CHAPTER 1

Epidemiology and Its Progress

"What we think, we become."
—Gautama Buddha

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OBJECTIVES

- Describe epidemiology and the role played by nurses in this field of health care.
- Discuss epidemiological studies that have led to the discovery of various microorganisms.
- Explain the importance of statistics in epidemiology.
- Compare and contrast the terms "endemic," "epidemic," and "pandemic."
- Evaluate the types of prevention that are most cost-effective for the community.
- Integrate the components of epidemiological research.

EPIDEMIOLOGY AND ITS CHANGING DEFINITIONS

Scholars have defined epidemiology in various ways. Morris (2007) refers to epidemiology as the "study of health and populations in relation to their environment and ways of living." (p. 1165). Frost (1936) considers epidemiology to be "something more than the total of its established facts …" and to include the "… orderly arrangement of facts into chains of inference which extend more or less beyond the bounds of direct observation." The most acceptable definition is "the study of the distribution and determinants of health related status or events in specified populations" (Last, 1988, p. 159).

Epidemiology is a branch of science that investigates the risk factors responsible for the causation of diseases through retrospective and prospective observations, a complete history of disease, and the frequency of occurrence or transmission mechanisms of disease in populations and explores preventive and therapeutic control measures. A responsible public health approach does not end at the level of investigation and planning for the solution of a particular disease. Public health professionals advance study conclusions and use these data to formulate public health policy and law.

Specific public health organizations in the United States implement public health regulations and policies in focused areas of expertise for the protection and benefit of the public. For example, the U.S. Food and Drug Administration regulates drug and medical equipment safety and usage. The ultimate goal of epidemiology is to eliminate or reduce the influence of risk factors that cause disease and promote health in the community.

In the 19th century most scientists believed the cause of disease was infection (Germ Theory). We now know that diseases are caused not only by infection, but also through other factors related to nutrition, environment, and trauma. Most of the epidemiological studies in the past were observational. Our current ability to integrate technology into studies for the investigation of disease causation has proved to be advantageous in preventing the spread of disease. The availability of advanced microbiological, chemical, and drug testing devices as well as our ability to communicate instantaneously have had a tremendous positive effect on our efforts toward prevention and planning. Both scientific and technological advances have permitted conclusions to be reached in less time while conserving resources and operating in a fully ethical manner.

ROLE OF ADVANCED PRACTICE NURSING IN PUBLIC HEALTH

The concept of public health has a long and distinguished history within the nursing profession. In 1893 Lillian Wald coined the term "public health nursing" to describe the teams of nurses who worked outside the hospital (Reverby, 1993). The main idea behind public health nursing was prevention of diseases for those who did not have access to medical care. Florence Nightingale (**Figure 1-1**) was instrumental in the creation of the position of "district nurse" whose primary responsibility was to promote health and prevent diseases through nursing care and education (Monteiro, 1985). According to the Association of Community Health Nursing Educators (1991), the goals of public health nursing are to promote, protect, and restore the health of populations as well as to prevent disease and disability.

Advanced practice nurses must be familiar with epidemiology, statistics, health promotion, disease surveillance, community health assessment, and current health policy to effectively deal with illness that transcends individuals. Nurses have been participating in providing health education, vaccination programs, and screening procedures in the community as part of primary prevention practices. Specialized educational programs have been encouraged by public health departments and universities across the country to enable nurses to become public health nurses. Although it is clear that all advanced practice nurses do not specialize in public health, it is essential

FIGURE 1-1 Florence Nightingale.
Source: National Library of Medicine; URL: http://ihm.nlm.nih.gov/luna/servlet/view/search?q=B020487; Accessed April 5, 2010.

that all nurses engaged in advanced practice regardless of specialty have a working knowledge of the concepts of the wellness–illness continuum from a community or population perspective.

Nurses have taken a leading role in public health administrative activities and also in responding to public health emergencies. To counter acts of biological terrorism, there is a great need to understand and report the unexplained illness to the responsible agencies (Mondy, Cardenas, & Avila, 2003). Nurses are often the first health professional contacts in such emergencies, when critical information needs to be identified and reported promptly. They have clinical expertise and are also capable of functioning within the community and influencing and evaluating health policy changes. Nurses continue to face challenges as they work to educate the community on specific health needs, mobilize resources, and effectively implement public health policy guidelines. Because nurses have access to families, they often have opportunities to establish beneficial relationships with those in the community. Beyond communicating only with individual patients, exposure to families may be especially useful in identifying such issues as chemical abuse, domestic violence, harmful lifestyles, emotional problems, and other issues arising that may be related to socioeconomic conditions. When health problems are detected early, intervention may be more effective and the expenditure of scarce healthcare resources reduced.

Through the U.S. Department of Health and Human Services Healthy People 2010 project, 10 essential public health services were established for public health professionals to focus effectively on community priorities (see http://www.healthypeople.gov/). The leading health indicators in a community are preventable risk factors that are responsible for the top 10 leading causes of death in the United States. Healthy People 2010 also offers resources to health professionals in association with each health indicator.

Nurses play a vital role in public health because of growing opportunities for the expansion of nursing roles in public health, the need for nurses in ongoing community assessment, planning for emergency responses, and community education (Plews, Billingham, & Rowe, 2000).

