3

Infectious Diseases in the Community

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Learning Outcomes

After reading this chapter, you should be able to

- Describe infectious diseases and how they spread.
- Explain significant disease epidemics in public health history.
- Describe the major infectious diseases currently affecting public health.
- Identify the environmental risk factors that cause infectious disease.
- Summarize the role of public health in controlling infectious disease.

Since the dawn of public health in the United States, great strides have been made in the control of infectious diseases. In fact, by the mid-20th century, some public health experts believed that the tide of *mortality* (death rates from a disease) and *morbidity* (how often diseases occur) from infectious diseases had been greatly reduced. Some even hoped that newly introduced antibiotics and other "magic bullets" could eradicate all infectious diseases. Today, few public health experts hold this opinion, as microbes have developed resistance to antibiotics, causing the reemergence of once-controlled infectious diseases. Indeed, conditions known as *emerging infections* have gained a foothold worldwide and continue to endanger the population.

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Though antibiotics have contributed to the increase in control of many infectious diseases, certain microbes have developed resistance to these "magic bullets."

An increasingly "small world" also plays a role. This means that a dangerous communicable disease from a remote corner of the globe can now be introduced, via modern jet travel, to a major city within a 24-hour period. A major increase in the international trade of food and medicines has also contributed to the spread of diseases. Improperly processed foods and medicines can bypass normal inspection and safety procedures, especially when the volume of such products exceeds the capacity of health authorities.

An additional possible factor linked with the spread of infectious diseases is deforestation in many parts of the world. Deforestation causes the destruction of natural ecosystems that are important for human survival. Among the consequences of ecosystem loss is the potential for increases in runoff of pollutants into human water supplies and changes in the distribution of disease-causing organisms. Growing urbanization and pressures from the human population explosion cause people to move into previously forested areas, where they may encounter new vectors, or pathogens, and infectious disease agents.

For all of these reasons, understanding infectious diseases continues to be a priority for those who work in public health. This chapter provides an overview of infectious diseases and their impact on the health of communities. Topics include the discovery of disease-causing microbes, the epidemiologic triangle, examples of significant infectious diseases, and methods for the prevention of communicable diseases. This chapter will also cover environmental risk factors that cause disease and the prevention efforts that have been enacted to reduce the burden of such diseases in the United States.

3.1 Introduction to Infectious Diseases

Infectious diseases, or *communicable diseases*, are disorders caused by organisms such as bacteria, fungi, viruses, or parasites. Infectious diseases are often highly contagious. Touch, breath, bodily fluids, and other paths of infection can easily transmit them. In the United States, infectious diseases continue to be major causes of mortality. In fact, the combined category of pneumonia and influenza was the eighth leading cause of death in 2016 (National Center for Health Statistics, 2017).

Globally, infectious diseases account for a significant proportion of deaths. In the United States in 2014, 17.8 million visits made to physicians' offices were connected to infectious or parasitic conditions. The following were the four leading infectious killers in 2014:

- Tuberculosis (9,421 cases)
- Salmonella (51,455 cases)
- Lyme disease (33,461 cases)
- Meningococcal disease (433 cases) (CDC, 2017p)

The Epidemiological Triangle

How can we explain the occurrence of infectious diseases such as tuberculosis and salmonella in the community? The **epidemiological triangle** is a model for understanding the causes of infectious diseases. It encompasses three major factors: agent, host, and environment (Figure 3.1). The triangle helps explain and control disease outbreaks that may occur in the community in general as well as in smaller units within the community—schools, hospitals, and other institutional settings.

Figure 3.1: The epidemiological triangle

The epidemiological triangle shows the three components involved in the spread of infectious disease: the environment, agent, and host.

Source: Adapted from *Epidemiology for Public Health Practice*, by R. H. Friis and T. A. Sellers (4th ed., p. 439), 2009, Sudbury, MA: Jones & Bartlett.

You can see an example of this triangle in the Flint, Michigan, water crisis (see *Case Study: Water Crisis in Flint, Michigan* in Chapter 2). The agent was the contaminants (such as fecal matter and trash) in the water supply from the Flint River, the host was the human drinking the water that was not filtered appropriately, and the environment was the Flint River itself. If we follow the situation from the contaminated environment (Flint River) to the agent within it (trash/fecal matter), to the host (human consumption), we see the triangle in action, and unless there is a break in the triangle, the crisis continues. That break could be at any point: The agent stops contaminating the river, the host avoids drinking the water, or the environment is cleared of contamination. The following sections take a closer look at each point of the triangle.

Infectious Agent

An **infectious agent**, or disease agent, such as a bacterium, virus, parasite, or fungus causes an infectious disease (Table 3.1). When accounting for the etiology of an infectious disease, the triangle specifies that an infectious microbial agent must be present for an infection to occur. Infections of the human immunodeficiency virus (HIV), seasonal influenza, and *Salmonella*-associated foodborne disease outbreaks are all examples of conditions caused by infectious agents. A **vector**—a living insect or animal that carries a disease without getting sick—sometimes transmits infectious agents. Mosquitoes are one example of a vector and are often responsible for transmitting vector-borne diseases such as malaria.

Table 3.1: Infectious agents and their diseases

Disease agents	Diseases produced
Bacteria	Tuberculosis, salmonellosis, streptococcal infections, and methicillin-resistant *Staphylococcus aureus*
Viruses	Viral hepatitis A, herpes simplex virus, influenza, and viral meningitis
Rickettsia	Q fever, Rocky Mountain spotted fever, and rickettsial pox
Fungi	San Joaquin Valley fever, blastomycosis, ringworm, and athlete's foot
Protozoa	Malaria, amebiasis, babesiosis, cryptosporidiosis, and giardiasis
Helminths	Intestinal parasites—ascariasis, trichinellosis, and schistosomiasis
Arthropods	Malaria, encephalitis, Rocky Mountain spotted fever, trypanosomiasis, and leishmaniasis

Source: Adapted from *Epidemiology for Public Health Practice* (pp. 440–441), by R. H. Friis and T. A. Sellers, 2009, Burlington, MA: Jones & Bartlett.

Infectious agents differ in their ability to infect and cause disease. Other aspects of disease agents are the severity of illnesses they cause and the eventual outcome of infection in the host (Friis & Sellers, 2013):

- **Infectivity** is the potential of the agent to infect and multiply within a host. Polio and measles are diseases of high infectivity and are highly contagious.
- **Pathogenicity** is the capacity of the agent to cause disease in the infected host. Measles is a disease of high pathogenicity. In comparison, polio is a disease of low pathogenicity; while the poliovirus is very contagious (high infectivity), most people infected with polio will exhibit no symptoms. The iceberg concept of infection posits that the tip of the iceberg, which corresponds to active clinical disease, accounts for a relatively small proportion of cases and exposures to disease agents. This situation applies particularly well to polio.
- **Virulence** explains the severity of the disease, or how severely it manifests. The rabies virus, which almost always produces fatal disease in humans, is an extremely virulent agent.

Host

The **host** is the person (or sometimes animal) infected by a disease agent. A primary or definitive host is an organism that harbors the parasite, typically providing nourishment. An intermediate or secondary host harbors the parasite for only a short period of time, during which a developmental stage is completed. For example, in sleeping sickness, the tsetse fly is the primary host and humans are the secondary host.

The host does have its defenses. The human body is able to reduce the likelihood that an agent will penetrate its defenses, lodge, and cause disease. For instance, there are *nonspecific defense mechanisms* against microbial agents. An example of a nonspecific defense is the protection afforded by the skin, which prevents most environmental agents from entering the body. Similarly, the mucosal surfaces also afford protection against foreign invading microbes. Tears and saliva can be thought of as a means of washing away would-be infectious agents. Finally, the high acidity (low pH level) of gastric juices helps to inactivate disease agents that managed to bypass the body's defenses via ingestion of contaminated foods.

Disease-specific defense mechanisms include immunity and the immune system, which also play a central role in warding off invading infectious agents. **Immunity** is the presence of antibodies (proteins produced by the body) that act against disease-causing microorganisms. Immunity can be either active or passive and either natural or artificial (Table 3.2).

Table 3.2: Types of immunity

Active	A disease organism causes the potential host's immune system to create antibodies against the disease.
Passive	A preformed antibody is administered to a recipient; the immunity is usually of short duration for immune globulin (gamma globulin) derived from the pooled plasmas of adults.
Natural, active	An infection by the agent causes the body to produce antibodies.
Artificial, active	An injection with a vaccine stimulates antibody production in the host. All or part of a microorganism or a modified part of that microorganism is administered to invoke an immunologic response. The response mimics the natural infection but presents little or no risk to the recipient.
Natural, passive	Preformed antibodies during pregnancy are transferred across the placenta to the fetal bloodstream to produce short-term immunity in the newborn.
Artificial, passive	Preformed antibodies against a specific disease are administered to an exposed individual to offer protection against a disease.

Source: Adapted from *Epidemiology for Public Health Practice* (pp. 498–499), by R. H. Friis and T. A. Sellers, 2009, Burlington, MA: Jones & Bartlett.

After an agent lodges in a susceptible host, the **incubation period**, the time period between a host's exposure to an infection and the first appearance of disease symptoms, begins. During this interval, the infectious organism replicates within the host. The incubation period is often a fixed period of hours, days, or weeks, and it can provide a clue as to the time and circumstance of exposure to the agent.

