [e.g., drug-resistant strains of TB, new forms of Escherichia coli]) have emphasized the dangers that can occur with these diseases. Also, potential threats from terrorist use of infectious agents (e.g., anthrax, smallpox) have once again placed the epidemiology of infectious diseases in the spotlight. Epidemiological methods also have been applied to a broader spectrum of health-related outcomes, including accidents, injuries and violence, occupational and environmental exposures, psychiatric and sociological phenomena, health-related behaviors, and health services research.

Epidemiologists were among the first to respond to both the terrorist attacks of September 11, 2001 and the anthrax letters, and they remain at the center of public health planning and the design of response plans using epidemiological methods.

HOW NURSES USE EPIDEMIOLOGY

Nurses play a key role in the community’s interdisciplinary team looking at health, disease causation, and how to both prevent and treat illness. Nurses use epidemiology in the community to examine factors that affect the individual, family, and population group because it is more difficult to control these factors in the community than in the hospital. Specifically, it is difficult to control the environment, including water and food supplies; air quality conditions, including pollutants; disposal of garbage and trash; quality of paint used to ensure it contains no lead; or what comes in the mail. Therefore, community residents are often exposed to many factors affecting their health.

Nurses work in an interdisciplinary team to solve epidemiological problems. (© 2012 Photos.com, a division of Getty Images. All rights reserved. Image #121198999.)

Nurses are involved in the surveillance and monitoring of disease trends. In settings such as homes, schools, workplaces, clinics, and health care organizations, nurses can identify patterns of disease in a group. For example, if several children in a school become sick with abdominal problems within a short period (e.g., a 24-hour period), the nurse would try to determine what these children had in common. For instance, did they eat the same food, drink from the same source of water, or swim in the same pool? Likewise, if workers in a plant displayed a similar pattern of symptoms, the nurse would look for factors in the workplace to locate the cause. The reason for looking at the workplace first is that it is the setting the individuals have in common.

Care of clients, families, and population groups in the community uses the following steps of the nursing process: (1) assessment, (2) diagnosis, (3) planning, (4) implementation, and (5) evaluation. When using the nursing process, epidemiology provides baseline information for assessing needs, identifying problems, designing appropriate strategies to evaluate the problems, setting priorities to develop a plan of care, and evaluating
how effective the care was. The information learned from the Human Genome Project completed in 2003 will continue to be the basis of new discoveries about the consequences of genetic variations and the outcomes of the interaction between genes and the environment. Nurses, in their focus on health, can use the information that is now available and will increasingly become available as a result of further research. The “Essential Nursing Competencies and Curricula Guidelines for Genetics and Genomics” will help nurses care for individuals, families, communities, and populations by including genetic and genomic information in their practice. For example, this information could assist a nurse to recognize whether a newborn is at risk for morbidity or mortality resulting from errors in genetic metabolism (American Nurses Association, 2006). The sections that follow discuss the “tools of epidemiology” that are needed by nurses who work in community settings.

CASE STUDY 9-1  CHURCH PICNIC

Mary Miles is the nurse epidemiologist for the Warren County Health Department. A local church contacted Ms. Miles when several church members became sick after the annual church picnic. Of the 200 people who attended the picnic, 100 were ill with diarrhea, nausea, or vomiting. Ten people required emergency medical treatment or hospitalization. Incubation periods ranged from 1.5 to 30 hours, with a mean of 8 hours and a median of 3.5 hours. Duration of illness ranged from 1 to 80 hours, with a mean of 30 hours and a median of 15 hours.

The annual church picnic is a potluck lunch buffet. The menu included macaroni casserole (brought by the Joneses), turkey with gravy and stuffing (brought by the Smiths), potato salad (brought by the Champs), green bean casserole (brought by the Beckmans), chili (brought by the Turners), homemade bread (brought by Granny Ivy), chocolate cake (brought by the Bushes), and cookies (brought by the Champs). Ms. Miles interviewed the church members who were ill and found that three food items were significantly associated with illness: turkey, gravy, and stuffing.

Ms. Miles interviewed the Smiths, who brought the turkey, gravy, and stuffing to the picnic. Review of food-handling procedures indicated that the turkey had cooled for 4 hours at room temperature after cooking—a time and temperature sufficient for bacterial growth and toxin production. Furthermore, the same utensils were used for both the turkey and other foods before and after cooking.

Ms. Miles talked with the Smiths about proper food-handling practices, emphasizing hand washing, proper cooling and preserving methods, and better equipment and utensil sanitation. Ms. Miles also offered a similar class to the church congregation.

1. For the nurse to evaluate why people at the picnic became sick, what questions should she ask the people who brought the food?
   A. Cooking time and how they cooked the food
   B. Hygiene of their equipment
   C. Sources of the water used in cooking the food
   D. All of the above
2. Identify the agent, host, and environment in this case study.
3. Is Ms. Miles performing descriptive epidemiology or analytic epidemiology?
4. Which level of prevention is Ms. Miles exemplifying?
   A. Primary prevention
   B. Secondary prevention
   C. Tertiary prevention
   D. Combination of the above
   E. None of the above

It is important that nurses understand the relationship between population health concepts and clinical practice. Within the field of epidemiology, the definition of population is not necessarily confined to large groups of people, such as a population of the United States. Population health concepts also apply to other types of groups, such as the collective group of clients at one clinical practice site. In this case, the clinical epidemiologic application of population health concepts is evident in questions such as: What are the factors that contribute to the health and illness of issues among clients that I see in my clinic? Why do some of my clients fare better than others with the same disease conditions? Are there alternative clinical practices that might help my clients? All of these clinical questions incorporate epidemiologic concepts of describing the burden of disease in a population, identifying and understanding determinants of health, and examining possible root causes of health outcomes. Two important documents highlight ways in which epidemiologic knowledge and skills are essential in nursing practice. The Council on Linkages between Academia and Public Health Practice (2010) outlined essential analytic/assessment and public health science skills, and the Quad Council of Public Health Nursing Competencies (2011) provided details and examples of ways to implement these skill sets in nursing practice.

BASIC CONCEPTS IN EPIDEMIOLOGY

Measures of Morbidity and Mortality

Rates, Proportions, and Risk

Epidemiology looks at the distribution of health states and events. Because people differ in their probability or risk for disease, the primary concern is how they differ. Today epidemiologists use tools such as geographic information systems to study health-related events to identify disease distribution patterns, similar to how John Snow mapped cases of cholera in one area of London. However, mapping cases is limited in what it can reveal. A larger number of cases may simply be the result of a larger population with more potential cases or the result of a longer period of observation. Any description of disease patterns should take into account the size of the population.
Measures of Incidence

Measures of incidence reflect the number of new cases or events in a population at risk during a specified time. An incidence rate quantifies the rate of development of new cases in a population at risk (Greenberg et al., 2005), whereas an incidence proportion indicates the proportion of the population at risk that experiences the event over some period of time (Rothman, 2002). The population at risk is considered to be persons without the event or outcome of interest but who are at risk for experiencing it. People who already have the disease or outcome of interest are excluded from the population at risk for this calculation because they already have the condition and are no longer at risk for developing it. The incidence proportion is also referred to as the cumulative incidence rate because it reflects the cumulative effect of the incidence rate over the time period. The risk for disease is a function of both the rate of new disease development and the length of time the population is at risk. The interpretation can be for an individual (i.e., the probability that the person will become ill) or for a population (i.e., the proportion of a population expected to become ill over that period). In epidemiology, we often calculate proportions on the basis of population frequencies. These frequencies are then translated into personal risk statements for people representative of the population on which the estimates are based.

For example, suppose a health department and hospital partner want to develop an intensive, broad-based screening program in an area with overcrowded housing, limited access to services, and underuse of preventive health practices. They might include physical examinations; tuberculin skin tests with follow-up chest radiography where indicated; cardiovascular, glaucoma, and diabetes screening; and mammography for women and prostate screening for men older than 45 years of age. Of the 8000 women screened, 35 were previously diagnosed with breast cancer; by screening and follow-up, 20 with no history of breast cancer were found to have cancer of the breast. We could follow the 7945 women in whom no breast cancer was detected and note the number of new cases of breast cancer detected over the following 5 years. Assuming no losses to follow-up (i.e., moved away or died from other causes), if 44 women were diagnosed over the 5-year period, the 5-year incidence proportion of breast cancer in this population would be as follows:

\[ \frac{44}{7945} = 0.005538, \text{ or } 553.8 \text{ per} 100,000 \]

Note the multiplication by 100,000, so that the number of cases is expressed as per 100,000 women. A cumulative incidence
rate estimates the risk for developing the disease in that population during that time. Also, as a proportion, each event in the numerator must be represented in the denominator, and only those persons at risk for the event counted in the numerator may be included in the denominator.

A ratio can be used as an approximation of a risk. For example, the infant mortality "rate" is the number of infant deaths (infants are defined as being younger than 1 year of age) in a given year divided by the number of live births in that same year. It approximates the risk for death in the first year of life for live-born infants in a specific year. Some of the infants who die that year were born in the previous year, and some of the infants born that year may die in the following year before their first birthday. However, because about two thirds of infant deaths occur within the first 28 days of life, the number of infants in the numerator (i.e., deaths in a given year) but not in the denominator (i.e., live births in that same year) will be small. It can be assumed that current year deaths from the previous year’s cohort approximately equal the deaths from the current year’s cohort occurring in the following year. Although technically a ratio, this is an approximation to the true proportion and, therefore, an estimate of the risk.

An epidemic occurs when the rate of disease, injury, or other condition exceeds the usual (i.e., endemic) level of that condition. No specific threshold of incidence indicates that an epidemic exists. Because smallpox has been eradicated, any occurrence of smallpox might be considered an epidemic by this definition. In contrast, given the high rates of ischemic heart disease in the United States, an increase of many cases would be needed before an epidemic was noted, although some might argue that the current high rates in contrast to earlier periods already indicate an epidemic.