HISTORICAL EPIDEMIOLOGICAL STUDIES

In 1798 Edward Jenner (**Figure 1-2**) introduced the practice of vaccination. He carried out experiments by inoculating material infected with cowpox virus into incisions made on the upper left arm of human subjects (Baxby, 1999). Jenner described the disease's transmission as making "its progress from the horse to the nipple of the cow, and from cow to the human subject" (Dudgeon, 1980, p. 582). Those who were infected with the cowpox virus also were immune to infection with the smallpox virus. An infected individual previously living with other family members exposed to smallpox showed no signs of infection. This observation of immunity to smallpox in an individual who has been infected with the cowpox virus led Jenner to further experiment, finding that all patients inoculated with cowpox virus were no longer susceptible to smallpox. It was thought that the cowpox virus and smallpox virus shared the same antigens, resulting in cross-immunity.

Although current smallpox vaccines are completely different from Jenner's original vaccination material, the experiments of Jenner and others led to the development of vaccines that have been successful in combating smallpox and many other infectious diseases. Each of these discoveries involved the detailed study of the disease history, identification of mode of transmission, cross-immunity observations, and the courage to experiment.

John Snow (**Figure 1-3**) is considered a pioneer in modern epidemiology. He became famous for his study on the mode of transmission of the deadly cholera disease caused by the bacterium, *Vibrio cholerae*. Cholera is believed to have originated in India, spreading to other countries in Asia over time. The disease was believed to be a deadly, untreatable disease, infecting a larger number of individuals than the plague. Snow hypothesized that cholera was transmitted through water. He created a map

FIGURE 1-2 Edward Jenner.
Source: National Library of Medicine; URL: http://ihm.nlm.nih.gov/luna/servlet/view/search?q=B015691; Accessed April 5, 2010.

showing streets and water pumps to track the incidence of disease. He discovered that people drinking water originating from the upper regions of the Thames River did not suffer as high an incidence of cholera as those who were drinking water from the lower regions contaminated with sewage. He removed the handle of the Broad Street pump located in the lower region of the Thames River, and the number of cases decreased gradually.

Snow was instrumental in the application of epidemiological methods such as identifying common symptoms (case definition), creating maps showing the incidence and prevalence of disease, recording incidence data with time and place, testing water sources, communicating with local politicians, scientifically integrating the chain of events, proposing the mode of transmission of disease (water), and then taking effective public health action by pulling out the handle of the pump that he suspected to be involved in disease transmission (Snow, 1991).

FIGURE 1-3 John Snow.
Source: National Library of Medicine; URL: http://ihm.nlm.nih.gov/luna/servlet/view/search?q=B08304; Accessed April 5, 2010.

Sir Richard Doll studied the incidence of cardiac and lung disorders in workers exposed to asbestos. He compared incidences of heart failure, pulmonary tuberculosis, lung cancer, and other respiratory diseases between workers who were exposed to asbestos and those who were not. Doll found that the risk of developing lung cancer was 10 times greater in the population exposed to asbestos as compared with those not exposed and that the incidence of chest malignancies decreased with a decrease in duration of exposure.

Smith and Spalding (1959), working as temporary advisers to the World Health Organization (WHO), investigated an outbreak of paralysis in Morocco. Local health authorities had been efficient in collecting incidence data. The advisers further investigated the outbreak, drawing conclusions from clinical and laboratory evidence, the

geographical distribution of cases, socioeconomic factors, and case follow-ups. The clinical signs and symptoms of those affected were muscle weakness and loss of superficial sensations in the hands and legs. The affected were diagnosed with acute peripheral neuritis. Even though some patients suffered from fever and diarrhea, no trace of infection was detected. All routine blood tests and cerebrospinal fluid tests were negative. The role of infection as a cause of the epidemic was ruled out, because the culture of secretions from those affected yielded no growth of any microorganisms. The advisers suspected that poisoning caused the neuritis, which primarily affected those in living in poverty. One affected family suspected the olive oil they used for cooking was responsible for the paralysis. They fed the dog food cooked with the dark oil and then they also ate it. After several days the family and dog developed paralytic signs and other symptoms. On further investigation, the dark olive oil sold in the lower socioeconomic communities was found to be contaminated with orthocresyl phosphate, a synthetic oil used to lubricate jet engines. Similar outbreaks were reported in Switzerland, Germany, and the United States. The prognosis of the disease depended on the extent to which individuals were affected. Those who had spinal damage were permanently disabled; those whose distal muscles only were affected recovered within a year. This study, conducted by Smith and Spalding, shows that epidemiological investigations can take long periods of time and demand teamwork, a background in the clinical sciences, and knowledge of similar past incidents.

Goldberger (**Figure 1-4**), Waring, and Tanner studied the mode of transmission of pellagra, conducting an important classic experimental study in 1914. Pellagra is characterized by diarrhea, dermatitis, dementia, psychomotor disturbances, and sensitivity to light and can be fatal. Pellagra was initially believed to be a communicable disease because of the high incidence and prevalence rates noted in the United States. Despite treatment, there was no improvement in disease symptomology. The growing spread of this disease was identified as a public health emergency, with quarantine and isolation implemented for those affected or exposed. However, isolation and quarantine of such a large number of individuals began to drain public health resources, also impacting the nation's economic productivity.

U.S. Public Health Service officials conducted a study at both an orphanage and a sanatorium to better understand the disease and identify prevention strategies. The subjects' diets were slightly modified to replace grits (maize or corn) with protein products such as milk and meat. Within a year researchers noticed that the signs and symptoms associated with pellagra disappeared completely. The subjects were followed for second and third year, with the disease recurring only in those who reverted

FIGURE 1-4 Joseph Goldberger.
Source: National Library of Medicine; URL: http://ihm.nlm.nih.gov/luna/servlet/view/search?q=B012870; Accessed April 5, 2010.

to eating corn products. In those who continued to consume a diet high in protein, pellagra was not noted again. Sanitation, isolation, and other preventive measures did not help the subjects (Laguna & Carpenter, 1951).