Environment

The **environment**, the third component of the triangle, is the unique niche in which disease agents exist, survive, or originate (Friis & Sellers, 2009). Some infectious agents, such as fungi, can live in the soil; other agents can live within a human being or an animal. In these latter cases, the human or animal is not affected by the agent but can spread infection to others. Certain aspects of the physical environment can promote the survival of disease agents and bring the host and agents into contact, including poor sanitation, urban crowding, the unavailability of clean water, and the presence of disease vectors, or carriers, such as rats and mosquitoes.

Poor sanitation and associated living conditions also place people at risk for water-, sanitation-, and hygiene-related diseases (CDC, 2015d). About one third of the world's population, or 2.5 billion people, does not have access to basic sanitary services, such as clean water, garbage collection services, sanitation systems, wastewater treatment, and industrial hazard waste management (CDC, 2015d). One of the most crucial environmental factors in the transmission of infectious diseases is the availability of clean water. An improved water supply is one that has been managed in some way to increase its safety, although drinking water from improved sources is not always safe. Another issue is the safe disposal of human waste (Friis & Sellers, 2009). Contact with human waste is linked to the spread of diseases such as cholera, typhoid, hepatitis, and polio. Unsafe waste disposal includes the use of latrines or open deposits of fecal matter on fields. As the global population continues to grow, the problem of inadequate basic sanitary services is likely to be exacerbated.

Regional climate patterns are also a crucial aspect of infectious disease transmission. An area's prevailing weather patterns directly affect disease transmission by possibly shortening the incubation period as well as shifting the geographic range or movement of the vector or pathogen (Friis & Sellers, 2013). For example, heavy rainfall in some areas contributes to standing water, which can promote the growth of mosquito populations. Moist, tropical climates promote the survival of diseases such as dengue fever. Another consequence of heavy rainfall is sewage overflow from overtaxed sewage processing facilities. Sewage can then contaminate drinkable water supplies. Rain also can

cause ocean contamination by runoff from urban streets. Additionally, climate change, especially global warming, could result in the invasion of disease-carrying insects into areas that were formerly too cold for them.

Mechanisms of Disease Transmission

There is an explicit **chain of infection** that explains how diseases form in the human body (see Figure 3.2). Disease transmission involves an agent's access to a vulnerable location in the body or some means of injection into the body. For a new host to become infected, an agent must be transmitted from a **reservoir**, or the site where infectious agents survive, such as a specific animal or insect. For a human reservoir of disease, the agent needs to be released from a portal of exit. **Portals of exit** are sites where infectious agents may leave the body, such as passages of the respiratory system, the colon, skin wounds, and the reproductive and urinary systems. After the agent has left a portal of exit, it needs access to a **portal of entry**, where the agent can enter the body of the new host. The portals of entry are the respiratory system for diseases such as influenza and the common cold, the mouth and digestive system for diseases such as hepatitis A and staphylococcal food poisoning, and the mucous membranes or wounds in the skin for other types of disease (Friis & Sellers, 2013). Regardless of how the agents enter the body, there are two types of transmission: direct and indirect.

Figure 3.2: Chain of infection

Infections move from various reservoirs to a transmission mode and then to a host through a variety of entry points.

Source: Adapted from *Principles of Epidemiology: Selected Lessons* (2nd ed., p. 45), by R. C. Decker, 1992, Atlanta: U.S. Department of Health and Human Services (**http://www.ciphi.ca/hamilton/Content/documents/principles.pdf** (http://www.ciphi.ca/hamilton/Content/documents/principles.pdf)).

Direct Transmission

Centers of Disease Control/SuperStock

Airborne transmission, a common form of direct transmission, occurs when droplets from an infected individual's sneeze or cough, which contains infectious particles, are inhaled by another individual.

Direct transmission is the spread of infectious diseases directly from one person to another (Friis & Sellers, 2013). A common form of direct transmission is airborne transmission. *Airborne transmission* occurs when droplets that contain infectious particles are expelled into the air by the cough or sneeze of an infected host and then inhaled by another person. Examples of airborne respiratory tract infections include tuberculosis, influenza, and the common cold.

Direct transmission of disease agents can also occur during intimate personal contact such as touching, kissing, or sexual intercourse. During contact, skin lesions and the mucous membranes can exude infectious agents from the infected person; in turn, the agents can gain access to an uninfected host. Similarly, sexually transmitted infections (STIs) such as syphilis and herpes simplex virus infections may be spread when the genitals of one person come into direct contact with the genitals of another person who is infected with an STI.

An infected person can be classified as subclinical or asymptomatic, which means that even though the person may not show active signs and symptoms of an infectious disease, that individual can transmit the disease to others. For example, a child who has an asymptomatic infection of hepatitis A does not show any observable outward symptoms but is still infectious.

Some individuals can also lapse into a chronic carrier state and can unknowingly transmit infections even though they themselves do not have obvious symptoms. This was the case with "Typhoid Mary" Mallon, a New York City cook who was an alleged asymptomatic carrier of typhoid fever during the early 1900s and who infected more than 50 people with typhoid, with several associated deaths.

While the method of transmission is the same, there is a distinction between acute and chronic infectious diseases. An **acute infectious disease** is short lived, usually running its course in a matter of days. An example of an acute condition is influenza. A **chronic infectious disease** lasts weeks or months in duration. An example of this type of infection is HIV/AIDS.

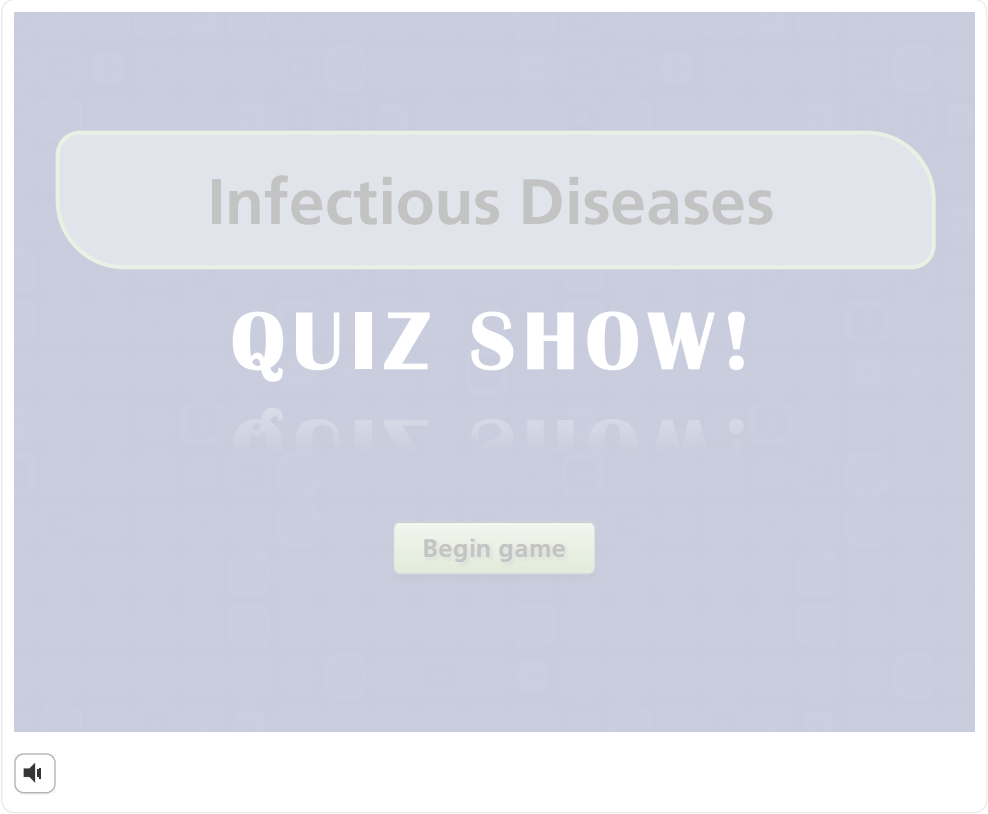
Indirect Transmission

Indirect transmission denotes the spread of infection through intermediary sources known as vehicles, fomites, or vectors. A **vehicle for transmission** is a contaminated, nonmoving object causing the transmission of disease (Friis, 2009). Possible vehicles are contaminated foods and milk, polluted water, and infectious bodily fluids. For example, when foods contaminated with *E. coli* bacteria are consumed, they can bypass the body's defenses and cause a foodborne illness. Polluted water is associated with waterborne diseases from bacterial, protozoal, and viral infections. Amebiasis, cholera, giardiasis, cryptosporidiosis, and winter vomiting disease are all examples of waterborne diseases. Another example of vehicle transmission is unintentional sticks from "sharps" used in a medical setting. Employees of hospitals may receive unintentional needle sticks from hypodermic needles that are contaminated with infectious blood from patients and develop a blood-borne infection. Medical personnel should receive instruction in safe procedures for administering injections and disposing of used hypodermic needles.

Fomites are inanimate objects such as towels, cups, used eating utensils, doorknobs, or medical instruments that are laden with disease-causing agents. Preventing the spread of disease from fomites involves avoiding the use of unsanitary utensils and contact with other fomites. In the hospital environment, potential fomites such as bed linen, towels, and used medical supplies must be processed to prevent transmission of disease agents from sick patients.

As mentioned previously, a vector is a living insect or animal that is involved with transmission of a disease agent. Arthropod vectors are certain species of flies, ticks, fleas, and mosquitoes that may carry pathogens. Mosquitoes are known to act as vectors for many diseases of great significance for community health, including West Nile virus, malaria, and viral encephalitis. Ticks are involved with the transmission of Lyme disease and Rocky Mountain spotted fever. Rats and some other rodents can harbor fleas infected with the bacteria that cause plague. For this reason, control of rodent vectors is a crucial dimension of public health.