**Prevalence Proportion**

The prevalence proportion is a measure of existing disease in a population at a particular time (i.e., the number of existing cases divided by the current population). It is also possible to calculate the prevalence of a specific risk factor or exposure. In the breast cancer example given earlier, the screening program discovered 35 of the 8000 women screened had previously been diagnosed with breast cancer and 20 women with no history of breast cancer were diagnosed as a result of the screening. The prevalence proportion of current and past breast cancer events in this population of women would be as follows:

\[
\frac{55}{8000} = 0.006875, \text{ or } 687.5 \text{ per } 100,000
\]

A prevalence proportion is not an estimate of the risk for developing disease, because it is a function of both the rate at which new cases of the disease develop and how long those cases remain in the population. In this example, the prevalence of breast cancer in this population of women is a function of how many new cases develop and how long women live after the diagnosis of breast cancer. A fairly constant prevalence might be seen, for example, if improved survival after diagnosis were offset by an increasing incidence rate. The duration of a disease is affected by case fatality and cure. (For simplicity, in this example, women with a history of the disease are counted in the prevalence proportion even though they may have been cured.) A disease with a short duration (e.g., an intestinal virus) may not have a high prevalence proportion even if the rate of new cases is high, because cases do not accumulate (see the discussion of point epidemic). A disease with a long course will have a higher prevalence proportion than a rapidly fatal disease that has the same rate of new cases.

**Incidence and Prevalence Compared**

The prevalence proportion measures existing cases of disease. The prevalence odds \(P[1 − P]\) are roughly proportional to the incidence rate multiplied by the average duration of disease (Rothman, 2002). The prevalence proportion is therefore affected by factors that influence risk (i.e., incidence) and factors that influence survival or recovery (i.e., duration). For that reason, prevalence measures are less useful when looking for factors related to disease etiology. Because prevalence proportions reflect duration in addition to the risk for getting the disease, it is difficult to sort out what factors are related to risk and what factors are related to survival or recovery. In mathematical notation,

\[
P / (1 − P) ≅ I \times D,
\]

or, when \(P\) is small \((< 0.1)\), the \(P ≅ I \times D\),

where \(P =\) prevalence, \(I =\) incidence rate, and \(D =\) average duration.

For example, the 5-year survival rate for breast cancer is approximately 85%, but the 5-year survival rate for lung cancer in women is only about 15%. Even if the incidence rates of breast and lung cancer were the same in women (and they are not), the prevalence proportions would differ because, on average, women live longer with breast cancer (i.e., it has a longer duration). Incidence rates and incidence proportions, on the other hand, are the measure of choice to study etiology because incidence is affected only by factors related to the risk for developing disease and not to survival or cure. Prevalence is useful in planning health care services because it is an indication of the level of disease existing in the population and therefore of the size of the population in need of services. In the previous example about screening, the health department would want to know both the existing level of TB in the area (the prevalence), to plan services and direct prevention and control measures, and the rate at which new cases are developing (the incidence), to study risk factors and evaluate the effectiveness of prevention and control programs (see the “How To” box).

### HOW TO Determine If a Health Problem Exists in the Community

Planning for resources and personnel often requires quantifying the level of a problem in a community. For example, to know how different districts compare in the rates of infants with very low birth weight, you would calculate the prevalence of births of infants with very low birth weight in each district:

1. Determine the number of live births in each district from birth certificate data obtained from the vital records division of the health department.
2. Use the birthweight information from the birth certificate data to determine the number of infants born weighing less than 1500 g in each district.

Continued
3. Calculate the prevalence of births of infants with very low birth-weight by district as the number of infants weighing less than 1500 g at birth divided by the total number of live births.
4. If the number of births of infants with very low birth weight in each district is small, use several recent years of data to obtain a more stable estimate.

**Attack Rate**

One final measure of morbidity, often used in infectious disease investigations, is the **attack rate**, or the proportion of persons who are exposed to an agent and develop the disease. Attack rates are often specific to an exposure; food-specific attack rates, for example, are the proportion of persons becoming ill after eating a specific food item.

**Mortality Rates**

Several key mortality rates are shown in Table 9-3. Many commonly used mortality rates are not true rates but are

<table>
<thead>
<tr>
<th>RATE/RATIO</th>
<th>DEFINITION AND EXAMPLE*</th>
</tr>
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| Crude mortality (death) rate | Number of deaths from any cause during time interval Estimated mid-interval population (mid-year population)  
Example: In 2010 there were 2,465,932 deaths in a total population of 275,264,999, or 873.1 per 100,000. |
| Age-specific rate       | Number of deaths among persons of a given age group per mid-year population of that age group = rate per 100,000  
\[
\frac{17,744}{18,484,615} = 96 \text{ per } 100,000 \text{ persons ages 20 to 24 years} 
\]  
| Cause-specific rate     | Number of deaths from a specific cause per mid-year population = rate per 100,000  
\[
\frac{97,900 \text{ accidental deaths}}{275,264,999 \text{ midyear population}} = 35.6 \text{ per } 100,000 
\]  
| Case fatality rate      | Number of deaths from a specific disease in a given period Number of persons diagnosed with that disease  
Example: If 87 of every 100 persons diagnosed with lung cancer die within 5 years, the 5-year case fatality rate is 87%; the 5-year survival rate is 13%. |
| Proportionate mortality ratio | Number of deaths from a specific disease per total number of deaths in the same period  
Example: If there were 710,760 deaths from diseases of the heart and 2,403,351 deaths from all causes:  
\[
\frac{710,760}{2,403,351} = 0.296 \text{ or } 29.6\% \text{ of all deaths were due to heart disease} 
\]  
| Infant mortality ratio  | Number of deaths of infants under 1 year of age in a year per number of live births in the same year  
Example: If there were 28,035 infant deaths and 4,058,814 live births:  
\[
\frac{28,035}{4,058,814} = 0.00689 \text{ or } 0.69 \text{ per } 1000 \text{ live births} 
\]  
| Neonatal mortality rate | Number of deaths of infants under 28 days of age in a year per number of live births in the same year  
Example: If there were 18,776 neonatal deaths and 4,058,814 live births:  
\[
\frac{18,776}{4,058,814} = 4.63 \text{ per } 1000 \text{ live births} 
\]  
| Postneonatal mortality rate | Number of deaths of infants from 28 days to 1 year of age in a year per number of live births in the same year  
Example: If there were 9259 postneonatal deaths and 4,058,814 live births:  
\[
\frac{9259}{4,058,814} = 2.28 \text{ per } 1000 \text{ live births} 
\]  

proportions, because the population changes throughout the year. Although measures of mortality reflect serious health problems and changing patterns of disease, they have limited usefulness. They provide information only about fatal diseases and do not provide direct information about either the level of existing disease in the population or the risk for getting a particular disease. Also, a person may have one disease (e.g., prostate cancer) yet die from a different cause (e.g., stroke).

The crude annual mortality rate is an estimate of the risk for death for a person in a given population for that year. These rates are multiplied by a scaling factor, usually 100,000, to avoid small fractions. The result is then expressed as the number of deaths per 100,000 persons. Although a crude mortality rate is calculated easily and represents the actual death rate for the total population, it has certain limitations. It does not reveal specific causes of death, which change in relative importance over time. Also, the mortality rate is affected by the population’s age distribution, because older people are at much greater risk for death than younger people.

Mortality rates are also calculated for specific groups (e.g., age-specific, gender-specific, race-specific rates). In these instances, the number of deaths occurring in the specified group is divided by the population at risk, now restricted to the number of persons in that group. This rate is then viewed as the risk for death for persons in the specified group during the period of observation.

The cause-specific mortality rate is an estimate of the risk for death from some specific disease in a population. It is the number of deaths from a specific cause divided by the total population at risk, usually multiplied by 100,000. Two related measures should be distinguished from the cause-specific mortality rate. The case fatality rate (CFR) is the proportion of persons diagnosed with a particular disorder (i.e., cases) who die within a specified period. It is considered an estimate of the risk for death within that period for a person newly diagnosed with the disease (e.g., the proportion of persons with a disease who die during the natural history of the disease). Because the CFR is the proportion of diagnosed persons who die within the period, 1 minus the CFR yields the survival rate. For example, if the 5-year CFR for lung cancer is 86%, then the 5-year survival rate is only 14% (Remington, Brownson, and Wegner, 2010).

The second measure to be distinguished from the cause-specific mortality rate is the proportionate mortality ratio (PMR), the proportion of all deaths resulting from a specific cause. Some sources, especially those used in occupational health, say it is the proportion of all deaths resulting from a specific cause divided by the same proportion in a standard population. The denominator is not the population at risk for death but the total number of deaths in the population; therefore, the PMR is not a rate nor does it estimate the risk for death. The magnitude of the PMR is a function of both the number of deaths from the cause of interest and the number of deaths from other causes. If deaths from certain causes decline over time, deaths from other causes that remain fairly constant may have increasing PMRs. For example, motor vehicle accidents accounted for 3.3 deaths per 100,000 persons ages 5 to 14 years in the United States in 2006 which was 21.8% of all deaths in this age group (the PMR). By comparison, motor vehicle accidents caused 22.3 deaths per 100,000 persons 75 to 84 years of age in 2006, which was less than 0.5% of all deaths in the older age group (Heron et al, 2009). This demonstrates that although the risk for death from a motor vehicle accident was more than four times as great in the older group (based on the rates), such accidents accounted for a far greater proportion of all deaths in the younger group (based on the PMR). This is because of the much greater risk for death from other causes in the older group.