In this example, successful investigations were carried out during the peak incidence of a disease in a situation where public health action was necessary to conserve public health resources, resulting in identification of the cause and transmission of disease that led to a decrease in mortality and morbidity. Other lessons learned were that dietary deficiencies can result in disease and that a balanced diet is essential to good health.

The summer is a perfect time in New York for mosquitoes to breed and spread disease. In 1946 an outbreak of an unclassified disease was reported in epidemic numbers, with both the New York City Department of Health and the U.S. Public Health Service investigating (Greenberg, 1947). The causative agent was unknown, but signs

and symptoms were similar to chickenpox (fever, chills, sweats, backache, headache, and a maculopapular and papulovesicular rash). A black eschar (necrotic tissue) was also noted at the site of a bite and was assumed to be due to mites. An in-depth investigation was carried out in the apartment where the outbreak was believed to occur in an attempt to determine the cause of the disease. Using a step-by-step approach, clinicians, epidemiologists, and laboratory personnel were together able to solve the mystery after 3 months. Blood samples from the infected patients were collected and tested. Blood from mice was tested and found to contain an antigen similar to that found in human blood samples. Mites (*Allodermanyssus sanguineus*) were detected as ectoparasites on the rodents. Even though *Culex pipiens* mosquitoes were found in the basement of the apartment, laboratory investigations ruled out their involvement in the disease's transmission. Mice (*Mus musculus*) were surviving on garbage left in the incinerator. The signs and symptoms of the disease were grouped under "rickettsial pox" with the identified strain named *Rickettsia akari* based on the unique complement-fixation reactions of the serum antigens. This investigation involved keen exploration of the environment; the collection and laboratory testing of blood samples from humans, mites, mosquitoes, and rodents; and extraordinary teamwork.

Clarke and Anderson (1979) worked to identify whether the Papanicolaou (Pap) smear was an effective screening procedure for invasive cervical cancer. They conducted a case-control study in the city of Toronto. Interviewing the subjects helped identify the risk factors for cervical cancer. Higher education, higher age, lower annual income, and unemployment contributed to higher relative risk of cervical cancer in those who failed to have a Pap smear. Pap smear was considered to be less effective in those with adenocarcinoma because it arises from the mucous glands located in the endocervix in contrast to the squamous cell carcinoma that occurs at the squamocolumnar junction. The researchers concluded that "the Pap smear itself has no preventive value, and there must be appropriate follow-up and treatment of abnormal smears."

In 1976 an outbreak occurred as a result of an unknown agent that resulted in the hospitalization of 147 patients and 29 deaths. Patients all had signs and symptoms of pneumonia and a common history of attending the American Legion Convention at a Philadelphia hotel. During the epidemiological investigation, clinical, epidemiological, and laboratory criteria were clearly defined to identify the place, person, and time factors and cause of the disease. Clinical criteria included cough, fever, and signs of pneumonia in chest x-rays. Epidemiological criteria included patient attendance at the American Legion Convention in the period from July 21 to 24, 1976, in Philadelphia. A person was considered seropositive if he or she had a titer of 1:128 or greater by indirect fluorescent antibody assay used to detect unknown gram-negative microorganisms. The

well-defined criteria, preparation of a quality survey questionnaire, interviewing skills, the ability to conduct a multistate study, systematic tracking of data, microbiological assistance, and resources for autopsy led to the study's successful conclusions. The newly identified pathogen was named *Legionella pneumophila*, with the signs and symptoms caused by it grouped under "Legionnaires' disease." Although the source was not identified, it was concluded that the pathogen was airborne and that air conditioners contributed to its spread. This is typical of an epidemiological investigation that led to the discovery of a previously unknown pathogen (Fraser et al., 1977).

Global efforts were carried out to eradicate smallpox, including mass vaccination campaigns conducted on a large scale in numerous countries. WHO experts initially believed the most effective way to eradicate smallpox was mass vaccination. The experts focused least on an epidemiological approach such as interrupting the transmission of the virus. Known to kill 400,000 Europeans a year in the 18th century, smallpox is transmitted by an airborne virus (Behbehani, 1983). Smallpox spreads slowly, with a lower transmission rate and incidence during September. In contrast, high incidence was noted in the month of April, but the seasonal relationship of virus incidence could not be explained.

An epidemiological approach called "eradication escalation" was implemented in 20 countries within west and central Africa during September 1968, a low incidence period. In this effort, four principal methods were used: (1) active surveillance, (2) outbreak investigation, (3) outbreak control, and (4) rapid communication of disease intelligence. Active surveillance included identification of the cases that were not otherwise reported through a disease-reporting system and through outreach involving newspapers, radio, and public alerting systems.

Outbreaks were actively investigated and efforts were made to identify and describe such events. The close contacts of those affected were vaccinated, and various epidemiological measures were taken to interrupt transmission of the virus. Incidence data from several locations within Africa were reported to the Centers for Disease Control and Prevention (CDC) in the United States. Weekly update from CDC was circulated to all active surveillance sites in Africa so that rapid prevention measures could be taken. With the same staff involved in both the active surveillance and mass vaccination programs, the effect of these combined actions had a positive impact on disease transmission. The incidence rate not only decreased drastically, but the seasonal variation also decreased, with the WHO certifying the eradication of smallpox in 1980 (WHO, 2010b). The effects of these epidemiological control efforts on a mass scale are noted in "West and Central Africa Small Pox Eradication Program" (Foege, Millar, & Lane, 1971).

Even with an appropriate plan, longitudinal epidemiological studies pose additional challenges for the researcher. These studies typically involve many participants, effective distribution of resources, a lengthy duration of time, implementation phase obstacles, extensive data collection, the training of interviewers, follow-up, participant intervention compliance, and participant access to study locations.