The following interaction gives you an opportunity to review and apply your understanding of the epidemiological triangle, chain of infection, and types of immunity.



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3.2 Historical Infectious Disease Epidemics

The causes of infectious diseases were largely unknown for most of history. During the mid-19th century, disease detectives became aware of microbes as the cause of human diseases. The **germ theory of disease** arose from the discovery that certain infectious diseases were caused by microorganisms that invade the body. Microorganisms are small organisms that cannot be seen without magnification. This germ theory of disease contributed to an understanding of the function that microbial agents perform in causing the spread of infectious disease. Eventually, these new insights gained the attention of the public health community and led to the development of disease prevention efforts.

Among the scientists who stood out in history as instrumental in identifying causative microbes for infectious diseases were Ignaz Semmelweis in 1840 and Robert Koch in 1847. Other breakthroughs in the control of infectious diseases included Edward Jenner's development of a vaccine against smallpox (see *Spotlight on Public Health Figures*) and Jonas Salk's formulation of a polio immunization in 1953. These innovations led to the eradication of many formerly common epidemic diseases worldwide. Smallpox, the ancient scourge of humanity, was declared eradicated in 1979. Polio now has a very limited presence in the United States and does not exist in epidemic form in most parts of the globe.

Spotlight on Public Health Figures: Edward Jenner (1749–1823)

Heinz-Dieter Falkenstein/age fotostock/SuperStock

Edward Jenner studied inoculation techniques and ultimately used his experiences to develop a vaccination for smallpox.

Click each of the questions provided to learn more about Edward Jenner.

Who is Edward Jenner?

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Edward Jenner was born in 1749 in England, long before modern-day sanitation systems and vaccinations. The son of a vicar, he was one of nine children. Unfortunately, Jenner was orphaned at age 5 and went to live with his brother. He was one of the first to identify the concept of immunization and is often called the "father of immunology." A strong interest in science and nature was a factor in his later career and successes.

What was the political climate at the time?

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Britain was dealing with riots from the American colonies across the Atlantic after levying a series of taxes. Jenner lived during the Boston Tea Party and America's declaration of independence from Britain.

In Great Britain, this time frame marked the start of the Industrial Revolution, which meant more people were moving into the cities, creating larger populations. More population meant more diseases, especially communicable ones. Although inoculations against certain diseases were beginning to become standard practice, they were extremely risky. Inoculation, more commonly known at the time as variolation, was harsh: A lancet was used to take pus from a ripe pustule (boil or abscess) of a person with the disease, which was placed subcutaneously in the arm or leg of the nonimmune person. In many cases, those who were inoculated with the live disease became carriers. However, it was common knowledge that those who survived smallpox were immune to it. Many felt it was worth the risk.

What was his contribution to public health?

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Jenner worked with several physicians who believed and tested the theory that pus from cowpox could prevent smallpox. Jenner's research resulted in successful tests of inoculating children with cowpox pus that protected them against smallpox. He reported his findings to the Royal Society in England, but the organization did not publish his work. After more research, the papers and results were finally published. In 1840, the British government banned the former dangerous inoculation technique in favor of Jenner's smallpox vaccination. This began the era of eradicating smallpox across the globe. In 1979, the World Health Organization declared smallpox eradicated.

What motivated him?

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Jenner's upper-class upbringing gave him the education many children never received in the mid-1700s, and he was able to attend medical school for surgery and medical practice. His interest lay in immunology and started when he was 13 years old, when he served as an apprentice to an apothecary in Sodbury. Reportedly, he overheard a dairymaid say, "I shall never have smallpox for I have had cowpox" (Riedel, 2005, p. 23). In fact, dairymaids surprisingly never suffered from smallpox, and legend claimed they were magically immune. However, Jenner felt there was more to the situation than magical immunity. Intrigued by the milkmaid's statement, he began researching the link between cowpox and smallpox. After that, immunology became his life's work.

Sources: Hevey, M. (2015). Evolution of medicine in Europe. Retrieved from **https://eurohistorymed.weebly.com/1800s.html (https://eurohistorymed.weebly.com/1800s.html)**

Riedel, S. (2005). Edward Jenner and the history of smallpox and vaccination. *Baylor University Medical Center Proceedings, 18*(1), 21–25.

The history of infectious diseases helps us understand how to prevent and treat infectious diseases today. Handling and investigating the diseases of the past has helped to determine the symptoms, the cause, the treatment, and, in some cases, the cure. The following four major outbreaks all resulted in changes in how infectious diseases were handled, investigated, and later prevented.

The Black Death (Bubonic Plague, 14th Century)

The bubonic plague causes fever and painful swelling of the lymph glands called buboes, which is how the disease got its name. The disease struck China in the early 1330s and quickly spread through Asia and Europe. The disease is typically seen in rodents, but because fleas are vectors, they can transmit the disease from rodents to people. The bubonic plague killed millions of people, including 25 million people in the 5 years between 1347 and 1352. Figure 3.3 shows the progression of the disease over time in terms of population numbers (The Middle Ages, 2011).

Figure 3.3: Population and deaths from bubonic plague

The Black Death took millions of lives in Europe during the 14th century, including 25 million deaths in 1352 alone.

Source: Data from "The Black Death: Bubonic Plague," by the Middle Ages, 2011 (**http://www.themiddleages.net/plague.html (http://www.themiddleages.net/plague.html)**).

In the 14th century, most people believed that the disease was a punishment for sin. It was also thought that if men wore white robes marked with a red cross on the front and back, they would be safe from it (The Middle Ages, 2011). Others believed rituals, such as burning certain scents, eating special diets, and sleeping in a certain position, would be enough protection.

The Black Death eventually subsided, but there is not a definitive explanation as to why. Some believe that the disease ran out of people to infect; however, the most popular theory is that of quarantine. When infected individuals (as well as the infected rats and fleas) were kept away from healthy people, the disease halted (Gale Cengage Learning, 2017). Over time, humanity started to understand the benefits of hygiene and clean air, which affects the spread of disease in general, including the bubonic plague.

Resurgences of the Black Death were commonplace during medieval times, and other outbreaks did occur over the next couple of centuries, but nothing to the extent seen in the mid-1300s (Gale Cengage Learning, 2017). In the early 1900s, San Francisco encountered an outbreak; in the 1960s during the Vietnam War, the plague appeared in Vietnam. Between 2010 and 2016, Madagascar also recorded an outbreak of the plague (Gale Cengage Learning, 2017).

The United States is still reporting cases of the bubonic plague, with the most recent being in New Mexico in early 2017 (Bichell, 2017). The CDC reported a total of 11 recent cases of human plague, as shown in Table 3.3. Unlike during medieval times, today common antibiotics will treat and cure the plague in humans.

Table 3.3: Recent cases of human plague

State	Number
Arizona	2
California	1
Colorado	4
Georgia	1
New Mexico	2
Oregon	1
TOTAL	11

Source: From "Human Plague – United States, 2015," by Centers for Disease Control and Prevention, 2015, in *Morbidity and Mortality Weekly Report, 64*(33), pp. 918–919.

Cholera (1854)

Cholera is an acute diarrheal disease that can be fatal if not treated (WHO, 2017c). The disease was prevalent in the 1800s simply because there was no understanding of its etiology. Today, we understand cholera to be caused by ingestion of contaminated water. It is directly linked to a lack of clean water and sanitation.

In the mid-1800s and earlier, cholera outbreaks were common mostly among lower-class neighborhoods. One of the best-known outbreaks of cholera occurred in September 1854 in the Soho district of London, England. It was here that public health saw the beginnings of formal disease investigations known as epidemiology (which will be discussed in detail in Chapter 6). The prevailing thought was that people contracted cholera through miasmas, or "in the air." This common misbelief stemmed from the fact that animal and human wastes, and their associated smells, were more commonly found in lower-class neighborhoods. It made sense at the time, but John Snow, the person who eventually discovered the cause of the outbreak, felt something wasn't adding up (see *Spotlight on Public Health Figures: John Snow* in Chapter 1). When he realized that he was also treating people from wealthier neighborhoods for cholera, he knew that the miasma theory was wrong. He discovered that his patients were using wells from various parts of the city, including those in poorer neighborhoods. He came to believe that the disease was spread through contaminated water (Mackenzie, n.d.).

When he examined water samples from several wells, he confirmed the presence of a bacterium (unknown at the time) from a commonly used well at Broad Street. After mapping the cholera deaths to where people obtained their water supply, he had staggering evidence. When the pump handle was finally removed, the incidences of cholera

dropped.

The key takeaway of this cholera outbreak was twofold: 1) discovering the bacterium that caused cholera and 2) the mapping techniques used by Snow to begin the modern field of epidemiology (see Chapter 6). Today, there are cholera vaccines (an oral immunization) along with improved infectious disease surveillance, increased water and sewer sanitation, and better medical treatment for cholera. But, as the *Case Study: Water Crisis in Flint, Michigan* in Chapter 2 shows, there is still work to be done in terms of sanitation and hygiene.

Influenza (1918)

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The 1918 influenza pandemic took the lives of approximately 50 million people. Details that explain why the virus was so deadly were not discovered until 2008.