Infant mortality is used around the world as an indicator of overall health and availability of health care services. The most common measure, the infant mortality rate, is the number of deaths to infants in the first year of life divided by the total number of live births. Because the risk for death declines considerably during the first year of life, neonatal (i.e., newborn), and postneonatal mortality rates are also of interest.

**Epidemiologic Triangle: Agent, Host, and Environment**

Epidemiologists understand that disease results from complex relationships among causal agents, susceptible persons, and environmental factors. These three elements—agent, host, and environment—are called the epidemiologic triangle (Figure 9-1, A). Changes in one of the elements of the triangle can influence the occurrence of disease by increasing or decreasing a person’s risk.
for disease. Figure 9-1, B, shows that agent and host, as well as their interaction, are influenced by the environment in which they exist. They also may influence the environment. Specifically, these elements or variables are defined as follows:

- **Agent**: An animate or inanimate factor that must be present or lacking for a disease or condition to develop
- **Host**: A living species (human or animal) capable of being infected or affected by an agent
- **Environment**: All that is internal or external to a given host or agent and that is influenced and influences the host and/or agent

Examples of these three components are listed in Box 9-1.

Causal relationships (one thing or event causes another) are often more complex than the epidemiological triangle conveys. The term web of causality recognizes the complex interrelationships of many factors interacting, sometimes in subtle ways, to increase (or decrease) the risk for disease. Also, associations are sometimes mutual, with lines of causality going in both directions. Recently, some researchers advocated for a new paradigm that goes beyond the two-dimensional causal web and considers multiple levels of factors that affect health and disease (Macintyre and Ellaway, 2000). This is consistent with the ecological model for population health supported by the Institute of Medicine’s report (2002) that expands epidemiological studies both upward to broader contexts such as neighborhood characteristics and social context and downward to the genetic and molecular level. The ecological model treats the multiple determinants of health as interrelated and acting synergistically (or antagonistically), rather than as discrete factors. This model encompasses determinants at many levels: biological, mental, behavioral, social, and environmental factors, including policy, culture, and economic environments, and includes a lifespan perspective. The IOM’s vision of “healthy people in healthy communities” requires a model that recognizes that healthy communities are more than a collection of healthy individuals and that the characteristics of communities affect the health of people who live in them (IOM, 2002).

**Levels of Preventive Interventions**

The goal of epidemiology is to identify and understand the causal factors and mechanisms of disease, disability, and injuries so that effective interventions can be implemented to prevent the occurrence of these adverse processes before they begin or before they progress. The natural history of disease is the course of the disease process from onset to resolution (Porta et al, 2008). The three levels of prevention—primary, secondary, and tertiary—provide a framework often used in public health practice. See the Levels of Prevention box later in the chapter.

**Primary prevention** refers to interventions that promote health and prevent the occurrence of disease, injury, or disability. Primary prevention is aimed at individuals and groups who are susceptible to disease but have no discernible pathological process (i.e., they are in a state of pre-pathogenesis). An example of primary prevention is when a nurse provides health education and training for daycare workers about issues of health and hygiene, such as proper hand hygiene, diapering, and food preparation and storage. Immunizations are another example of primary prevention, as are teaching about the importance of wearing seat belts and about taking folic acid supplementation at preconception to prevent neural tube defects, fluoridation of water supplies to prevent dental caries, and actions taken to reduce human exposure to agents that may cause cancer.

**Secondary prevention** refers to interventions designed to increase the probability that a person with a disease will have that condition diagnosed early enough that treatment is likely to result in cure. Health screenings are at the core of secondary prevention. Early and periodic screenings are critical for diseases, such as breast cancer, for which there are few specific primary prevention strategies. Screening programs are discussed in the section on screening that follows.

Interventions at the secondary level of prevention often take place in community settings. For example, a nurse may teach an asthmatic client to recognize and avoid exposure to asthma triggers and assist the family to implement specific protection strategies.
EVIDENCE-BASED PRACTICE

Sexual health and well-being affects people of all cultures regardless of race, social class, education, age, or country of origin. Also, sexually transmitted infections (STIs) can affect people of all ages even though the rates are highest among people under 25 years of age. Peate (2012) writes about the importance for public health nurses to understand the dangers inherent in people ages 45 years and older for contracting STIs. In the United Kingdom, STI diagnoses in the over 45 age group included 5356 people with genital warts, 3025 with genital herpes, and more than 125 with gonorrhea in 2009. By the end of 2010, an estimated 91,500 people in the United Kingdom were living with human immunodeficiency virus (HIV). Better treatment and improved survival rates have increased the longevity of people living with HIV. It is expected that the diagnoses of STIs and HIV will continue to increase as the population ages and remains more active and mobile. Older adults may be at greater risk for STIs because they may not see themselves as being at risk and they may not take adequate precautions or they may not think the risk factors pertain to them.

Nurse Use
Nursing services and information should be given in a way that the client can understand the message and see how the message might apply to him or her. The nurse should first find out what information the client has and what he or she needs. This can be done through a routine health check, during new client assessment, or at a travel clinic. This may mean using posters, brochures, individual meetings, or telephone follow-up and pointing out accurate and useful websites. The nurse must also assure the client of confidentiality when talking about sexual health issues. Men are less likely to engage in sexual health discussions, so the nurse will need to take any potential opportunity for this type of health education.

CASE STUDY 9-2 INMATES AT THE LOCAL JAIL

An infection preventionist (IP) at a local hospital contacted the nurse epidemiologist at the local health department to report that the hospital had received three laboratory reports of Acinetobacter baumannii infection from inmates at the local jail. The IP states that the jail typically sends all of their laboratory specimens to them for processing. The IP stated that the specimens were obtained from wounds and collected within a 2-month period.

1. The nurse epidemiologist suspects an outbreak and launches an investigation because the situation is:
   A. An unusual problem
   B. There is a potential risk to the public
   C. There is a casual pathway
   D. All the above

2. The nurse epidemiologist decided to visit the jail. Based on what she knows about the transmission of Acinetobacter baumannii, she should collect the following information:
   A. Underlying infections and chronic diseases of inmates
   B. Medical procedures performed in the jail
   C. The number of air exchanges in the jail
   D. All the above
   E. A and B only

3. The nurse epidemiologist discovers that all of the infected inmates have their wound dressings changed on the same day of the week in the same treatment room. She notices there is no sink or evidence of hand sanitizer in the treatment room. She recommends the following strategies except:
   A. Install hand hygiene stations in convenient locations in treatment rooms
   B. Clean and disinfect examination tables after each inmate is seen
   C. Educate staff on proper wound care and hand hygiene
   D. Recommend antibiotics for all inmates and staff
   E. She decides to educate all staff about the organism, including how it is transmitted and prevention strategies. This level of prevention is:
      A. Primary
      B. Secondary
      C. Tertiary


Epidemiological Applications

The number of air exchanges in the jail such as replacing carpets, keeping air systems clean and free of mold, staying inside when the pollution level is high, and avoiding pets. A nurse also might ask a family about their history of cancer, heart disease, diabetes, and mental illness as part of a client’s health history and then follow up with education about appropriate screening procedures. Other secondary prevention interventions include mammography to detect breast cancer, Papanicolaou (Pap) smears to detect cervical cancer, colonoscopy for early detection of colon cancer, and prenatal screening of pregnant women to screen for gestational diabetes.

Tertiary prevention includes interventions aimed at limiting disability and interventions that enhance rehabilitation from disease, injury, or disability. Interventions for tertiary prevention occur most often at secondary and tertiary levels of care (e.g., specialized clinics, hospitals, rehabilitation centers) but also may occur in community and primary care settings. Examples of tertiary prevention are medical treatment, physical and occupational therapy, and rehabilitation.

SCREENING

Screening, a key component of many secondary prevention interventions, involves the testing of groups of individuals who are at risk for a specific condition but do not have symptoms. The goal is to determine the likelihood that these individuals will develop the disease. From a clinical perspective, the aim of screening is early detection and treatment when these result in a more favorable prognosis. From a public health perspective, the objective is
to sort out efficiently and effectively those who probably have the disease from those who probably do not, again to detect early cases for treatment or begin public health prevention and control programs. A screening test is not a diagnostic test. Effective screening programs must include referrals for diagnostic evaluation for those who have positive findings on screening, to determine if they actually have the disease and need treatment.

Nurses must stay current about screening guidelines because these are regularly reviewed and revised on the basis of epidemiological research results. For example, the U.S. Preventive Services Task Force (2008) strongly recommends routine screening for lipid disorders in men ages 35 years and older and women ages 45 years and older. Screening for younger adults (men ages 20 to 35 years and women ages 20 to 45 years) is recommended when any of the following risk factors are present: diabetes, family history of cardiovascular disease before age 50 years in male relatives or age 60 years in female relatives, family history suggestive of familial hyperlipidemia, or multiple risk factors for CHD (e.g., tobacco use, hypertension). The Task Force also noted that all clients, regardless of lipid levels, should be offered counseling about the benefits of a diet low in saturated fat and high in fruits and vegetables, regular physical activity, avoidance of tobacco, and maintenance of a healthy weight. The rationale for the current guidelines is explained as follows.

The clearest benefit of lipid screening is identifying individuals whose near-term risk of CHD is sufficiently high to justify drug therapy or other intensive lifestyle interventions to lower cholesterol. Screening men older than 35 years and women older than 45 years will identify nearly all individuals whose risk for CHD is as high as that of the subjects in the existing primary prevention trials. Younger people typically have a substantially lower risk unless they have other important risk factors for CHD or a family history of hyperlipidemia. The primary goal of screening younger people is to promote lifestyle changes, which may provide long-term benefits later in life. The average effect of diet interventions is small, and screening is not needed to advise young adults about the benefits of a healthy diet and regular exercise, because this advice is considered useful for all age groups.