One such study in the 1940s involved an investigation of the effect of vitamin supplementation in the diet of pregnant women on children's intelligence (Harrell, Woodyard, & Gates, 1956). The study was conducted at two maternity clinics, one in Norfolk, Virginia, and one in Leslie County, Kentucky. The characteristics of the women attending these clinics were the same. Participants were divided into four groups, with each group receiving a dietary supplement (group A, 200 mg ascorbic acid; group B, 2 mg thiamine, 4 mg riboflavin, 20 mg niacin amide, and 15 mg iron; group C, placebo; and group D, 2 mg thiamine). The study started with 1,200 pregnant women in each clinic. By the end of the study, attrition reduced the sample size of participating women to almost half, and the numbers of children of participants who were tested for their intelligence had also declined. (The Terman-Merrill Revised Stanford-Binet Scale for 3 and 4 year olds was used to test intelligence levels.) Results showed that the intelligence level of participating 3- and 4-year-old children in Norfolk and Leslie County was higher than those of the placebo group. The intelligence level of children in Leslie County was found to be higher than that of children in Norfolk, with the higher intelligence attributed to the diets of pregnant women who had taken a combination of vitamins such as thiamine, riboflavin, ascorbic acid, and iron (mineral) as compared with women who had taken only thiamine or ascorbic acid. This study, conducted between 1945 and 1948, passed through many hurdles, with a high attrition rate for participants and their children, yet the success of the research was evident.

The effects of nuclear radiation on the human body were not well known before World War II. Even though animal studies were done to study the side effects of nuclear radiation, the difference in genetic structure makes comparison highly complicated. Moreover, studies have also shown that the outcomes of radiation differ depending on the age of the individual affected. The cities of Hiroshima and Nagasaki were destroyed with nuclear bombs at the end of World War II without considering the outcomes of such actions.

The Atomic Bomb Casualty Commission was established in the United States to monitor the effects of nuclear radiation on the survivors of Hiroshima and Nagasaki after survivors of the bombing reported a high incidence of leukemia (Lindee, 1994). The Commission's observations were based on incidence data for leukemia by age,

distance of exposure, and type of leukemia. High leukemia incidence was reported near the nuclear bombing site, and as the distance from the bomb site increased, the incidence decreased. A higher incidence of acute leukemia was detected in victims younger than age 30 years, and chronic leukemia appeared at a young age in the individuals near the bombing site (<1,500 meters). Granulocytic leukemia was most common in the chronic leukemia group. The incidence rate of both acute and chronic leukemia decreased with time (Bizzozero, Johnson, & Ciocco, 1966). These observations have allowed us to understand the effects of nuclear radiation and the extent of its influence over time.

DISEASE TRANSMISSION DYNAMICS

Based on the mode of transmission, diseases are classified as communicable or noncommunicable diseases. Communicable diseases are transmitted from human to animal, animal to animal, animal to human, and vice versa. The evolution of a microorganism to the degree that it can survive in a different species or genetic environment is a sign of an emergency. Pathogens can be directly transmitted through inhalation or wounds and can be indirectly transmitted when a vector is involved in the transmission process. Some pathogens produce free-living infective stages, and when taken up by a susceptible host, they further grow using the host's resources. The results of studies involving the identification of mode of transmission of a disease can significantly impact the action plan to contain the spread of disease. Such studies not only predict the probable response of the disease to control efforts but can also lead to further research on what happens when a pathogen is introduced in a system in which it does not currently exist.

Social and environmental factors affect the transmission dynamics of a disease (Weiss, 2004). Incidences of many diseases in the past were controlled through extensive public health initiatives, the use of antibiotics and vaccinations, insecticides targeting vectors, and improved surveillance. With globalization, climate changes, dietary preferences, deforestation, political decisions, misuse of and microbial resistance to antibiotics, and conflicts that disrupt a nation's economy influence the emergence and reemergence of disease. Other factors affecting transmission include modern technology, research on biological material, increasing nuclear radiation, and harmful gas emissions. Recently, the human immunodeficiency virus (HIV), Legionnaires' disease, swine flu (H_1N_1), and many other diseases have been newly discovered because of the availability of technology and planned epidemiological research studies. The containment of such diseases calls for collective human commitment and public health action.

The mode of transmission of a disease is dynamic, and patterns can change with time. Avian influenza initially was thought to be restricted to birds, and fears were expressed that it may spread to humans. Studies revealed that the glycoprotein virus receptor (Hemagglutinin) carried by the avian influenza virus attaches to sialic acid alpha-2,3-galactose receptors present on the alveolar cells in contrast to sialic acid alpha-2,6-galactose receptors present on the bronchial epithelial cells (Shinya & Kawaoka, 2006). The location of receptors makes it difficult for the avian influenza virus to spread from human to human. The human influenza virus attaches to sialic acid alpha-2,3-galactose receptors, which are present on bronchi and alveolar type II epithelial cells, thus easily transmitted through respiratory channels (Ma, 2007; Smith & Bazini-Barakat, 2003). Successful interspecies transmission and adaptation to a new genetic environment is possible through antigenic drift and antigenic shift processes. The 2009 pandemic swine flu has succeeded in this interspecies transmission.