Influenza (more commonly known as "the flu") is a contagious respiratory illness caused by a virus. The disease's symptoms can vary from mild to severe and can even lead to death. In fact, during the great influenza epidemic of 1918, 50 million people died from the disease, more than double the lives lost during the 4 years of World War I (16 million deaths).

The epidemic came in two phases. During the first phase, known as the "three-day fever," symptoms appeared without warning. Victims of this fever did recover after a few days, but the second phase was deadly. At the time, neither doctors nor scientists could identify the disease, which came on so rapidly that people died within a few hours of the onset of the second phase of symptoms. This new virus afflicted more than a quarter of the population of the United States, with the elderly and children hit the hardest. It wasn't until the early 1920s that the virus eventually ceased circulation in the human population, but even then, it continued to evolve in pigs (Shanks, 2015). In 2008, almost a century later, scientists discovered why the 1918 influenza virus was so deadly: Three particular genes that function within the body's lungs were significantly weakened by the virus, which allowed the bacteria to grow and multiply.

The first attempt at preventing influenza came on the heels of the 1918 pandemic. Two physicians, Thomas Francis Jr. and Jonas Salk, were key in developing the vaccine. It was approved and used for military personnel during World War II in 1945. Civilian use began the following year (The College of Physicians of Philadelphia, 2017).

Tuberculosis (19th Century)

Tuberculosis (TB) is a bacterial disease that primarily affects the lungs. Symptoms include a chronic cough, fever, and weight loss. In fact, the disease was originally called "consumption," as anyone who contracted it typically wasted away (University of Virginia, 2007). During the 19th century, tuberculosis was the leading cause of death in the United States. It was also the impetus for the creation of the American Lung Association, which was formed in 1904 to find a cure for tuberculosis (University of Virginia, 2007). By the turn of the century, it was estimated that 450 people in the United States died of tuberculosis every day.

TB was believed to have started in animals and been passed on to humans through agriculture; however, recent research has shown that it may have originated in early human ancestors long before their migration from Africa (Pruitt, 2013). The common belief was that a healthy climate and rest would cure people of the disease, so people sought help in what were known as sanatoriums (PBS, 2017). Eventually, Robert Koch discovered that tuberculosis was a bacterium and not genetic or affected by environment. Of more importance, he proved that this disease was highly contagious and prompted the launch of a massive public health campaign aimed at keeping healthy people away from those infected (see *Spotlight on Public Health Figures*). The campaign also promoted the idea of covering coughs and sneezes—which contained the dangerous bacteria.

Spotlight on Public Health Figures: Robert Koch (1843–1910)

World History Archive/SuperStock

Robert Koch was a microbiologist who identified the causes of tuberculosis.

Click each of the questions provided to learn more about Robert Koch.

Who is Robert Koch?

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Robert Koch was born in December 1843 in Germany. He taught himself how to read and write before he began formal schooling. He excelled in math and science and eventually studied natural science at the University of Göttingen. After three semesters, he began studying medicine in order to become a physician.

What was the political climate at the time?

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During Koch's career, Germany entered the Franco-Prussian War—during which Koch served as a surgeon. After the war, the nation became part of what was known as the German Empire, which lasted from 1871 to 1914, which was 4 years after Koch's death. The country's economy was on the rise as Germany became the land of big industry, big agriculture, big banks, and big government. Most people enjoyed a stable life during Koch's lifetime.

What was his contribution to public health?

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He was a microbiologist and is considered the founder of modern bacteriology. He identified the causes of tuberculosis, which led to the vaccine for the disease. He also pioneered new techniques that are currently used in laboratory research, including dyes for observing bacteria, and was the first to use an oil immersion lens and a condenser. The field of disease research expanded through Koch's contributions.

What motivated him?

(http://content.thuzelearning.com/books/Bell.5330.18.1/sections/title/books/Bell.5330.18.1/sections/title/books/Bell.5330.18.1/sections/tit

Koch was an engaged and bright child. His interest in changing the world motivated him to continue his work to improve population well-being and research methodology.

Sources: Biography.com editors. (2017, November 11). Robert Koch biography. *Biography.com*. Retrieved from **https://www.biography.com/people/robert-koch-9367370 (https://www.biography.com/people/robert-koch-9367370)**

Encyclopedia Britannica. (2018). Germany from 1871 to 1918. Retrieved from **https://www.britannica.com/place/Germany/Germany-from-1871-to-1918 (https://www.britannica.com/place/Germany/Germany-from-1871-to-1918)**

Improved hygiene did help reduce the incidence of TB; however, it has not disappeared. TB was the No. 2 and No. 3 killer in 1900 and 1920, respectively. In 1921, Camille Guérin and Albert Calmette developed a successful TB vaccine in France. As the vaccine availability spread across the word, disease numbers started to fall. In 1950, the disease dropped to No. 7. While it is no longer in the top 10, TB is still ranked among the top 40 causes of death in the United States (CDC, 2013b). TB incidence rates are still close to 10,000 but are dropping. (See *A Closer Look* for information about one of the environments where TB is still an issue.) Since the development of the vaccine, cases of TB have decreased significantly in the United States. In 1960, there were 55,494 reported cases, and by 2014, that number had decreased to 9,421 (National Center for Health Statistics, 2017).

A Closer Look: TB in Prisons

While the world's population now has an inoculation against tuberculosis, the disease is still significantly high in prisons. The World Health Organization has stated that on any given day of the year, the level of TB in prisons could be 100 times higher than in the general population. Studies have shown that many people incarcerated come from vulnerable populations, such as those who are disadvantaged, homeless, substance abusers, and immigrants. These vulnerable populations are often unvaccinated because of the lack of access to health care. When they are incarcerated, problems arise due to late diagnosis of the disease, inadequate treatment, overcrowding, poor ventilation, and repeated prison transfers that encourage disease transmission. Because of prison conditions, prisoners are solid reservoirs for diseases, with the ability to infect visitors, prison staff, and other inmates.

Improving TB control in prisons is a priority for the World Health Organization. To assist countries with this issue, the WHO (2018) created a five-point list.

1. The priority strategy must be the widespread implementation of the End TB Strategy in the incarcerated population. Every prisoner should have unrestricted access to the correct diagnosis and treatment of TB.
2. Delays in the detection and treatment of TB cases must be minimized to reduce further transmission of infection and pressures to self-treat TB.
3. Unregulated, erratic treatment of TB in prisons should cease.
4. Urgent action is needed to integrate prison and civilian TB services to ensure treatment completion for prisoners released during treatment.
5. Measures to reduce overcrowding and to improve living conditions for all prisoners should be implemented to reduce transmission of TB.

Source: World Health Organization. (2018). Tuberculosis in prisons. Retrieved from **http://www.who.int/tb/areas-of-work/population-groups/prisons-facts/en/ (http://www.who.int/tb/areas-of-work/population-groups/prisons-facts/en/)**

3.3 Contemporary Infectious Diseases

The late 20th century brought with it the emergence of HIV/AIDS and increased concerns surrounding other sexually transmitted diseases such as chlamydia, gonorrhea, and syphilis. Other infectious diseases that are still in existence include hepatitis (A, B, and C), diphtheria, Lyme disease, mumps, pertussis, rubella, salmonellosis, and shigellosis.

HIV/AIDS

While some people use the acronyms *HIV* and *AIDS* interchangeably, they are not the same thing. HIV stands for *human immunodeficiency virus*, which is a virus that attacks the body's immune system by preventing it from fighting off any type of bodily infection (including the common cold). HIV has no cure and has the potential to turn into acquired immunodeficiency syndrome, or AIDS. HIV can be treated to reduce immune system damage; however, there is no treatment today that removes HIV from the body. Once people contract it, they have it for the remainder of their lives.

HIV has three stages: acute HIV infection, when often there are no symptoms of distress; clinical latency, in which the cells slowly divide and symptoms of illness begin; and AIDS. AIDS is the most severe stage of HIV, in which the immune system is damaged beyond treatment, resulting in severe illnesses. HIV is contracted through bodily fluids, usually blood or semen. It once was considered a "gay man's disease" spread from men having sex with other men. In fact, the disease can be contracted by anyone sharing infected needles, receiving blood transfusions, or undergoing other similar contact with bodily fluids.

In 1981, five gay men in Los Angeles were identified as the first cases of what would become known as the AIDS epidemic. At the time, each case was described as a rare lung infection (PCP) (HIV.gov, 2016). There were also significant other infections within the patients' bodies that affected their immune systems. In June of that year, newspaper reports on the cases exposed the nation to the as-yet unnamed emerging disease. After reviewing the newspaper coverage, doctors across the nation flooded the CDC with reports of similar cases (HIV.gov, 2016). By the end of that year, 270 cases of severe immune deficiency in gay men were reported. Almost half of those men were deceased.

By September 1982, the government had provided $5 million to the CDC for AIDS surveillance and $10 million to the National Institutes of Health for research into the disease and potential cure. The term *AIDS* was officially coined at that time, when the CDC called the disease "acquired immune deficiency syndrome" and defined it as "a disease at least moderately predictive of a defect in cell-mediated immunity, occurring in a person with no known cause for diminished resistance to that disease" (CDC, 1982, para. 7). The virus that caused AIDS was later identified and named *HIV*, or "human immunodeficiency virus" (HIV.gov, 2016, 1986 section, para. 3).