As community health advocates, nurses are responsible for planning and implementing screening and prevention programs targeted to higher risk populations, such as prostate-screening programs among African-American men. Occupational health nurses and nurses in community health may work together to target populations on the basis of occupational risk. Men with questionable prostate specific antigen (PSA) levels need to be referred, especially if they have increased risk factors for prostate cancer, such as African-American heritage or a family history of prostate cancer. Successful screening programs have several characteristics that depend on the tests and on the population screened (Box 9-2). Criteria for evaluating the usefulness of a screening test include cost-effectiveness, ease and safety of administration, availability of treatment, ethics of administration or wide-spread implementation, sensitivity, specificity, validity, and reliability (Gordis, 2009; McKeown and Learner, 2009).

**Reliability and Validity**

**Reliability**

It is important to pay attention to the precision, or reliability, of the measure (i.e., its consistency or repeatability) and the accuracy of the measure, its validity (i.e., whether it is really measuring what we think it is and how exactly). Suppose you want to screen for blood pressure in a community. You will take blood pressure readings on a large number of people, perhaps following up with repeated measures for individuals with higher pressures. If the readings of the sphygmomanometer used for the screening vary so that two consecutive readings are not the same, the sphygmomanometer lacks sensitivity. The instrument would be unreliable even if the overall mean of repeated measurements was close to the true overall mean for the persons measured. The problem would be that the readings would not be reliable for any individual, which is what a screening program requires.

On the other hand, suppose the readings are reliably reproducible, but, unknown to you, they tend to be about 10 mm Hg too high. This instrument is producing precise readings, but the uncorrected (or uncalibrated) instrument lacks accuracy. In short, a measure can be consistent without producing valid results.

The following three major sources of error can affect the reliability of tests:

1. **Variation inherent in the trait being measured** (e.g., blood pressure changes with time of day, activity, level of stress, and other factors)
2. **Observer variation**, which can be divided into intraobserver reliability (i.e., consistency by the same observer) and interobserver reliability (i.e., level of consistency from one observer to another)
3. **Consistency in the instrument**, which includes the level of internal consistency of the instrument (e.g., whether all items in a questionnaire measure the same thing) and the stability (i.e., test-retest reliability) of the instrument over time

**Validity: Sensitivity and Specificity**

Validity in a screening test is typically measured by sensitivity and specificity. Sensitivity quantifies how accurately the test identifies those with the condition or trait. Sensitivity represents the proportion of persons with the disease whom the test correctly identifies as positive (true positives). High sensitivity is needed when early treatment is important and when identification of every case is important.

Specificity indicates how accurately the test identifies those without the condition or trait (i.e., the proportion of persons whom the test correctly identifies as negative for the disease

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**BOX 9-2 CHARACTERISTICS OF A SUCCESSFUL SCREENING PROGRAM**

1. **Valid (accurate):** A high probability of correct classification of persons tested
2. **Reliable (precise):** Results are consistent from place to place, time to time, and person to person
3. **Capable of large group administration:**
   a. Fast in both the administration of the test and the obtaining of results
   b. Inexpensive in both personnel required and the materials and procedures used
4. **Innocuous:** Few if any side effects, and the test is minimally invasive
5. **High yield:** Able to detect enough new cases to warrant the effort and expense (yield defined as the amount of previously unrecognized disease that is diagnosed and treated as a result of screening)
High specificity is needed when rescreening is impractical and when it is important to reduce false-positive results. The sensitivity and specificity of a test are determined by comparing the test results with results from a definitive diagnostic procedure (sometimes called the gold standard). For example, the Pap smear is used frequently to screen for cervical dysplasia and carcinoma. The definitive diagnosis of cervical cancer requires a biopsy with histological confirmation of malignant cells.

The ideal for a screening test is 100% sensitivity and 100% specificity. That is, the test is positive for 100% of those who actually have the disease and it is negative for all those who do not have the disease. In practice, sensitivity and specificity are often inversely related. That is, if the test results are such that it is possible to choose some point beyond which a person is considered positive (a “cutpoint”), as in a blood pressure reading to screen for hypertension or a serum glucose reading to screen for diabetes, then moving that critical point to improve the sensitivity of the test will result in a decrease in specificity, or an improvement in specificity can be made only at the expense of sensitivity.

A third measure associated with sensitivity and specificity is the predictive value of the test. The positive predictive value (also called predictive value positive) is the proportion of persons with a positive test who actually have the disease, interpreted as the probability that an individual with a positive test has the disease. The negative predictive value (or predictive value negative) is the proportion of persons with a negative test who are actually disease free.

Two or more tests can be combined, in series or in parallel, to enhance sensitivity or specificity. In series testing, the final result is considered positive only if all tests in the series were positive, and it is considered negative if any test was negative. For example, if a blood sample were screened for HIV, a positive enzyme-linked immunosorbent assay (ELISA) might be followed with a Western blot test, and the sample would be considered positive only if both tests were positive. Series testing enhances specificity, producing fewer false positives, but sensitivity will be lower. In series testing, sequence is important; a very sensitive test is often used first to pick up all cases, including false positives, and then a second, very specific test is used to eliminate the false positives. In parallel testing, the final result is considered positive if any test was positive and is considered negative only if all tests were negative. To return to the example of a blood sample being tested for HIV, a blood bank might consider a sample positive if a positive result was found on either the ELISA or the Western blot. Parallel testing enhances sensitivity, leaving fewer false negatives, but specificity will be lower.

**BASIC METHODS IN EPIDEMIOLOGY**

**Sources of Data**

It is important to know early in any epidemiological study how the data will be obtained (Gordis, 2009; Koepsell and Weiss, 2003). The following three major categories of data sources are commonly used in epidemiological investigations:

1. Routinely collected data: census data, vital records (i.e., birth and death certificates), and surveillance data (i.e., systematic collection of data concerning disease occurrence) as carried out by the Centers for Disease Control and Prevention (CDC)
2. Data collected for other purposes but useful for epidemiological research: medical, health department, and insurance records
3. Original data collected for specific epidemiological studies

**Routinely Collected Data**

The United States census is conducted every 10 years and provides population data, including demographic distribution (i.e., age, race, sex), geographic distribution, and additional information about economic status, housing, and education. These data provide denominators for various rates.

Vital records are the primary source of birth and mortality statistics. Registration of births and deaths is mandated in most countries and provides one of the most complete sources of health-related data. However, the quality of specific information varies. For example, on birth certificates, sex and date of birth are fairly reliable, whereas reports of gestational age, level of prenatal care, and smoking habits of the mother during pregnancy are less reliable. On death certificates, the quality of the cause-of-death information varies over time and from place to place, depending on diagnostic capabilities and custom. Vital records are readily available in most areas; they are inexpensive and convenient and allow study of long-term trends. Mortality data, however, are informative only for fatal diseases.

**Data Collected for Other Purposes**

Hospital, physician, health department, and insurance records provide information on morbidity, as do surveillance systems, such as cancer registries and health department reporting systems, which solicit reports of all cases of a particular disease within a geographic region. Other information, such as occupational exposures, may be available from employer records.

**Epidemiological Data**

The National Center for Health Statistics sponsors periodic health surveys and examinations in carefully drawn samples of the U.S. population. Examples are the National Health and Nutrition Examination Survey (NHANES), the National Health Interview Survey (NHIS), and the National Hospital Discharge Survey (NHDS). The CDC also conducts or contracts for conduct of surveys such as the survey for the Youth Risk Behavior Surveillance System (YRBISS), Pregnancy Risk Assessment Monitoring System (PRAMS), and the Behavioral Risk Factor Surveillance System (BRFSS). These surveys provide information on the health status and behaviors of the population. For many studies, however, the only way to obtain the needed information is to collect the required data in a study specifically designed to investigate a particular question. The design of such studies is discussed later. Global positioning system and geographic information system technology can be used to examine health issues such as access to prenatal care, mapping the distribution of health exposures or outcomes, linking data with geo-coded addresses of individuals to sources of potentially toxic exposures (McLafferty and Grady, 2005).
**Rate Adjustment**

Rates, which are essential in epidemiological studies, can be misleading when compared across different populations. For example, the risk for death increases considerably after 40 years of age, so a higher crude death rate is expected in a population of older people in contrast to a population of younger people (Gordis, 2009; Koepsell and Weiss, 2003; Rothman, 2002). Comparing the overall mortality rate in an area with a large population of older adults with the rate in a younger population would be misleading. Methods that adjust for differences in populations can be used to compare death rates. Age adjustment is based on the assumption that a population’s overall mortality rate is a function of the age distribution of the population and the age-specific mortality rates.

Age adjustment can be performed by direct or indirect methods. Both methods require a standard population, which can be an external population, such as the U.S. population for a given year, a combined population of the groups under study, or some other standard chosen for relevance or convenience.

**HOW TO Assess Health Problems in a Community**

1. Examine local epidemiologic data (e.g., incidence, morbidity, mortality rates) to identify major health problems.
2. Examine local health services data to identify major causes of hospitalizations and emergency department visits. Consult with key community leaders (e.g., political, religious, business, educational, health, cultural) about their perceptions of identified community health problems.
3. Mobilize community groups to elicit discussions and identify perceived health priorities within the community (e.g., focus groups, neighborhood or community-wide forums).
4. Analyze community environmental health hazards and pollutants (e.g., water, sewage, air, toxic waste).
5. Examine indicators of community knowledge and practices of preventive health behaviors (e.g., use of infant car seats, safe playgrounds, lighted streets, seatbelt use, designated driver programs).
6. Identify cultural priorities and beliefs about health among different social, cultural, racial, or national origin groups.
7. Assess community members’ interpretation of and degree of trust in federal, state, and local assistance programs.
8. Engage community members in conducting surveys to assess specific health problems.

A direct adjusted rate applies the age-specific death rates from the study population to the age distribution of the standard population. The result is the (hypothetical) death rate of the study population if it had the same age distribution as the standard population.