Changing Patterns of Disease Incidence

WHO disease incidence data collected across the world are analyzed based on income. In high-income countries, coronary heart disease is the leading cause of death followed by cerebrovascular diseases, lung cancers, and lower respiratory infections (Mokdad, Marks, Stroup, & Gerberding, 2004) (**Table 1-1**). In contrast, infections cause the most deaths in low-income countries. This disparity is not just a result of income differentials but also many other factors. In the United States modifiable behavioral factors, such as tobacco smoking, physical inactivity, alcohol and drug use, unsafe sexual practices, use of firearms, and unsafe motor vehicle driving practices, contribute greatly to higher disease incidence rates among low socioeconomic status populations (Jemal, Ward, Hao, & Thun, 2005). Federal and state governments in the United States offer educational intervention programs to encourage behavior change to conserve the nation's health resources. WHO conducts preventive, educational, and immunization programs in developing countries to reduce mortality caused by infectious disease (WHO, 2010a).

Health Data Collection and Interpretation

John Graunt is considered the first epidemiologist (Rothman, 1996). In the 17th century he published a book, entitled *Natural and Political Observations Mentioned in a Following Index, and Made upon the Bills of Mortality* (Graunt, 1665), and also produced a weekly report, *Bills of Mortality*. He first described the relationship between population size and disease and was able to provide an estimate of the population of the city

Table 1-1 Leading Causes of Death in the United States in 2000

Cause of Death	No. of Deaths	Death Rate per 100,000 Population
Heart disease	710,760	258.2
Malignant neoplasm	553,091	200.9
Cerebrovascular disease	167,661	60.9
Chronic lower respiratory tract disease	122,009	44.3
Unintentional injuries	97,900	35.6
Diabetes mellitus	69,301	25.2
Influenza and pneumonia	65,313	23.7
Alzheimer disease	49,558	18
Nephritis, nephritic syndrome, and nephrosis	37,251	13.5
Septicemia	31,224	11.3
Other	499,283	181.4
Total	2,403,351	873.1

Source: Mokdad, A. H., Marks, J. S., Stroup, D. F., & Gerberding, J. L. (2004). Actual causes of death in the United States, 2000. Journal of the American Medical Association, 291(10), 1238–1245.

of London. William Farr and Rowe Edmonds developed the idea of vital statistics, and, using Graunt's data, they interpreted the health and welfare of the people (Eyler, 2002; Farr, 1852). In recent years the Framingham heart study, the community intervention trials of fluoride supplementation in water, and the Surgeon General's report on smoking and health have been recognized for their contributions, signifying the importance of health statistics.

PUBLIC HEALTH SURVEILLANCE

If a foreign army had landed on the coast of England, seized all the seaports, . . . ravaged the population through the summer and . . . in the year it held possession of the country slain fifty-three thousand two hundred and ninety-three men, women and children, . . . the task of registering the dead would be inexpressibly painful; and the pain is not greatly diminished by the circumstance that in the calamity to be described the minister of destruction was a pestilence.

—William Farr (**Figure 1-5**)

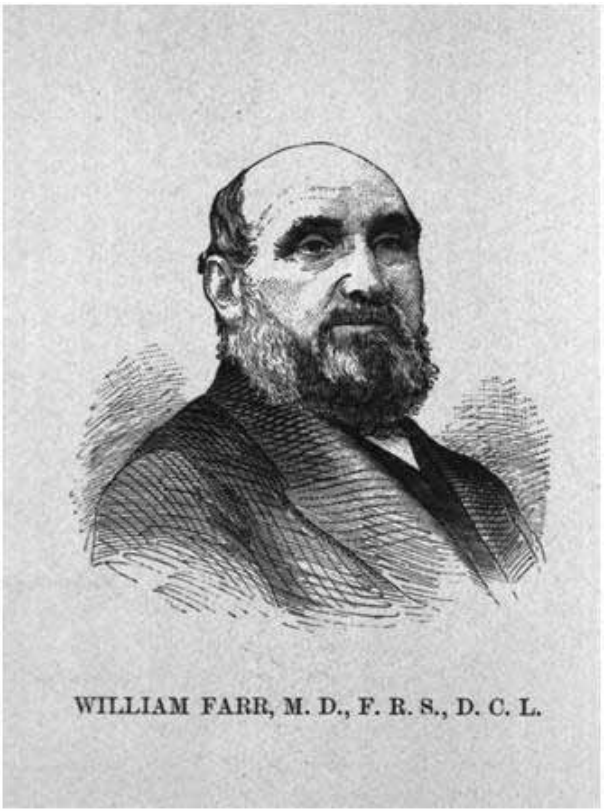


FIGURE 1-5 William Farr.
Source: National Library of Medicine; URL: http://ihm.nlm.nih.gov/luna/servlet/view/search?q=B06814; Accessed April 5, 2010.

Langmuir (1963) defined surveillance in its early days as "close observation of persons exposed to a communicable disease to detect early symptoms and institute prompt isolation and control measures." CDC has defined public health surveillance as "ongoing, systematic collection, analysis, and interpretation of data that is then disseminated to those responsible for preventing diseases and other health conditions." The monitoring of health status in the community had its beginnings in Italy, where isolation and quarantine were used as a means to control the spread of infectious diseases (Gensini, 2004). In 1935 the first national health survey was conducted in the United States. The

establishment of the Epidemiological Surveillance Unit at WHO headquarters, Geneva, initiated global public health surveillance efforts (Declich & Carter, 1994). The main objectives of surveillance activity include detecting changes in the patterns of the disease across the world, recording the natural history and epidemiology of a disease (essential in formulating a control action plan), and providing information to healthcare professionals. Health data are collected by various methods.

Passive surveillance includes data collection through various data notification systems established by health departments as part of mandatory health law. Hospitals, physicians, and laboratories report these data to local health departments. The CDC issues yearly updates on notifiable diseases, with all resource agencies reporting on either case diagnosis or suspicion.