In January 1983, the first female AIDS cases were discovered and reported. There were numerous theories about the cause of AIDS, including that it was a virus transmitted through blood or blood products, a retrovirus transmitted through bodily fluid, or a disease transmitted through casual contact with a person. It wasn't until later that year that the CDC identified the actual transmission of the virus, which ruled out food, water, air, and environmental surfaces. In October 1983, the World Health Organization organized the first global meeting on the AIDS situation, and international surveillance of the disease began.

Hillery Smith Garrison/Associated Press

The CDC estimates that more than a half million people died of AIDS between 1981 and 2007. The AIDS Memorial Quilt, pictured, is a project that helps document the lives of many individuals who have died of AIDS.

By 1985, AIDS was spreading by means beyond sexual intercourse with a gay individual. Teenager Ryan White was the first person who contracted the virus from a contaminated blood product, which was used to treat his hemophilia. His contraction of AIDS spurred the campaign to reverse the discrimination against people with this disease.

The total number of reported AIDS cases reached 100,000 before 1990. By the end of 1995, that number was 500,000, and by the end of 2002, more than 10 million people worldwide were living with AIDS (HIV.gov, 2016). By the end of 2007, the CDC reported that more than a half million people had died of AIDS since it had been discovered.

Those infection numbers continued to grow. According to surveillance reports, by the end of 2012, approximately 35.3 million people worldwide were living with HIV, with 1.2 million of those people in the United States (HIV.gov, 2016). As the epidemic has spiraled seemingly out of control, medical advances have identified medication to treat HIV. Currently, there is only one antiviral medication on the market that may prevent HIV infection, a pre-exposure prophylaxis (or PrEP). The CDC has stated that it is effective for high-risk people taking it exactly as prescribed: It reduces the risk of HIV from sex by more than 90% and reduces the risk from needle injections (drug use) by more than 70% (CDC, 2017j).

Thanks to treatments, medications, and behavior changes, HIV diagnoses have declined over the last decade; however, the disease has not been eliminated. Though the rates of new HIV cases may be down overall, certain demographic regions are seeing an increase, such as the southern U.S. states. According to a report from the CDC, death rates of people with HIV are three times higher in the South than elsewhere in the United States (Highleyman, 2015). Worldwide, the increases in HIV cases are staggering: Eastern Europe and Asia saw a 57% increase in new cases between 2010 and 2015, the Caribbean experienced a 9% increase over the same time period, and the Middle East and Africa saw a 4% increase. Table 3.4 shows a global perspective on the AIDS epidemic.

Table 3.4: Global summary of the AIDS epidemic in 2015

Number of people living with HIV	
Total	36.7 million
Adults	34.9 million
Women	17.8 million
Children (<15 years)	1.8 million

Number of people newly infected with HIV	
Total	2.1 million
Adults	1.9 million
Children (<15 years)	150,000
AIDS-related deaths	
Total	1.1 million
Adults	1.0 million
Children (<15 years)	110,000
Number of people on HIV treatment	
Total	17 million

Source: "UNAIDS Warns That After Significant Reductions, Declines in New HIV Infections Among Adults Have Stalled and Are Rising in Some Regions," by UNAIDS, 2017 (**http://www.unaids.org/en/resources/presscentre/pressreleaseandstatementarchive/2016/july/20160712_prevention-gap (http://www.unaids.org/en/resources/presscentre/pressreleaseandstatementarchive/2016/july/20160712_prevention-gap)**). Used with permission.

Syphilis

Syphilis is a sexually transmitted infection that presents in the form of sores on or around the penis, vagina, anus, rectum, lips, or mouth. If left untreated, it could spread into a rash on the entire body, particularly the torso area. In the latter stages of the disease, it can cause paralysis, headache, or dementia. It can be treated with the appropriate antibiotics; however, damages that occur during the later stages cannot be undone.

Syphilis was present in the Americas prior to the arrival of Columbus, as the disease was noted in the remains of various people dating back to 800 CE (Rothschild, 2005). Its presence was widely known around the world, although it was not called "syphilis" until the 1530s (Rothschild, 2005).

The resurgence of syphilis, as with many sexually transmitted diseases, has happened dramatically over the past 20 years in North America. In 1993, there were only 177 cases, and in 2010, there were 1,750 cases (Houser, 2012). In the United States, syphilis is rising among women and newborns. Figure 3.4 shows the rise of syphilis in that population over the past 3 years to be about 28% (CDC, 2016a).

Figure 3.4: Number of newborns with syphilis, 2014–2016

There is a resurgence of syphilis among newborns in the United States.

Source: "CDC Fact Sheet. Reported STDs in the United States, 2016," by Centers for Disease Control and Prevention, 2016 (**https://www.cdc.gov/nchhstp/newsroom/docs/factsheets/STD-Trends-508.pdf (https://www.cdc.gov/nchhstp/newsroom/docs/factsheets/STD-Trends-508.pdf)**).

In addition, syphilis rates have increased in men by 15%. Men accounted for 89% of all primary and secondary syphilis cases in 2016. Most of these men were gay, bisexual, or those who had sex with other men. The distribution of syphilis cases is shown in Figure 3.5.

Figure 3.5: Distribution of syphilis cases by sex and sexual behavior, 2016

More than half of the syphilis cases in 2016 occurred among men who have sex with other men only.

n *is the number of cases*

Source: "Sexually Transmitted Disease Surveillance 2016," by Centers for Disease Control and Prevention, 2016 (**https://www.cdc.gov/std/stats16/CDC_2016_STDS_Report-for508WebSep21_2017_1644.pdf (https://www.cdc.gov/std/stats16/CDC_2016_STDS_Report-for508WebSep21_2017_1644.pdf)**).

Lyme Disease

In the 1960s in the town of Lyme, Connecticut, a group of children and adults was suffering from debilitating health issues that were mystifying both doctors and researchers (Bay Area Lyme Foundation, 2017). Symptoms included swollen knees, paralysis, headaches, skin rashes, and chronic fatigue (Bay Area Lyme Foundation, 2017). The only common thread was that all victims recalled being bitten by a tick. For lack of a better name, researchers began calling the disease Lyme disease after the town (Bay Area Lyme Foundation, 2017). But Lyme disease isn't a new phenomenon; it was detected on a 5,300-year-old mummy during a recent autopsy (Bay Area Lyme Foundation, 2017).

In 1981, scientist Willy Burgdorfer finally made the connection between deer ticks and the disease when he discovered that a "spirochete" carried by ticks was causing the Lyme disease. A *spirochete* is a bacterium more commonly associated with syphilis. This particular strain of spirochete was named after Dr. Burgdorfer: *Borrelia burgdorferi*. As in most infectious diseases, the common treatment was the use of antibiotics (Bay Area Lyme Foundation, 2017).

The rates of Lyme disease steadily grew through 2009, after which the United States experienced a slight decrease (Figure 3.6). According to the CDC (2017m), nearly all of the cases of Lyme disease were reported in 14 states: Connecticut, Delaware, Maine, Maryland, Massachusetts, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and Wisconsin.

Figure 3.6: Reported cases of Lyme disease by year, 1996–2016

Actual reported cases of Lyme disease have leveled off, implying some success in prevention. However, it is believed that there are unreported cases that, when added to the actual cases, would show an increase in Lyme disease.

National Surveillance case definition revised in 2008 to include probable cases; details at* **https://wwwn.cdc.gov/nndss/conditions/lyme-disease/case-definition/2008/ (https://wwwn.cdc.gov/nndss/conditions/lyme-disease/case-definition/2008/)

Source: Adapted from "Lyme Disease: Data and Statistics," by Centers for Disease Control and Prevention, 2017 (**https://www.cdc.gov/lyme/stats/index.html (https://www.cdc.gov/lyme/stats/index.html)**).

Lyme disease cases have leveled off, providing good news on the outbreak front but bad news on mitigation. In the United States, approximately 30,000 new cases of Lyme disease are reported annually, and that number has not varied much over the past 10 years. There is no cure. The best approach is through prevention—protecting against ticks by wearing long sleeves and pants as well as wearing tick repellent.

Zika Virus

A newly emerging virus, Zika is a mosquito-borne flavivirus first identified in 1947 during regular monitoring of yellow fever in monkeys in Uganda (WHO, 2016b). A *flavivirus* is defined as a single-stranded RNA virus that is transmitted by ticks and mosquitoes such as dengue fever, hepatitis C, encephalitis, West Nile virus, and yellow fever. Zika could have become a massive epidemic in the United States. However, quick actions by public health organizations have largely prevented it—something that would not have occurred back during the days of the Black Death or the influenza outbreak of 1918.

Zika outbreaks had been recorded starting in the 1960s through the 1980s across Africa and Asia and were reported as being a mild illness of fever, headache, and joint pain. The first large outbreak was discovered on the island of Yap in 2007 (Duffy et al., 2009). Estimates indicated that about 75% of the population was infected. There were no deaths reported or hospitalizations, and interestingly, studies could not find one mosquito infected. This led to a question of transmission. It is possible that the easy accessibility to travel and the abundance of mosquito vectors in the Pacific region caused the spread. More alarming was how easily this virus spread undetected despite solid surveillance systems.

It wasn't until Brazil reported an outbreak in 2015 that the world was alerted to the virus (WHO, 2016b). As the virus spread across South America and into the Caribbean nations, Cuba, the Bahamas, and Jamaica, so did a bit of panic in the United States. The Zika virus is primarily spread through infected mosquitoes, which do exist in the United States. But Zika does not have a routine U.S. presence, although cases have been reported in both south Florida and south Texas.