The indirect method, as the name suggests, is more complicated. The age-specific death rates of the standard population applied to the study population’s age distribution result in an index rate that is used with the crude rates of both the study and standard populations to produce the final indirect adjusted rate, which is also hypothetical. The indirect method may be required when the age-specific death rates for the study population are unknown or unstable (e.g., based on relatively small numbers).

Often, instead of an indirect adjusted rate, a standardized mortality ratio (SMR) is calculated. This is the number of observed deaths in the study population divided by the number of deaths expected on the basis of the age-specific rates in the standard population and the age distribution of the study population (Gordis, 2009; Szklo and Nieto, 2007).

**Comparison Groups**

Comparison groups are often used in epidemiology. To decide if the rate of disease is the result of a suspected risk factor, the exposed group should be compared with a group of comparable unexposed persons. For example, you might investigate the effect of smoking during pregnancy on the rate of low-birth-weight infants by calculating the rate of low-birth-weight infants born to women who smoked during their pregnancy. However, the hypothesis that smoking during pregnancy is a risk factor for low birth weight is supported only when the low-birth-weight rate among smoking women is compared with the (lower) rate of low-birth-weight infants born to nonsmoking women.

Ideally you want to compare one group of people who all have a certain characteristic, exposure, or behavior with a group of people exactly like them except they all lack that characteristic, exposure, or behavior. In the absence of that ideal, you can either randomize people to exposure or treatment groups in experimental studies or select comparison groups that are comparable in observational studies. It is especially important in observational studies to control for confounding variables or factors.

**DESCRIPTIVE EPIDEMIOLOGY**

Descriptive epidemiology describes the distribution of disease, death, and other health outcomes in the population according to person, place, and time. This type of epidemiology provides a picture of how things are or have been and describes the who, where, and when of disease patterns. In contrast, analytic epidemiology looks for the determinants of the patterns observed—the who and why. That is, epidemiological concepts and methods are used to identify what factors, characteristics, exposures, or behaviors might account for differences in the observed patterns of disease occurrence. Descriptive and analytic studies are observational. In these studies the investigator observes events as they are or have been and does not intervene to change anything or to introduce a new factor. Experimental or intervention studies, however, include interventions to test preventive or treatment measures, techniques, materials, policies, or drugs.

**BRIEFLY NOTED** Lung cancer has surpassed breast cancer as the leading cause of cancer mortality among women. The increasing rate of lung cancer deaths in women mirrors the patterns of increased rates of smoking among women and increased cigarette advertising directed toward women.

**Person**

Personal characteristics of interest in epidemiology include race, sex, age, education, occupation, income (and related
HOW TO Assess Health Problems in an Individual

1. Obtain a history of physical and mental health problems.
2. Ask the individual to identify major health problems. Always start interventions with what the individual views as important.
3. Obtain a family history of diseases. Identify a possible genetic link based on early age of onset of a disease or multiple family members with a disease.
4. Do a clinical examination, including laboratory work.
5. Evaluate health risk based on lifestyle. Include smoking status, dietary patterns of fiber and fat, exercise patterns, stress factors, and risk-taking behaviors.
6. Identify immediate and long-range safety concerns.
7. Assess individual’s cultural beliefs about health.
8. Assess social support.
9. Examine the knowledge and practice of preventive health care.
10. Provide appropriate age-based screening (e.g., cancer screening, hypertension screening).

Place

When looking at the distribution of a disease, examine geographic patterns. Does the rate of disease differ from place to place (e.g., with local environment)? If geography had no effect on disease occurrence, random geographic patterns might be seen, but that is often not the case. For example, at high altitudes, oxygen tension is lower, which might result in smaller babies. Other diseases reflect distinctive geographic patterns. For example, Lyme disease is transmitted from animal reservoirs to humans by a tick vector. Disease is more likely to be found in areas in which there are animals carrying the disease, a large tick population for transmission to humans, and contact between the human population and the tick vectors (Heymann, 2008). Geographic variations can be caused by the following:

- Differences in the chemical, physical, or biological environment
- Differences in population densities, customary patterns of behavior and lifestyle, or other personal characteristics

Geographic variations might occur because of high concentrations of a religious, cultural, or ethnic group that practices certain health-related behaviors. The high rates of stroke found in the southeastern United States are likely to be the result of social and personal factors that have little to do with geographic features per se. Other neighborhood-level variables include the unemployment and crime rate, social cohesion, and access to important services (Bradman et al, 2005; Fuller et al, 2005; McLafferty and Grady, 2005).

Time

Secular Changes

Time is the third component of descriptive epidemiology. Is there an increase or decrease in the frequency of the disease over time, or are other temporal patterns evident? Long-term patterns of morbidity or mortality rates (i.e., over years or decades) are called secular trends. SECULAR TRENDS may reflect changes in social behavior or practices. For example, increased lung cancer mortality rates in recent years reflect a delayed effect of the increased smoking in prior years. Also, the decline in cervical cancer deaths is primarily the result of widespread screening with the Pap test (Remington, Brownson, and Wegner, 2010).

Some secular trends may result from increased diagnostic ability or changes in survival (or case fatality) rather than in incidence. For example, case fatality from breast cancer has decreased in recent years, although the incidence of breast cancer has increased. Some, though not all, of the increased incidence is the result of improved diagnostic capability. These two trends result in a breast cancer mortality curve that is flatter than the incidence curve (Remington, Brownson, and Wegner, 2010). Relying on mortality data alone does not accurately reflect the true situation. SECULAR TRENDS also are affected by changes in case definition or revisions in the coding of a disease according to the International Classification of Diseases (ICD).

Point epidemic is a time-and-space–related pattern that is important in infectious disease investigations and as an indicator for toxic exposures. A point epidemic is most clearly seen when the frequency of cases is graphed against time. The sharp peak characteristic of such graphs indicates a concentration of cases over a short interval of time. The peak often indicates the population’s response to a common source of infection or contamination to which they were all simultaneously exposed. Knowledge of the incubation or latency period (i.e., the time between exposure and development of signs and symptoms) for the specific disease entity can help determine the probable time of exposure. A common example of a point epidemic is an
outbreak of gastrointestinal illness from a food-borne pathogen. Nurses who are alert to a sudden increase in the number of cases of a disease can chart the outbreak, determine the probable time of exposure, and, by careful investigation, isolate the probable source of the agent.

In addition to secular trends and point epidemics, there are also cyclical time patterns of disease. Seasonal fluctuation is a common type of cyclical variation in some infectious illnesses. Seasonal changes may be influenced by changes in the agent itself, changes in population densities or behaviors of animal reservoirs or vectors, or changes in human behaviors resulting in changing exposures (e.g., being outdoors in warmer weather and indoors in colder months). Also, calendar events may create artificial seasons, such as holidays and tax-filing deadlines, that are associated with patterns of stress-related illness. Patterns of accidents and injuries also may be seasonal, reflecting differing employment and recreational patterns. Some disease cycles, such as influenza, have patterns of smaller epidemics every few years, depending on strain, with major pandemics occurring at longer intervals (Heymann, 2008). Public health workers need to pay attention to cyclical patterns so they are prepared to meet increased demands for service.

A third type of temporal pattern is nonsimultaneous, event-related clusters. These are patterns in which time is not measured from fixed dates on the calendar but from the point of some exposure, event, or experience presumably held in common. As an example of this pattern would be vaccines during an immunization program. Clearly, if vaccinations are given on a regular basis, nonspecific symptoms, such as fever, headaches, or rashes, might be seen fairly consistently over time, making identification of a cluster related to the vaccinations difficult. If, however, the occurrence of symptoms is plotted against the amount of time since vaccination, the number of vaccine reactions is likely to peak at some period after the immunization.

**CASE STUDY 9-3 STUDENT NURSE CASE**

On August 26, an open house is held by the Dean of the School of Nursing to welcome new and returning nursing students. Approximately 50 nursing students and professors attend. Light appetizers and cider are served. On the morning of August 28, two nursing students report to the student health clinic with nausea and vomiting. Later that day, three other students report to the clinic with headache, nausea, and vomiting. Two of the five students report that their symptoms began the evening of August 27, and the other three report symptom onset the morning of August 28. Two nursing professors call in sick with nausea and diarrhea on August 28. Both attended the Dean’s open house and a reception earlier in the week.

The student health nurse notifies the nurse epidemiologist at the local health department that she has seen five nursing students with gastrointestinal symptoms. She reports their names, dates of birth, dates and times of onset of symptoms.

1. The nurse epidemiologist at the health department develops a line list to organize the data. The line list includes the information reported by the student health nurse. What is the term used to describe the type of epidemiology associated with time, place, and person?
   A. Descriptive
   B. Analytic
   C. Scientific
   D. Environmental

2. The nurse epidemiologist notes that the infections are clustered in time, place, and person. She interviews all of the ill nursing students and learns that all of them attended the open house at the Dean’s home. What should the nurse do next?
   A. Close the nursing school
   B. Arrange to collect stool specimens
   C. Contact the Dean
   D. Quarantine all of the open house attendees

3. The nurse epidemiologist notifies the student health nurse that all of the stool specimens were positive for norovirus. Based on the incubation period for norovirus (12-48 hours) and the dates of onset of symptoms, the nurse epidemiologist suspects the students were exposed to the virus at or around the same time. She hypothesizes that the nurses contracted norovirus from a contaminated item consumed at the open house event. She makes arrangements to meet with the Dean to discuss the situation and gather additional information. What information would be useful to the nurse epidemiologist?
   A. A list of items served at the event
   B. A list of persons who prepared and served the refreshments
   C. A list of students, faculty, and staff who attended the event
   D. A list of faculty and student absences
   E. All of the above

4. The nurse epidemiologist decides to interview everyone (ill and well) who attended the open house. This type of study is called a.
   A. Case-control study
   B. Cohort study
   C. Longitudinal study
   D. Case study

5. Based on the data analysis the nurse epidemiologist determined that the fresh vegetable tray is associated with illness. She also learned that two of the food handlers were not feeling well during the event. What measures should she take at this point to control the outbreak?
   A. Try to obtain stool specimens from the catering staff
   B. Educate catering and serving staff about safe food preparation
   C. Encourage food service staff not to prepare or serve food when they are ill with gastrointestinal symptoms
   D. Call the Better Business Bureau

Case prepared by Mary Beth White-Comstock, MSN, RN, CIC.
The Cohort Studies of each design. Table 9-4 designs and the related measures of association derived from adverse outcomes. This section discusses analytic study designs and the related measures of association derived from them. Table 9-4 summarizes the advantages and disadvantages of each design.