Active surveillance includes actively searching for cases and inquiring directly with individuals for signs and symptoms during epidemics or in a situation where an epidemic is anticipated. Surveys are conducted to collect these types of data in the community. The collected data are then analyzed and interpreted, with results disseminated to professionals so that prompt action can be taken. Because infectious diseases do not recognize any political border, an effective integrated and global public health surveillance system is needed to counteract the potential evolution of an endemic to an epidemic in this current world of globalization.

Epidemiological Triangle

Epidemiological studies on infectious diseases have helped epidemiologists identify the core factors involved in the disease process. Agent, host, and environment (as well as time) are most important in a disease's transmission (**Figure 1-6**). The agent is a microorganism that has the ability to cause disease. The host is generally either a human or animal infected by the agent. The agent survives on the resources of the host or is attacked by the host's immune system. Environmental factors such as air, water, soil, chemicals, diet, and genetics influence the disease transmission process. The time taken for the appearance of signs and symptoms caused by an agent in the host is the *incubation period*. The study of the epidemiological triad components of a disease helps the epidemiologist plan for an effective intervention to interrupt the transmission process and stop further evolution of the disease.

Epidemic

An epidemic is defined as the "occurrence in a community or region of cases of an illness, specified health behavior, or other health related events clearly in excess of

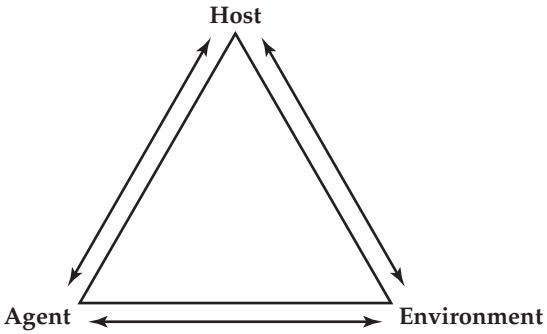
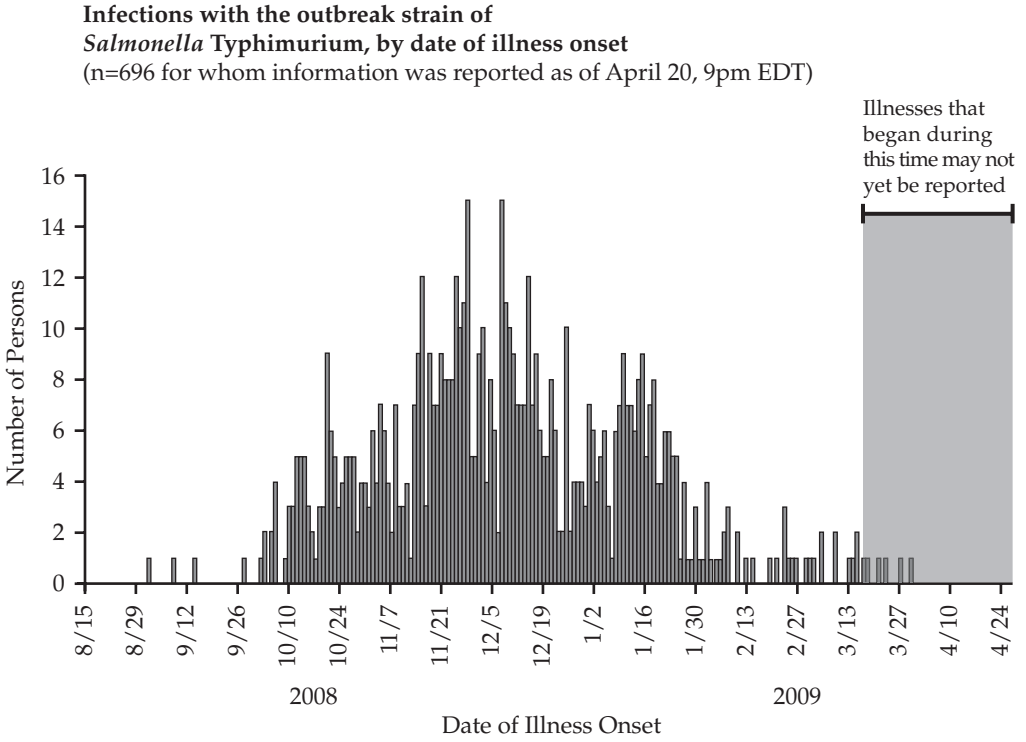


FIGURE 1-6 Epidemiological triangle.

normal expectancy; the community or region, and the time period in which cases occur, are specified precisely" (WHO). Epidemics are limited in space and time. Gradually they end and incidence rates decline with time because of recovery, secondary complications, or death. Immunity plays an important role in the recovery process. If there is only a minor change in the antigen, the exposed and unaffected may be vaccinated, the infected may be treated with drugs, drug prophylaxis can be offered to the exposed, and secondary complications arising as a result of the disease can be addressed. For example, individuals infected with influenza virus generally present with upper respiratory tract signs and symptoms such as sneezing and coughing and constitutional symptoms including fever, muscle aches, and fatigue. Acute respiratory distress syndrome can result, and the patient may die. Effective healthcare communication and timely action can stop the progression of disease, saving thousands of lives.