The largest concern with the Zika virus is its link to birth defects in children, thereby making pregnant women especially vulnerable if they contract the Zika virus. An individual who has been infected by the virus can transmit it to his or her partner through vaginal, anal, or oral sex. Therefore, it is important to follow contraception precautions if Zika is suspected.

There is no cure for Zika; however, the best prevention is the use of mosquito repellent. Other protections include wearing long sleeves and pants when outdoors, staying indoors, and removing standing water from the home (CDC, 2017bb). Nationwide campaigns have focused on the importance of travel safety and the use of best practices when traveling to and from mosquito-infested areas.

Tracking Contemporary Diseases

The CDC has been tracking diseases since it was founded in 1946. But the National Notifiable Diseases Surveillance System (NNDSS) was not officially born until 1961, when the CDC assumed responsibility for all issues of diseases in the United States (CDC, 2017r). NNDSS's first list of nationally notifiable diseases was published on January 13, 1961 (CDC, 2017r).

NNDSS was set up to protect people from serious illnesses. It is a nationwide system to monitor, control, and prevent about 120 diseases (CDC, 2017r). These include both infectious diseases such as salmonellosis and noninfectious diseases such as lead poisoning.

The tracking of such diseases starts locally with health care providers (hospitals and doctor's offices) calling their local health departments about incidences of specific diseases (a partial list can be found on Table 3.5). Across the nation, there are about 3,000 public health departments that collect data on their areas and enter them into the National Notifiable Diseases Surveillance System. The CDC is responsible for securing, processing, and providing additional information on such diseases, including managing outbreaks and epidemics. Table 3.5 shows the number of reported diseases over time.

Table 3.5: Selected notifiable disease rates and number of new cases in the United States, 1950–2015

Disease	1950	1960	1970	1980	1990	2000	2010	2015

Acute hepatitis B viral infection	- - -	- - -	4.08	8.39	8.48	2.95	1.10	–
Measles (Rubeola)	211.01	245.42	23.23	5.96	11.17	0.03	0.02	–
Mumps	- - -	- - -	55.55	3.86	2.17	0.13	0.85	–
Pertussis (whooping cough)	79.82	8.23	2.08	0.76	1.84	2.88	8.97	–
Tuberculosis*	- - -	30.83	18.28	12.25	10.33	6.01	3.64	–

* Case reporting for tuberculosis began in 1953. Data prior to 1975 are not comparable with subsequent years.

- - - Data not available

– Quantity zero

Source: Data from *Health, United States, 2016 With Chartbook on Long-Term Trends in Health*, by National Center for Health Statistics, 2017, Washington, DC: U.S. Government Printing Office. Available online at **https://www.cdc.gov/nchs/data/hus/hus16.pdf#019 (https://www.cdc.gov/nchs/data/hus/hus16.pdf#019)** .

3.4 Environmental Risk Factors for Infectious Diseases

The physical environment is one of the most crucial dimensions of the health of communities, both globally and in the United States. Environmental hazards associated with work, the home setting, recreation, or commuting to work affect the health of almost all human beings and demonstrate ecological principles in operation. This section explores environmental determinants of human morbidity and mortality as they relate to infectious diseases.

kyleespeletaphotography/iStock/Thinkstock

In some American cities, high air pollution levels have been linked to asthma attacks, cancers, and the exacerbation of certain diseases.

The WHO has noted that during the beginning of the 21st century, changes in the environment such as air pollution and ozone-depleting gases accounted for about one quarter of the global burden of disease (Prüss-Üstün & Corvalán, 2006). Among the world's children, the burden of environmentally associated disease was even higher—approximately one third. Almost 10% of the world's deaths and disease burden were related to five environmental factors (WHO, 2009):

1. Indoor air pollution from smoke generated by solid fuels
2. Unsafe water in combination with poor sanitation and hygiene
3. Outdoor air pollution in cities
4. Global climate change
5. Lead exposure

Although health effects caused by the environment are particularly noticeable in developing countries, many of the same environmental factors contribute to adverse health outcomes in the United States. High air pollution levels in some U.S. cities have been linked to asthma attacks, lung disease, heart disease, cancer, and exacerbation of other chronic diseases. In addition, urban air pollution has been shown to have a direct association with mortality. Toxic wastes, pesticides used in agriculture and in people's homes, and urban runoff have permanently contaminated water supplies in some regions of the nation. Children and adults who live near industrial facilities may be exposed to unsafe levels of toxic pollutants. These are only a few examples of environmental hazards that are affecting communities in some parts of the country. The next few sections discuss the various types of environmental hazards.

Water and Sanitation

A significant portion of the world's population lacks satisfactory drinking water. Consumption of contaminated drinking water can lead to gastrointestinal illness, reproductive problems, neurological disorders, and other adverse health outcomes. In the United States, the Environmental Protection Agency (EPA) regulates the quality of water from public supplies, which are among the safest in the world. According to the CDC (2014), almost 300 million Americans obtain their water from the tap. Regulating the water supply is important to minimize water chemicals and pollutants that can lead to disease.

From time to time, waterborne disease outbreaks do occur in the United States. These may result from sewage contamination when processing plants fail or from overflows during heavy rainfall. Contaminants and microbes from agriculture, animal feed lots, and urban streets can find their way into aquifers and groundwater. The CDC (2014) listed the following as the leading 10 causes of waterborne illness outbreaks in public water systems:

1. *Giardia*
2. *Legionella*
3. Norovirus
4. *Shigella*
5. *Campylobacter*
6. Copper
7. *Salmonella*
8. Hepatitis A
9. *Cryptosporidium*
10. *E. coli* and fluorosis (excess fluoride) (tie)

Two parasites that cause waterborne illness are noteworthy because they are commonly found within water systems today in the United States. *Cryptosporidium* is a microscopic parasite associated with a diarrheal disease called cryptosporidiosis, one of the most frequent waterborne diseases in the United States. Cryptosporidiosis can be acquired from drinking water and recreational water (water used primarily for sports such as fishing, swimming, and boating) that are contaminated with the parasite. Another condition that can be spread by unclean drinking and recreational water is giardiasis, an infection of the intestines that causes diarrhea and other gastrointestinal distress. This waterborne disease also is caused by a microscopic parasite, called *Giardia*.

Likely one of the shocking causes of diseases listed on here is excess fluoride, as adding fluoride to the water systems across the nation was one of the greatest accomplishments in public health. But accidentally adding too much fluoride results in fluorosis, a condition that includes severe skeletal problems. High levels can also be caused by exposure to fires or explosions. Moderate exposure is more common, as people are affected by multiple sources over time: in food, water, air from industrial waste, or excessive use of toothpaste (WHO, 2017k).

Fluoride is a naturally occurring mineral found in soil, water, and foods. It is typically concentrated in specific regions—usually at the foot of high mountains or close to the ocean. Fluoride is also a synthesized substance that is made in a laboratory. This particular version of fluoride is what is commonly added to drinking water and other products such as toothpaste and mouthwashes to help prevent dental cavities (Nordqvist, 2016).

Less than one quarter of the population ages 6 through 49 had dental fluorosis between 1999 and 2004. See Figure 3.7 for a distribution of fluorosis in the United States. In the early part of the 2000s, regulations set maximum numbers of safe fluoride levels in water and other products. This has, in turn, reduced the rate of fluorosis. The CDC's latest numbers only show reports of fluorosis up through 2004.

Figure 3.7: Distribution of dental fluorosis: Ages 6–49, 1999–2004

Some citizens might express concerns about having fluoride in their water systems because of the potential of fluorosis, but there have been very few cases of fluorosis. Better safeguards have improved safe fluoride levels in water and other products.

Note: Dental fluorosis is defined as having very mild, mild, moderate, or severe forms and is based on Dean's Fluorosis Index. Percentages do not add up to 100 due to rounding.

Source: Adapted from "CDC/NCHS, National Health and Nutrition Examination Survey, 1999–2004," as appears in "Prevalence and Severity of Dental Fluorosis in the United States, 1999–2004," by E. D. Beltrán-Aguilar et al., November 2010, *NCHS Data Brief No. 53*.

While fluoride in drinking water has benefited the majority of the population in terms of reduced dental caries, or cavities, there is some evidence that some U.S. water supplies contain an excessive amount. Removing this excess amount is difficult and expensive. The easiest solution is to find and access a safer water supply.

Climate Change

Environmental changes can greatly influence the spread of infectious diseases by affecting the water supply, food supply, and sanitation processes. Lack of access to a safe water supply can cause a tremendous burden of infectious diseases. While the United States and other developed nations have few issues with safe water, emergencies and natural disasters often increase the risk to the water supply. Flooding after heavy rains or a hurricane can cause sewage overflow and widespread water contamination (WHO, 2017f).

Other climate changes can have an adverse effect on human health beyond excessive water. According to the CDC (n.d.-a), climate change decreases air quality, which in turn increases health risks. Increased ground-level ozone and particulate matter from burning fossil fuels such as gas and coal will increase smog and diminish lung function in humans. In worst-case scenarios, it could lead to irreversible lung diseases such as asthma or lung cancer.

Increased wildfires linked to hotter and drier air caused by climate change can also lead to significant respiratory diseases (CDC, n.d.-a). Wildfires have increased in frequency over the past years, leading to an increase in acute and chronic lung malfunctions. In addition to wildfires and poor air quality, extreme heat can cause other health conditions, such as heat stress and heat stroke.

Climate change has also been blamed for a series of natural disasters across the world, including the Japan tsunami in 2004 and Hurricane Katrina in 2005, which was one of the most devastating natural disasters ever in the United States (see *A Closer Look*).