**Table 9-4** COMPARISON OF MAJOR EPIDEMIOLOGIC STUDY DESIGNS

<table>
<thead>
<tr>
<th>STUDY DESIGN</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecologic</td>
<td>Quick, easy, inexpensive first study</td>
<td>Ecologic fallacy: The associations observed may not hold true for individuals</td>
</tr>
<tr>
<td></td>
<td>Uses readily available existing data</td>
<td>Problems in interpreting temporal sequence (cause and effect)</td>
</tr>
<tr>
<td></td>
<td>May prompt further investigation or suggest other or new hypotheses</td>
<td>More difficult to control for confounding and “mixed” models (ecologic and individual data); more complex statistically</td>
</tr>
<tr>
<td></td>
<td>May provide information about contextual factors not accounted for by individual characteristics</td>
<td></td>
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<tr>
<td>Cross sectional (correlational)</td>
<td>Gives general description of the scope of problem; provides prevalence estimates</td>
<td>No calculation of risk; prevalence, not incidence</td>
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<tr>
<td></td>
<td>Often based on population (or community) sample, not just who sought care</td>
<td>Temporal sequence unclear</td>
</tr>
<tr>
<td></td>
<td>Useful in health service evaluation and planning</td>
<td>Not good for rare disease or rare exposure unless there is a large sample size or stratified sampling</td>
</tr>
<tr>
<td></td>
<td>Data obtained at once; less expense and quicker than cohort because of no follow-up</td>
<td>Selective survival can be a major source of selection bias; surviving subjects may differ from those who are not included (e.g., death, institutionalization)</td>
</tr>
<tr>
<td></td>
<td>Baseline for prospective study or to identify cases and controls for case-control study</td>
<td>Selective recall or lack of past exposure information can create bias</td>
</tr>
<tr>
<td>Case-control (retrospective, case comparison)</td>
<td>Less expensive than cohort; smaller sample required</td>
<td>Greater susceptibility than cohort studies to various types of bias (selective survival, recall bias, selection bias in choice of both cases and controls)</td>
</tr>
<tr>
<td></td>
<td>Quicker than cohort; no follow-up</td>
<td>Information on other risk factors may not be available, resulting in confounding</td>
</tr>
<tr>
<td></td>
<td>Can investigate more than one exposure</td>
<td>Antecedent-consequence (temporal sequence) not as certain as in cohort</td>
</tr>
<tr>
<td></td>
<td>Best design for rare diseases</td>
<td>Not well suited to rare exposures</td>
</tr>
<tr>
<td></td>
<td>If well designed, it can be an important tool for etiologic investigation</td>
<td>Gives only an indirect estimate of risk</td>
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<tr>
<td></td>
<td>Best suited to a disease with a relatively clear onset (timing of onset can be established so that incident cases can be included)</td>
<td>Generally limited to a single outcome because of sampling effect on disease status</td>
</tr>
<tr>
<td>Prospective cohort (concurrent cohort, longitudinal, follow-up)</td>
<td>Best estimate of disease incidence</td>
<td>Expensive in terms of time and money</td>
</tr>
<tr>
<td></td>
<td>Best estimate of risk</td>
<td>More difficult organization</td>
</tr>
<tr>
<td></td>
<td>Fewer problems with selective survival and selective recall</td>
<td>Not good for rare diseases</td>
</tr>
<tr>
<td></td>
<td>Temporal sequence more clearly established</td>
<td>Attrition of participants can bias the estimate</td>
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<tr>
<td></td>
<td>Broader range of options for exposure assessment</td>
<td>Latency period may be very long; may miss cases</td>
</tr>
<tr>
<td></td>
<td>Combines advantages of both prospective cohort and case-control</td>
<td>May be difficult to examine several exposures</td>
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<tr>
<td></td>
<td>Shorter time (even if follow-up into the future) than prospective cohort</td>
<td>Shares some disadvantages with both prospective cohort and case-control</td>
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<tr>
<td></td>
<td>Less expensive than prospective cohort because it relies on existing data</td>
<td>Subject to attrition (loss to follow-up)</td>
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<tr>
<td></td>
<td>Temporal sequence may be clearer than case-control</td>
<td>Relies on existing records that may result in misclassification of both exposure and outcome</td>
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**Cohort Studies**

The cohort study is the standard for observational epidemiological studies. It comes closest to the idea of a natural experiment (Rothman, 2002). The term cohort is used in epidemiology to describe a group of persons who are born at about the same time. In analytic studies, cohort refers to a group of persons generally sharing some characteristic of interest. They are enrolled in a study and followed over time to observe some health outcome (Porta, 2008). Because of this ability to observe the development of new cases of disease, cohort study designs allow for calculation of incidence rates and therefore estimates of risk for disease. Cohort studies may be prospective or retrospective (Gordis, 2009; Rothman, 2002).

**Prospective Cohort Studies**

In a prospective cohort study (also called a longitudinal or follow-up study), subjects who do not have the outcome under investigation are classified on the basis of the exposure of interest at the beginning of the follow-up period. The subjects are then followed for some period of time to determine the occurrence of disease in each group. The question is, “Do persons with the factor (or exposure) of interest
develop (or avoid) the outcome more frequently than those without the factor (or exposure)?”

For example, a cohort of subjects could be recruited who would be classified as physically active (“exposed”) or sedentary (“not exposed”). If you had adequate information you could quantify the amount of the “exposure.” You could then follow these subjects over time to determine the development of CHD. This study design avoids the problem of selective survival seen in other designs. The cohort study also has the advantage of allowing estimation of the risk for acquiring disease for those who are exposed compared to those who are unexposed (or less exposed). This ratio of cumulative incidence rates is called the relative risk.

Suppose 1000 physically active and 1000 sedentary middle-aged men and women were enrolled in a prospective cohort study. All were free of CHD at enrollment. Over a 5-year follow-up period, regular examinations detect CHD in 120 of the sedentary men and women and in 48 of the active men and women. Assuming no other deaths or losses to follow-up, the data could be presented as shown in Figure 9-2.

The incidence of CHD in the active group is \( \frac{48}{1000} \), and the incidence of CHD in the sedentary group is \( \frac{120}{1000} \). The relative risk is:

\[
\frac{48/1000}{120/1000} = 0.4.
\]

Because physical activity is protective for CHD, the relative risk is less than 1. In this example over a 5-year period, the risk for CHD in persons who are physically active compared to the risk among sedentary persons was 0.4. In the cohort study design, subjects are enrolled before disease onset, and this allows the researcher to study more than one outcome, calculate incidence rates and estimate risk, and establish the temporal sequence of exposure and outcome with greater clarity and certainty. The researcher may need a large sample to ensure that enough cases are observed to provide statistical power to detect meaningful differences between groups and may have to wait a long time for some diseases to develop.

**Retrospective Cohort Studies**

Retrospective cohort studies combine some of the advantages and disadvantages of case-control studies and prospective cohort studies. These studies rely on existing records, such as employment, insurance, or hospital records, to define a cohort that is classified as having been exposed or unexposed at some time in the past. The cohort is followed over time using the records to determine if the outcome occurred. Retrospective cohort (also called historical cohort) studies may be conducted entirely using past records or may include current assessment or additional follow-up time after study initiation. This approach saves time; however, its accuracy relies on existing historical records.

**Case-Control Studies**

In the case-control study, subjects are enrolled because they are known to have the outcome of interest (these are the cases) or they are known not to have the outcome of interest (these are the controls). Case-control status is verified using a clear case definition and some previously determined method or protocol (e.g., by an examination, laboratory test, or medical chart review). Information is then collected on the exposures or characteristics of interest, frequently from existing sources, subject interview, or questionnaire (Rothman, 2002; Sztklo and Nieto, 2007). The question in a case-control study is “Do persons with the outcome of interest (cases) have the exposure characteristic (or a history of the exposure) more frequently than those without the outcome (controls)?”

Because of the method of subject selection in case-control studies, neither incidence nor prevalence can be calculated directly. In a case-control study, an odds ratio tells us how much more (or less) likely the exposure is to be found among cases than among controls. The odds of exposure among cases \((a/d)\) are compared with the odds of exposure among controls \((b/c)\). The ratio of these two odds provides us with an estimate of the relative risk.