Epidemic Curve

The graphic representation of new cases originating because of the rapid transmission of a disease in an area during an interval of time is called an epidemic curve, or epicurve. Assimilating data to produce this graphic is time consuming on the part of epidemiologists. When retrospectively analyzed, the curve provides valuable information. For example, the incubation period of a disease can be calculated if the time of exposure is approximately known. The planning of responses to epidemics depends on the magnitude of the situation and may be associated with the number of cases that can be tracked on the graph. Looking at the pattern of the curve, one may be able to determine whether individuals were exposed to the source at one time or continuously



*Some illness onset dates have been estimated from other reported information

FIGURE 1-7 Salmonella outbreak.
Source: From Centers for Disease Control and Prevention. Retrieved March 21, 2010, from http://www.cdc.gov/salmonella/typhimurium/epi_curve.html

exposed or whether the pathogen was transmitted from person to person or individuals were intermittently exposed. The CDC offers Epi Info software for practice and understanding at its website (see http://www.cdc.gov/epiinfo/downloads.htm). **Figure 1-7** is an example of an epidemic curve.

Pandemic

A pandemic is an epidemic where the incidence of disease extends to a whole country or large part of the world. Pandemics are generally the result of the antigenic shift

process in which new antigens are produced by the microorganism (Cinti, 2005). It can take several weeks for the immune system to develop a primary response to such situations. During this period the severity of complications in such infected populations will be worse. The key public health response to such pandemic challenges includes the development of a vaccine, which can also take some time. The strategies adopted in an epidemic are different from that of pandemics because vaccines are not readily available. Chemoprophylaxis and infection control practices such as hand washing, isolation, and quarantine are the immediate measures taken. When the vaccine is made available, mass vaccination is preferred. A strong political commitment is needed for such public health actions to meet the challenge. Long-term commitment and strategy depend on the information gathered from public health surveillance (Osterholm, 2005).

Endemic Disease

A disease that is prevalent in a population in a certain area for a long period of time is defined as an endemic. The risk factors for endemic diseases can include lack of personal hygiene, malnutrition, poor sanitation, contaminated water or food, unclean surroundings, low socioeconomic status, climatic conditions, the presence of other diseases, and an unresponsive political climate.

Herd Immunity

The inherent or acquired immune resistance offered by populations to the prevalence of a disease in a community is referred to as herd immunity. Vaccinations of populations play an important role in the development of immunological barriers toward the entry of a disease into the community (John, 2000; Paul, 2004). This immune resistance effectively reduces the efficiency of the microbe to transmit from person to person. Generally, 83% to 94% of the population needs to be vaccinated to achieve herd immunity to a given disease. Immune levels also depend on the virulence of the disease. The protection offered by herd immunity to those unimmunized because of the break in transmission process is called herd protection. Herd immunity and herd protection are two different terms. The oral polio vaccine offers both herd immunity and herd protection (because live virus is excreted in stools and can spread in the community), whereas the inactivated polio vaccine offers only herd protection. Tetanus vaccination does not provide any additional benefits to the unimmunized.

PREVENTION

"Prevention is better than cure."
—Desiderius Erasmus

When medical science was developing, there was no treatment to limit the spread of infectious diseases, and prevention was an effective tool. In the modern world we tend to believe we have gained relative dominance over infectious diseases with the discovery of antibiotics. However, the prevalence of noncommunicable diseases in developed countries is higher than the prevalence of infectious diseases. The only cost-effective way to reduce the incidence of diseases in the community is prevention. Prevention is divided into three levels.

1. *Primary prevention:* Actions taken to promote one's health that prevent disease and disability in an individual are referred to as primary prevention. Examples of primary prevention include vaccinations, the addition of fluoride to water and toothpaste, the use of a seat belt to prevent accident injuries, exercise, and folic acid supplementation in pregnancy.
2. *Secondary prevention:* Actions leading to the early identification, diagnosis, and treatment of a disease to limit the consequences of such exposure and to interfere with disease transmission are referred to as secondary prevention. Examples include screening procedures such as the Pap smear for cervical cancer detection, sigmoidoscopy for detecting colon cancer, blood pressure and serum cholesterol level measurements to prevent coronary heart disease, and oral intake of calcium supplements for those at risk of osteoporosis.
3. *Tertiary prevention:* Actions that promote activities of daily living to limit the progression of disease and complications in people suffering from both communicable and noncommunicable diseases are referred to as tertiary prevention. Rehabilitation is a primary approach comprising this level of prevention. Examples include avoidance of allergens in asthmatic patients; eye, renal, and foot screening procedures for diabetics; and treatments to reduce the severity of disease.

Quarantine and Isolation

In many situations involving public health emergencies, quarantine and isolation have been viewed as the immediate solutions to contain a disease. Quarantine and isolation are two different terms. The word *quarante* means 40 in Italian. During the days of

the plague, ships were forced to anchor for 40 days at the port of Venice. "Quarantine" means physical separation of healthy individuals who have been exposed to a contagious disease. "Isolation" is defined as segregation and confinement of infected individuals from others who are known to be suffering from disease. Cholera, the plague, and other diseases that caused deaths on a large scale led to the idea of such preventive action. These actions can effectively interrupt the disease transmission chain, also offering the opportunity to treat infected individuals. From the information obtained from quarantined individuals, contact tracing can also be initiated. In Cuba from 1986 to 1994, HIV-positive individuals were quarantined. Quarantine does not work to reduce the incidence of a disease not transmitted through regular contact.

Not so long ago, sanatoria were set up for patients with tuberculosis, known as the "great white plague." The number of sanatoria declined with time as the incidence of tuberculosis declined. However, because of the reemergence of other diseases, the need for special facilities dedicated to housing those infected with one disease is growing. In Canada during the epidemic period of severe acute respiratory syndrome (aka SARS), almost 14,000 individuals were isolated. Such isolations can cause frustration in healthcare workers and also in quarantined individuals, restricting the movement of an individual, affecting one's employment status, and potentially imposing a psychosocial burden on society (Cava, 2005). To deal with such issues, strategies for emotional responses should be designed. Isolation can, however, save money and lives.