A Closer Look: Infectious Diseases and Hurricane Katrina

When it hit on August 29, 2005, Hurricane Katrina was the largest and costliest hurricane the United States had ever experienced. A Category 5 hurricane with sustained winds at 175 miles per hour (280 km/h), the massive weather anomaly struck the Gulf Coast, affecting at least 18 states and approximately 1 million people in an area of approximately 90,000 square miles.

Three major infectious diseases were reported as an aftereffect of the disaster: dermatological conditions, diarrheal disease, and respiratory disease.

- *Dermatological diseases*: Many people who evacuated were placed in close quarters in shelters, including one in Dallas, Texas. There, some children and adults were infected with methicillin-resistant *Staphylococcus aureus* (MRSA). In addition, 24 people were infected with hurricane-associated *Vibrio vulnificus* and *V. parahaemolyticus* wound infections. These two infectious diseases are more commonly caused by seafood consumption, but in this case, they were promoted by open wound exposure to warm, contaminated seawater. Six people died of the infection. Rescue workers also reported skin lesions and other rashes as they worked in the wet environment left behind by Katrina waters.
- *Diarrheal diseases*: Thousands of people congregated in centers in Louisiana, Mississippi, Tennessee, and Texas, and people packed into evacuation centers commonly reported such diseases. Norovirus was detected in stool specimens in the Texas evacuation center.
- *Respiratory diseases*: Evacuees commonly reported issues with breathing difficulties. One case of pertussis was found in a 2-year-old infant rescued from a rooftop in New Orleans. Tuberculosis was also found among a handful of evacuees who had no prior diagnosis of the disease. Local health department personnel tracked evacuees known to have TB to help them complete their treatment during the emergency. Untreated TB can cause life-threatening complications, including permanent lung damage.

Sources: Bross, M. H., Soch, K., Morales, R., & Mitchell, R. B. (2007). *Vibrio vulnificus* infection: Diagnosis and treatment. *American Family Physician, 76*(4), 539–544.

Jablecki, J., Norton, S. A., Keller, R., DeGraw, C., Ratard, R., Straif-Bourgeois, S., Holcombe, J. M., . . . Carpenter, L. R. (2005). Infectious disease and dermatological conditions in evacuees and rescue workers after Hurricane Katrina – Multiple states, August-September 2005. *Morbidity and Mortality Weekly Report, 54*(38), 961–964.

Foodborne Illnesses

Richard Cummins/SuperStock

Norovirus is a highly contagious foodborne illness. Norovirus outbreaks are common on cruise ships, where passengers share close quarters and common meals.

A foodborne illness is caused by ingestion of foods or beverages that have been contaminated by microorganisms or, in some cases, toxic chemicals. Foodborne illnesses are also known as *foodborne disease*, *foodborne infection*, or *food poisoning*. The burden of foodborne illness in the United States is substantial and is a significant health issue for many communities. According to the CDC, "Each year, 1 in 6 Americans get sick by consuming contaminated food" (CDC, 2017f, para. 1). These costly events—which often dominate the attention of the media—can produce severe illnesses and even deaths, and yet they are highly preventable.

More than 250 foodborne illnesses have been identified, and some sort of bacterium, virus, or parasite causes most of them. The CDC has identified the following microbial pathogens as the top five causes of foodborne illness:

1. Norovirus: This is the leading cause of foodborne illness in the United States. This virus is highly contagious; infections cause acute gastroenteritis (stomach pain, nausea, diarrhea, and vomiting). The illness can be transmitted through consumption of contaminated foods and liquids or by coming into contact with contaminated environmental surfaces and objects. On average, 21 million cases of norovirus-associated illnesses occur each year in the United States.
2. *Salmonella*: These bacteria cause approximately 1.2 million illnesses and 450 deaths from foodborne illness annually in the United States (CDC, 2016j). There are many kinds of *Salmonella* bacteria. *Salmonella* infections are called salmonellosis and appear from 12 to 72 hours after ingestion of contaminated foods. The symptoms of infection include diarrhea, fever, and cramps. Outbreaks of salmonellosis have been attributed to peanut butter, mangoes, cantaloupe, ground beef, live poultry, and

dry dog food (CDC, 2017e). (Refer to *Case Study: Hummus and Tahini* Salmonella *Outbreak* for more information.)
3. *Clostridium perfringens*: This is a bacterial agent that sometimes contaminates food such as meats and gravies when they have been inadequately heated or have been stored at temperatures that permit multiplication of the bacteria. The incubation period is from 10 to 12 hours with symptoms of diarrhea.
4. *Campylobacter*: This bacterial agent can be present in undercooked chicken or pork, raw milk, and other contaminated foods and water. The incubation period is from 2 to 5 days with typical symptoms that include diarrhea, abdominal pain, malaise, and fever.
5. *Staphylococcus aureus*: This bacterial agent develops a toxin when it grows in foods. Staphylococcal food poisoning is an intoxication caused by a toxin and not an infection. The intoxication has a very short incubation period, frequently occurring as soon as 30 minutes after consumption of contaminated food. The primary symptoms are nausea, vomiting, stomach cramping, and diarrhea. *Staphylococcus aureus* resides on the skin of healthy people (up to 25% of the population) and can be seeded unintentionally into foods by food workers who are harboring the bacteria (CDC, 2016j).

Case Study: Hummus and Tahini *Salmonella* Outbreak

According to the CDC, "*Salmonella* is the most commonly reported cause of bacterial enteric infections in the United States, but determining the cause of an ingredient-driven outbreak is challenging" (2012b, para. 21). *Salmonella enterica* serotype Bovismorbificans (called *S*. Bovismorbificans) is one of the forms of *Salmonella* bacteria that can cause foodborne illness.

State and local health departments, the CDC, and the FDA collaboratively investigated an outbreak of *S*. Bovismorbificans in 2011. A total of 23 culture-confirmed cases with strains indistinguishable from the outbreak strain were identified. People began to be ill from August 19 to November 21, 2011, and the number of sick people peaked from September 8 to October 12. Most of the cases were identified in the mid-Atlantic region of the United States: Washington, DC (eight); Maryland (seven); and Virginia (three). One case per state was identified in California, Delaware, Michigan, New Hampshire, and New Jersey. State health department staff members conducted open-ended interviews and obtained information about 22 patients.

Among the 22 patients with exposure information, 20 reported eating at a restaurant in the Washington, DC, metropolitan area. Among 15 patients asked about Mediterranean-style restaurant exposure, most indicated that they had eaten at a Mediterranean-style restaurant in the DC metropolitan area, including six restaurants in DC and two in northern Virginia. Through either open-ended or targeted interviews, several reported eating at one of those restaurants (coined by investigators as restaurants A, B, and C) before symptom onset, with most of them reporting eating Mediterranean-style food. About half of those admitted to eating hummus. Other commonly reported foods eaten were lettuce, chicken, tomato, and cucumber. The median age of the patients was 27 years, and slightly more than half were female.

One patient was asymptomatic. Among the 22 symptomatic patients, 21 had one or more symptoms consistent with *Salmonella* infection: 21 reported diarrhea (defined as three or more loose stools during 24 hours), 16 reported abdominal cramps, 16 reported nausea, 15 reported fatigue, 13 reported fever, seven reported bloody diarrhea, and four reported vomiting. All 23 patients received outpatient medical care. No hospitalizations or deaths were reported.

November 7–8, the District of Columbia Department of Health (DOH) visited restaurants A and B to collect food samples; 15 prepared foods, including hummus and hummus ingredients (e.g., tahini), were collected for laboratory testing. Investigators learned that restaurants A, B, and C had the same owner. Restaurant A performed all food preparation for restaurants B and C. Specific food items, including hummus and tzatziki sauce, were prepared at restaurant A and delivered to restaurants B and C for sale to customers.

The District of Columbia Public Health Laboratory (PHL) isolated *S*. Bovismorbificans from the hummus sample collected from restaurant A. All other food items tested negative for *Salmonella*. An additional 18 samples of ingredients and prepared foods were collected during inspections of restaurants A, B, and C during November 16–17. *S*. Bovismorbificans that was indistinguishable from the outbreak strain was isolated from one sample of hummus collected from restaurants A and C; all other food samples tested negative for *Salmonella*. DOH also cited restaurants A, B, and C for multiple food safety violations, including inadequate food temperature control, insufficient hand washing, and the presence of insects and other pests.

On May 30, 2012, traceback by FDA suggested that tahini (sesame seed paste) used in hummus was a plausible source for *Salmonella* infections. The traceback revealed tahini used at the different restaurants in the DC metropolitan area came from a common foreign manufacturer from Lebanon associated with recent *Salmonella* outbreaks in Canada. FDA issued a mandate that all products imported from this manufacturer undergo *Salmonella* testing before entry into the United States.

Source: Adapted from "Multistate Outbreak of *Salmonella* Serotype Bovismorbificans Infections Associated With Hummus and Tahini—United States, 2011," by Centers for Disease Control and Prevention, November 23, 2012, *Morbidity and Mortality Weekly Report, 61*, 944–947.

Anthrax

Anthrax is an infectious disease that is caused by rod-shaped bacteria known as *Bacillus anthracis*. The substance is naturally found in soil and is common among domestic and wild animals around the world; however, people can become sick if they come into contact with it (CDC, 2015b). The bigger concern in recent years has been the heightened threat of anthrax exposure from bioterrorism activities. People became far more aware of the substance in the United States after the U.S. mail was contaminated with anthrax powder. "It only takes a small amount of anthrax to infect a large number of people," according to the CDC (2014, para. 7). Anthrax spores could potentially be released into the air to cause illness simply because inhalation of the spores is the most serious form of infection. It is fatal if not treated immediately.