Suppose a research group wanted to study risk factors for suicide attempts among adolescents. To do so they would enroll 100 adolescents who had attempted suicide, and select 200 adolescents from the same community with no history of a suicide attempt. The research group’s goal is to determine if the adolescents had a history of substance abuse (SA). Through a questionnaire and use of medical records they learned that 68 of the 100 adolescents who had attempted suicide had a history of substance abuse. They also found that 36 of the 200 adolescents with no suicide attempt had a history of substance abuse. The information could be presented as follows:

![Figure 9-2: Cohort study](image)
The odds of a history of substance abuse among suicide attempters are \( a/c \) or 68/32, whereas the odds of substance abuse among controls are \( b/d \) or 36/164. The odds ratio (equivalent to \( ad/bc \)) is the following:

\[
\frac{68 \times 164}{36 \times 32} = 9.68
\]

This would be interpreted to mean that adolescents who attempted suicide are almost 10 times more likely to have a history of substance abuse than are adolescents who have not attempted suicide. Note that an odds ratio of 1 is indicative of no association (i.e., the odds of exposure are similar for cases and controls). An odds ratio less than 1 suggests a protective association, that is, cases are less likely to have been exposed than controls. Because case-control studies know the number of cases involved, they do not require a large sample or take a long follow-up time. They may have biases. Bias is a systematic deviation from the truth. Because these studies begin with existing diseases, differential survival can produce biased results. The use of recently diagnosed (or “incident”) cases may reduce this bias. Because exposure information is obtained from subject recall or past records, there may be errors in exposure assessment or misclassification.

**Cross-Sectional Studies**

The cross-sectional study provides a snapshot, or cross section, of a population or group (Gordis, 2009). Information is collected on current health status, personal characteristics, and potential risk factors or exposures all at once. In the cross-sectional study there is a simultaneous collection of information necessary for the classification of exposure. Historical information can also be collected (e.g., past diet, history of radiation exposures).

One way cross-sectional studies evaluate the association of a factor with a health problem is to compare the prevalence of the disease in those with the factor (or exposure) with the prevalence of the disease in the unexposed. The ratio of the two prevalence rates is an indication of the association between the factor and the outcome. If the prevalence of CHD in smokers were twice as high as the prevalence among nonsmokers, the prevalence ratio would be 2. If a factor is unrelated to the prevalence of a disease, the prevalence ratio will be close to 1. A value less than 1 may suggest a protective association. For example, the prevalence of CHD is lower among physically active people than among sedentary persons. Thus, the prevalence ratio for the association between physical activity and CHD should be less than 1. Use caution in interpreting prevalence ratios because the prevalence measure is affected by cure, survival, and migration and does not estimate the risk for getting the disease.

Cross-sectional studies are subject to bias resulting from selective survival. That is, persons with existing cases who have survived to be in the study may be different from those diagnosed at about the same time who died and are unavailable for inclusion. Suppose physical activity not only reduced the risk for heart disease but also improved survival among those with heart disease. Sedentary persons with heart disease would then have higher fatality rates than physically active persons who developed heart disease. Higher rates of physical activity might be observed in a group of heart disease survivors than in a general population without heart disease. This might occur because of the survival advantage and also because of the participation of the survivors in cardiac rehabilitation programs. It might, however, erroneously appear that physical activity was a risk factor for heart disease.

**Ecological Studies**

An ecological study bridges descriptive and analytic epidemiology. The descriptive component looks at variations in disease rates by person, place, or time. The analytic component tries to determine if there is a relation of disease rates to variations in rates for possible risk (or protective) factors or characteristics. The identifying characteristic of ecological studies is that only aggregate data, such as population rates, are used, rather than data on individuals’ exposures, characteristics, and outcomes. Examples include the following:
1. Examination of information on per capita cigarette consumption in relation to lung cancer mortality rates in several countries, several groups of people, or the same population at different times
2. Comparisons of rates of breastfeeding and of breast cancer
3. Average dietary fat content and rates of CHD
4. Unemployment rates and level of psychiatric disorder

Ecological studies often use existing, readily available rates and are therefore quick and inexpensive to conduct. They are subject, however, to ecological fallacy (i.e., associations observed at the group level may not hold true for the individuals who make up the groups, or associations that actually exist may be masked in the grouped data). This can occur when other factors operate in these populations for which the ecological correlations do not account. For that reason, ecological studies may suggest possible answers, but they require confirmation in studies that use individual data (Gordis, 2009; Koepsell and Weiss, 2003).

**EXPERIMENTAL STUDIES**

The study designs discussed so far are called observational studies because the investigator observes the association between exposures and outcomes as they exist but does not intervene to alter the presence or level of any exposure or behavior. In contrast, in experimental or intervention studies, the investigator initiates a treatment or intervention to influence the risk for or course of disease. These studies test whether interventions can prevent disease or improve health. Both observational and experimental studies generally use comparison (or control) groups. In experimental studies, persons can be randomly assigned to a particular group; an intervention (i.e., a treatment or exposure) is applied, and the effects of the intervention are measured. The two types of intervention studies are clinical trials and community trials.
Clinical Trials
The goal of a clinical trial is generally to evaluate the effectiveness of an intervention, such as a medical treatment for disease, a new drug or existing drug used in a new or a different way, a surgical technique, or other treatment. In clinical trials, subjects should be randomly assigned to groups. In randomization, treatments are assigned to patients (subjects) so that all possible treatment assignments have a predetermined probability but neither subject nor investigator determines the actual assignment of any participant. Randomization avoids the bias that may result if subjects choose to be in one group or the other or if the investigator or clinician chooses subjects for each group.

Masking or “blinding” treatment assignments is a second aspect of treatment allocation. Generally it is best to use a double-blinded study in which neither subject nor investigator knows who is getting which treatment. Clinical trials usually are the best way to show causality because of the objective way in which subjects are assigned and the greater control over other factors that could influence outcome. Like cohort studies, they are prospective and provide the clearest evidence of correct temporal sequence.

They do tend to be conducted in a contrived (versus natural) situation, under controlled conditions, and with patient populations. That means that treatment may not be as effective when applied under more realistic clinical or community conditions in a more diverse patient population. There are also more ethical considerations involved in experimental studies than in observational studies. For example, it is fair to withhold a treatment, if the treatment truly appears to have the potential to alleviate a disease, to evaluate systematically this treatment using both an experimental and a control group? Finally, clinical trials are expensive in terms of time, personnel, facilities, and, in some cases, supplies.

Community Trials
Community trials are similar to clinical trials in that an investigator determines what the exposure or intervention will be. However, community trials often deal with health promotion and disease prevention rather than treatment of existing disease. The intervention is usually undertaken on a large scale, and the unit of treatment is a community, region, or group rather than individuals. Although a pharmaceutical product such as fluoridation of water or mass immunizations may be involved in a community trial, these trials often involve educational, programmatic, or policy interventions. Examples of community interventions would be measuring the rates of diabetes or cardiovascular disease in a community in which the availability of exercise programs and facilities was increased or in which a much larger supply of healthful fresh foods was made available.

Although community trials provide the best means of testing whether changes in knowledge or behavior, policy, programs, or other mass interventions are effective, they do present some problems. For many interventions, it may take years for the effectiveness to be evident, for example, the effect of changing the availability of exercise and healthful food on the rates of either diabetes or heart disease. While the study is being carried out over time, other factors can influence the outcome either positively (i.e., making the intervention look more effective than it really is) or negatively (i.e., making the intervention look less effective than it really is). Comparable community populations without similar interventions for comparative analysis are often difficult to find. Even when comparable comparison communities are available—especially when the intervention is improved knowledge or changed behavior—it is difficult and unethical to prevent the control communities from making use of generally available information, effectively making them less different from the intervention communities. Finally, because community trials are often undertaken on a large scale and over long periods, they can be expensive, require a large staff, have complicated logistics, and need extensive communication about the study.

CAUSALITY

Statistical Associations
Sample size, strength of association, and variance of measures can all affect statistical significance. For example, to determine if eating habits affect the onset of hypertension, a statistical association between the factor (diet) and the health outcome (hypertension) would need to be established. If the probability of disease seems unaffected by the presence or level of the factor, no association is apparent. If, on the other hand, the probability of disease does vary according to whether the factor is present, there is a statistical association. The earlier discussion of null values is pertinent at this point. When an observed measure of association (e.g., a risk ratio) does not differ from the null value, there is no evidence of an association between the factor and the outcome being studied. To say a result is statistically significant means that the observed result is unlikely to be due to chance. Sample size affects statistical significance.

Bias
A statistically significant result may also be observed because of bias, a systematic error as a result of the study design, the way it is conducted, or a confounding factor. For example, if there were a gum ball machine with colors randomly mixed and three red ones in a row came out, that would be due to chance. If, however, the person loading the gum ball machine had poured in a bag of red ones first, then green ones, then yellow ones, it would not be surprising to get three red ones in a row because of the way the machine was loaded. In epidemiological studies, results are sometimes biased because of the way the study was “loaded” (i.e., the way the study was designed or the way subjects were selected, information was collected, and subjects were classified). Although the types of bias are numerous, there are three general categories of bias (Rothman, 2002). Bias can be attributed to the following:

1. Selection or the way subjects enter a study: Selection bias has to do with selection procedures and the population from which subjects are drawn, and it may involve self-selection factors. Example: Are teenagers who agree to complete a questionnaire on alcohol, tobacco, and other drug use representative of the total teenage population?
2. Misclassification of subjects once they are in the study: This is information, or classification (or misclassification), bias. It is related to how information is collected, including the information that subjects supply or how subjects are classified.

3. Confounding or bias resulting from the relationship between the outcome and study factor and some third factor not accounted for. Example: There is a well-known association between maternal smoking during pregnancy and low-birth-weight babies. There is also an association between alcohol consumption and smoking that is not due to chance nor is it causal (i.e., drinking alcohol does not cause a person to smoke, nor does smoking cause a person to drink alcohol). If we were to investigate the association between alcohol consumption and low birth weight, smoking would be a confounder because it is related to both alcohol consumption and low birth weight. Failure to account for smoking in the analysis would bias the observed association between alcohol use and low birth weight. In practice, we can often identify potentially confounding variables and adjust for them in analysis.