Epidemiological Research

Once the need for research on a topic has been identified, epidemiological research involves understanding the concepts of epidemiology, planning an appropriate study design, data collection, statistical analysis, and interpretation of findings toward conclusions to improve health. A study can be planned with or without human participants. Data reported by hospitals and laboratories to health departments can also be used. Genetic and molecular tools have increased the chances of identifying the source of disease in less time. The research techniques and lessons learned in the research of infectious diseases have been applied most recently to studying chronic diseases. An interdisciplinary collaboration is almost always essential for the completion of a successful study. Consent, ethics, and data privacy are other important components to consider in epidemiological research.

Outbreak Investigation

An unexpected rise in the number of cases of a particular identified or unidentified disease alerts public health officials to respond to the situation through focused investigation. Public health departments record patterns of diseases all year as part of their surveillance. Epidemiological investigations conducted to identify the causes of outbreak have led to the discovery of many new microorganisms. Epidemiological studies on influenza have helped us to understand whether or not vaccination programs are effective. Designated preventive measures to contain a disease need to be reviewed continuously because of the changing patterns of some diseases. The outcomes of such outbreak investigations should be communicated to both the public and healthcare professionals throughout the world.

Because of rising fears of pandemics among healthcare professionals, the incidences of cases are sometimes over-reported. The epidemiologist role in such situations is a difficult one, because he or she has to collaborate with other teams to identify the most common symptoms that the disease presents. Laboratory, genetic, and molecular tools help to identify the disease-causing organism from various specimens obtained from infected individuals. The accurate description of cases and identification of a specific diagnostic tool can result in confirmation of the disease. Surveys can then be designed to gather information from infected and exposed individuals. These data are used to construct an epidemic curve from which the incubation period can be calculated. Descriptive data can define certain characteristics of the disease (e.g., age group and gender affected). The patterns of exposure to the source (continuous, propagated, or intermittent) can be identified. After preliminary investigation, the next step is to identify the source and transmission methods of the disease. A hypothesis is then constructed and tested in the field by designing an appropriate study (case-control, cohort, or survey study) to identify the source of infection. An environmental investigation is also an important component to identify disease transmission pathways. (Outbreak investigation involves the epidemiological triad: the study of host, agent, and environment.) Preventive and therapeutic measures are designed to treat infected individuals and also to break the transmission pathways. The information is disseminated to healthcare professionals, and diagnostic tools are made available on a large scale. Prevention measures involving vaccination involve complex research studies and surveillance for any adverse effects of the vaccination.

After disease numbers are controlled, an effective public health surveillance system should be placed into action to monitor the situation. The success of an outbreak investigation lies in effective communication. The information is not only shared with public health professionals but is also communicated to the public through the media.

KEY POINTS

- Nurses play an important role in the field of epidemiology with their background in nursing science as well as skills for working in the community. With additional training on epidemiological concepts, nurses can be easily integrated into epidemiological fields—an opportunity that can expand the limits of their profession.
- Epidemiology is a science that deals with the determinants of health. Health data are collected from various sources such as hospitals, laboratories, and mandatory reporting systems in the community.
- Methods for gathering and interpreting health data were first attempted in London, England. Past endeavors have led to present-day data collection systems, monitoring systems, surveillance systems, and new roles for biostatisticians. Graduate nursing education programs in the United States have integrated a statistics component into their curricula and have encouraged nurses to learn and interpret health data. These skills enable nurses to conduct research studies and to interpret data and come to conclusions to plan further actions.
- John Snow and other epidemiologists who conducted historical studies laid foundations for contemporary epidemiological studies and research. The creation of maps, basic statistics, accurate event recordings, and retrospective event analyses were the simple steps followed. Current studies involve larger populations with multiple variables and use of advanced genetic and molecular tools for accurate diagnoses.
- Epidemiological concepts used for the study of infectious diseases are now applied to chronic diseases. Large-scale studies on chronic diseases have led to the identification of risk factors that form the basis of comprehensive screening and preventive measures implemented by health agencies worldwide. Nurses are involved in vaccination and other prevention programs in several countries.
- The epidemiological triad explains the transmission pathway of a communicable disease involving an infectious organism and noncommunicable diseases. By understanding how the host, agent, and environment are involved in the disease process, epidemiologists can design strategies to break the links involved in transmission pathways. Noncommunicable disease risk factors are communicated to the public, with responsibility for adopting behavioral change resting with the individual. The knowledge and skills of nurses can be used in this communication process toward the reduction of risk factors in a community.

- The importance of primary prevention is growing in the community because it promotes health and conserves healthcare resources. A nurse's participation is encouraged in such preventive actions.
- The incubation period for an infectious disease is an important piece of information that determines the time limit for epidemiologists in responding to an outbreak situation.
- The epidemic curve provides incubation period information and can help us determine the source of infection and patterns of exposure.
- Deaths in developed countries are primarily associated with noncommunicable diseases, whereas in developing countries communicable diseases are responsible for most deaths. The resurgence/reemergence of infectious diseases is a major concern because we are less aware of the new behavior of a changing microorganism.

CRITICAL QUESTIONS

1. What is the importance of epidemiology in the field of science?
2. Describe the role of nursing in the field of epidemiology.
3. Describe lessons learned from select historical epidemiological studies.
4. Describe the importance of statistics in epidemiology.
5. How can prevention activities lessen the burden of disease in communities?
6. Discuss the ethical, psychosocial, and other issues involved in isolation and quarantine.
7. Describe the steps involved in planning an epidemiological research study.
8. Describe the steps involved in the management of an outbreak situation and, by using Web resources, describe an outbreak investigation conducted by the CDC.

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