Assessing for Causality
The existence of a statistical association does not necessarily mean that a causal relationship exists or that causality is present. As just discussed, the observed association may be a random event (due to chance) or may be the result of bias from confounding or from some aspect of the study design or execution. Statistical associations, although necessary to an argument for causal inference, are not adequate proof. Some epidemiologists refer to guidelines, a term originally established to evaluate the link between an infectious agent and a disease but revised and elaborated to apply also to other outcomes. Although various lists of guidelines have been proposed, the seven guidelines listed in Box 9-3 are often used (Gordis, 2009; Koepsell and Weiss, 2003).

APPLICATIONS OF EPIDEMIOLOGY IN NURSING
Nurses need to know and be able to use epidemiology. Nurses regularly collect, report, analyze, interpret, and communicate epidemiological data in many of the areas in which they work. Nurses involved in the care of persons with communicable diseases use epidemiology daily as they identify, report, treat, and provide follow-up on cases and contacts of TB, gonorrhea, and gastroenteritis. School nurses also function as epidemiologists, collecting data on the incidence and prevalence of accidents, injuries, and illnesses in the school population. They are also key players in the detection and control of local epidemics, such as outbreaks of lice. As described earlier in this chapter, nurses across practice settings are actively involved in activities related to primary, secondary, and tertiary prevention (see the discussion of levels of prevention and the Levels of Prevention box).

Some nursing jobs are specifically based in epidemiological practice. These include nurse epidemiologists and environmental risk communicators employed by local health departments, as well as hospital infection control nurses. Nurses are key members of local fetal and infant mortality review boards, which examine cases of newborn deaths for identifiable risk factors and quality of care measures. Members of these review boards may include public health and maternal and child nurses, as well as representatives from hospital labor and delivery and neonatal intensive care units. Nurses play a key role in disaster preparedness in their communities, and this work includes knowledge of epidemiology.

Nursing documentation on patient charts and records is an important source of data for epidemiological reviews. Patient demographics and health histories are often collected or verified by nurses. As nurses collect and document patient information, they might not be thinking about the epidemiological connection. However, the reliability and validity of such data can be key factors in the quality of future epidemiological studies.

### BOX 9-3 GUIDELINES FOR CAUSAL INFERENCE

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Strength of association:</td>
<td>A strong association between a potential risk factor and an outcome supports a causal hypothesis (i.e., a relative risk of 7 provides stronger evidence of a causal association than a relative risk of 1.5).</td>
</tr>
<tr>
<td>2. Consistency of findings:</td>
<td>Repeated findings of an association with different study designs and in different populations strengthen a causal inference.</td>
</tr>
<tr>
<td>3. Biological plausibility:</td>
<td>Demonstration of a physiological mechanism by which the risk factor acts to cause disease enhances the causal hypothesis. Conversely, an association that does not initially seem biologically defensible may later be discovered to be so.</td>
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<td>4. Demonstration of correct temporal sequence:</td>
<td>For a risk factor to cause an outcome, it must precede the onset of the outcome.</td>
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<td>5. Dose-response relationship:</td>
<td>The risk for developing an outcome should increase with increasing exposure (either in duration or quantity) to the risk factor of interest. For example, studies have shown that the more a woman smokes during pregnancy, the greater is the risk for delivering a low-birth-weight infant.</td>
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<td>6. Specificity of the association:</td>
<td>The presence of a one-to-one relationship between an agent and a disease (i.e., the idea that a disease is caused by only one agent and that agent results in only one disease) lends support to a causal hypothesis, but its absence does not rule out causality. This criterion grows out of the infectious disease model in which it is more often than not always satisfied and is less applicable in chronic diseases.</td>
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<td>7. Experimental evidence:</td>
<td>Experimental designs provide the strongest epidemiologic evidence for causal associations, but they are not feasible or ethical to conduct for many risk factor–disease associations.</td>
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### LEVELS OF PREVENTION

**Related to Cardiovascular Disease**

**Primary Prevention**
- Discuss a low-fat diet and the need for regular physical exercise with clients.

**Secondary Prevention**
- Implement blood pressure and cholesterol screening; give a treadmill stress test.

**Tertiary Prevention**
- Provide cardiac rehabilitation, medication, and surgery.
FOCUS ON QUALITY AND SAFETY EDUCATION FOR NURSES

Targeted Competency: Informatics—Use information and technology to communicate, manage knowledge, mitigate error, and support decision making.

Important aspects of informatics include:

- **Knowledge:** Identify essential information that must be available in a common database to support client care.
- **Skills:** Use information management tools to monitor outcomes of care processes.
- **Attitudes:** Value nurses’ involvement in design, selection, implementation and evaluation of information technologies to support client care.

Informatics Question

**Determine If a Health Problem Exists in the Community**

Nurses are involved in the surveillance and monitoring of health phenomena. Planning for resources and personnel often requires quantifying the level of a problem in the community. For example, to know how different districts compare in the rates of infants with very low birth weight, you would calculate the prevalence of infants with very low birth weight in each district:

1. Determine the number of live births in each district from birth certificate data obtained from the vital records division of the health department.
2. Use the birth-weight information from the birth certificate data to determine the number of infants born weighing less than 1500 g in each district.
3. Calculate the prevalence of births of infants with very low birth weights by district as the number of infants weighing less than 1500 g at birth divided by the total number of live births.
4. If the number of births of infants with very low birth weights in each district is small, use several years of data to obtain a more stable estimate.

PREPARATION

You are a nurse at a local health department where Rob Jones, a 46-year-old African American, comes for a routine blood pressure check. He mentions that his father recently died from prostate cancer and that he is worried about himself. Further assessment reveals that his father was diagnosed with prostate cancer when he was 52 years old and that Mr. Jones’s uncle, who is 56, was recently diagnosed with prostate cancer. You know from Mr. Jones’ health history that he smokes a pack of cigarettes per day and eats fried food frequently.

**Which action would be your best choice?**

A. Give Mr. Jones a digital rectal examination and prostate specific antigen (PSA) test immediately to screen for prostate cancer.

B. Do not discuss or provide prostate cancer screening with him, because he is younger than 50 years.

C. Advise Mr. Jones to be tested immediately for the prostate cancer gene, because of his family history.

D. Inform him of the risks and benefits of prostate cancer testing and of his increased personal risk for prostate cancer because of his family history, smoking, and dietary habits. Involve him in the decision-making process about prostate cancer screening.

**Answers can be found on the Evolve website.**

REMEMBER THIS!

- Epidemiology is the study of the distribution and determinants of health-related events in human populations and the application of this knowledge to improving the health of communities.
- Epidemiology is a multidisciplinary science that recognizes the complex interrelationships of factors that influence disease and health at both the individual and the community level; it provides the basic tools for the study of health and disease in communities.
- Epidemiological methods are used to describe health and disease and to investigate the factors that promote health or influence the risk for, or distribution of, disease. This knowledge can be useful in planning and evaluating programs, policies, and services and in clinical decision making.
- Basic epidemiological concepts include the interrelationships among the agent, host, and environment (the epidemiologic triangle); the interactions of factors, exposures, and characteristics in a causal web affecting the risk for disease; and the levels of prevention corresponding to stages in the natural history of disease.
- Primary prevention involves interventions to reduce the incidence of disease by promoting health and preventing disease processes from developing.
- Secondary prevention includes programs (e.g., screening) designed to detect disease in the early stages, before signs and symptoms are clinically evident, to intervene with early diagnosis and treatment.
- Tertiary prevention provides treatments and other interventions directed toward persons with clinically apparent disease, with the aim of lessening the course of the disease, reducing disability, or rehabilitating the client.
- Epidemiological methods are also used in the planning and design of screening (secondary prevention) and community health intervention (primary prevention) strategies and in the evaluation of their effectiveness.
- Basic epidemiological methods include the use of existing data sources to study health outcomes and related factors and the use of comparison groups to assess the association between exposures or characteristics and health outcomes.
- Epidemiologists use rates and proportions to quantify levels of morbidity and mortality.
- Prevalence proportions provide a picture of the level of existing cases in a population at a given time.
- Incidence rates and proportions measure the rate of new case development in a population and provide an estimate of the risk for disease.
CHAPTER 9  Epidemiological Applications

• Descriptive epidemiological studies provide information on the distribution of disease and health states according to personal characteristics, geographic region, and time. This knowledge enables practitioners to target programs and allocate resources more effectively and provides a basis for further study.

• Analytic epidemiological studies investigate associations between exposures or characteristics and health or disease outcomes, with the goal of understanding the etiology of disease. Analytic studies provide the foundation for understanding disease causality and for developing effective intervention strategies aimed at primary, secondary, and tertiary prevention.

WHAT WOULD YOU DO?

1. Read your local newspaper for a week and see if you can find any reports that use epidemiological methods. If yes, what was the health risk? What was the intervention? What might have prevented the disease or accident? Discuss this with two classmates to see if they agree or disagree with you.

2. Identify a current health issue in your local community (e.g., childhood lead poisoning, diabetes, HIV/AIDS, Escherichia coli, childhood obesity).
   A. Describe primary, secondary, and tertiary prevention interventions related to this health issue.
   B. How could nurses improve the effectiveness of their prevention activities related to this health issue?

3. Look at a recent issue of the Morbidity and Mortality Weekly Report (http://www.cdc.gov/mmwr) and find one health issue that is affecting or could possibly affect your community. Work with a group of your classmates and identify the most useful nursing and public health interventions.

4. Think about the last time you used public transportation (i.e., bus, train, airplane). What were likely sources of disease transmission? How could you protect yourself from getting a disease if, while you were present, another passenger was sneezing and spraying droplets through the air?

ADDITIONAL RESOURCES

http://evolve.elsevier.com/Stanhope/foundations

• NCLEX® Review Questions
• Case Studies, with Questions and Answers
• Glossary
• Clinical Application Answers

REFERENCES

American Nurses Association: Essential nursing competencies and curricula guidelines for genetics and genomics, Silver Spring, Md, 2006, ANA.