Medicine Contamination

Chemicals can also cause significant disease outbreaks, mostly of a neurological nature. Contamination of medicines caused an illness that became known as Jamaican ginger paralysis (WHO, 2017g). In the Prohibition 1920s, people turned to what was known as the medicinal remedy "Jamaica ginger" (Mindhacks, 2011). To fool the government tests for alcohol in products during Prohibition, this product contained the chemical known as triorthocresyl phosphate, an additive that disguised (albeit poorly) the alcohol content of the Jamaica ginger (Mindhacks, 2011).

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Several cases of illness caused by the toxin triorthocresyl phosphate were linked to contaminated filters in dialysis machines during 2001.

At the time, the toxin was unknown as a human health hazard, and people who ingested it reported lower leg muscular pain, tingling, and eventually paralysis. A report of the epidemic first appeared in the June 1930 issue of *The New England Journal of Medicine*. It wasn't until the late 1970s that it was discovered that the chemical was a neurotoxin affecting brain function, which in turn affected motor function. While triorthocresyl phosphate is still used today, it is highly regulated. It is found in flame retardants and resins

and is used as a gasoline additive as well as in other industrial manufacturing uses. Practices and controls have been in place since the late 1970s to monitor and protect against exposure (CDC, 1978).

Over the years, medicine and product contaminations continue to occur. In 2001, six countries reported Jamaica ginger paralysis in dialysis patients. It was later discovered that the dialysis machine filters were contaminated with perfluoroisobutylene (WHO, 2017g). In 2007, a counterfeit Colgate toothpaste contaminated with diethylene glycol (a chemical found in antifreeze) poisoned a number of people in New York, New Jersey, Pennsylvania, and Maryland (Associated Press, 2007). The problem was quickly discovered by the Food and Drug Administration's routine product testing, and no deaths occurred.

In 2012, contaminated methylprednisolone, an injectable drug used to treat pain and swelling in those with joint disorders such as arthritis, resulted in close to 1,000 cases of meningitis (McCotter et al., 2015). It is uncertain how the mold contaminated the product; however, it is important to note that the mold itself, *E. rostratum*, is widely found in the environment and rarely causes infection (Kauffman, Pappas, & Patterson, 2013). Strong treatments and improved environmental controls, in addition to recalling the contaminated product, helped to end the outbreak.

More recently, contamination of medical marijuana has become a significant concern. In early 2017, a cancer patient in California using medical marijuana for treatment died from what doctors believe was a contaminated product (Marijuana Business Daily, 2017). The product he was using to eliminate the side effects of his cancer treatment contained a rare fungus, causing an infection that killed him. Marijuana growing and production safety concerns are being discussed at the state level in states where medical marijuana is legalized.

3.5 Controlling Infectious Diseases

Although infectious diseases are responsible for a major worldwide toll in morbidity and mortality, the situation is not entirely dire, as many procedures and interventions are available to prevent the spread of infectious diseases. There are many ways in which public health is working to protect the population: surveillance activities, outbreak investigations, immunizations, food and water supply protections, and policies and programs.

Surveillance Programs and Reportable Diseases

Community Health and Measles: A Case Study

San Diego State Professor Dr. Thomas Novotny recalls a case of unvaccinated camp children in Colorado, and how a wider outbreak of measles was avoided.

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Critical Thinking Questions

Dr. Novotny also mentions a case of measles on a college campus that resulted in the deaths of 5 students. Who should be held responsible for those deaths? The families? The students? The school, or the state?

Surveillance programs involve the continuous monitoring of infectious diseases. The types of diseases under surveillance are called *notifiable* and *reportable* diseases. Ongoing surveillance programs aid in identifying unusual increases in the incidence of infectious diseases and can signal the occurrence of a bioterrorism event caused by the intentional distribution of a hazardous biological agent. Although disease surveillance systems have been in place for many years, interest in developing surveillance systems for bioterrorism increased after 2001 when anthrax spores were distributed intentionally in the U.S. mail and several individuals became ill or died as a result of their exposure.

Outbreak Investigations

Epidemiologic investigations help to identify the sources of infectious disease outbreaks and control them. Investigation of disease outbreaks is the main task of local health departments in the United States. Noteworthy outbreaks may first come to the attention of local health departments and then are followed up on with investigations by the CDC. Major outbreaks even command the attention of the media. Here are some examples:

- Foodborne illness (e.g., salmonellosis and other forms) associated with potlucks, cruise ships, agricultural products, and unsanitary food preparation
- Bacterial illnesses associated with a petting zoo or household pets
- Illnesses associated with mold exposure, following major flooding events such as Hurricane Katrina
- Epidemic and pandemic influenza such as the 2009 H1N1 influenza pandemic

Often, disease outbreaks are mysterious and life threatening and require immediate epidemiologic investigations in order to bring them under control. Epidemiology will be covered in detail in Chapter 6.

Immunization Programs

Vaccines are among the most cost-effective preventive action that anyone can partake in to prevent infectious diseases. About 42,000 adults and 300 children die annually in the United States from vaccine-preventable diseases, such as measles. In the United States, unvaccinated individuals and subpopulations are at particularly high risk for vaccine-preventable diseases, which could be introduced by travelers from areas where such diseases are prevalent. The impact of morbidity and mortality from vaccine-preventable diseases could be reduced substantially if more people complied with recommended vaccination schedules.

Immunizations have made a significant impact on the population in the United States. Childhood immunizations are required against the following diseases: diphtheria, tetanus, whooping cough, *Haemophilus* influenzae type B, polio, measles, mumps, rubella, hepatitis B, and varicella (chicken pox). For every birth cohort, these immunizations save 33,000 lives, prevent 14 million cases of disease, and reduce direct health care costs by $9.9 billion (Healthypeople.gov, 2017).

Other diseases, such as tuberculosis and viral hepatitis, can also be prevented through immunization efforts. These are not required vaccines, but they are made available to help support prevention efforts.

Herd immunity is the relative immunity a large group or community has against an infectious disease, based on a large number of members of that population having been immunized (through either past exposure or vaccination). Herd immunity can occur when immune persons prevent the spread of disease to unimmunized individuals. This kind of immunity offers protection to the population even though not every single individual has been immunized. This is particularly helpful for those who are too young, old, or ill to receive the immunization.

If a critical mass of people is vaccinated against a disease, it is less likely to spread and cause an outbreak. Challenges today involve a combination of new and emerging diseases plus a lack of herd immunity (see *A Closer Look* for more information). Newly infectious agents can travel much more quickly across the globe than they used to, thanks to international travel and trade. In addition, migration from one country to another can also introduce diseases where they have never been before. Further, bioterrorism concerns such as the potential disbursement of anthrax into the atmosphere are among the challenges in outbreak issues.

A Closer Look: Polio, Measles, and Herd Immunity

Immunity to a disease is often obtained through vaccination. Herd immunity, also called "the herd effect," is an indirect protection from an infectious disease. It occurs when a large percentage of the population has become immune to a disease and thereby protects other individuals who are not. When the majority of a population is vaccinated against a disease, it assists in protecting everyone, not just the individual with the immunization (Figure 3.8).

Figure 3.8: The effects of herd immunity

The more people receive immunization against diseases, the more it helps protect others in the community against the disease as well. Herd immunity is achieved when most of the population is immunized against a disease. It is highly unlikely that the disease can spread once herd immunity is achieved.

Source: "Community Immunity ('Herd' Immunity)," by National Institute of Allergy and Infectious Disease, U.S. Department of Health and Human Services, 2010 (**https://web.archive.org/web/20150110110713/http://www.niaid.nih.gov/topics/pages/communityimmunity.aspx (https://web.archive.org/web/20150110110713/http://www.niaid.nih.gov/topics/pages/communityimmunity.aspx)**).

What happens when herd immunity is not achieved? As Figure 3.8 shows, more and more people are exposed and contract an infectious disease. Let's look a few current examples.

Polio

Polio was once a disease that affected millions worldwide, causing sudden, life-long paralysis starting in childhood. Franklin D. Roosevelt lived with polio during his time as president of the United States. Polio is a highly infectious disease caused by the poliovirus. Besides causing paralysis, it can also be fatal. Before availability of the polio vaccine in the early 1950s, outbreaks caused more than 15,000 cases of paralysis in the United States every year (CDC, 2017v). Cases of the disease fell rapidly to less than 100 in the 1960s and fewer than 10 in the 1970s (CDC, 2017v). While not every person received the vaccine, herd immunity was created when enough of the population had been vaccinated. In 2014, the World Health Organization declared a public health emergency when polio started returning in multiple countries (Beaubien, 2014). While only about 200 cases exist across the world, if herd immunity is again established, then that number should be zero.

Measles

Measles is making a comeback thanks to a lack of herd immunity. In 2017, 15 states reported outbreaks of measles (CDC, 2017r). In 2016, 16 states reported the disease; in 2015, 24 states reported it; and in 2014, 27 states reported it (CDC, 2017r). Most of the people who contracted the infectious disease were not vaccinated. Probably the most publicized outbreak came in 2015, when a multiple-state outbreak was linked to Disneyland in California. It is likely that one overseas visitor brought the disease to Disneyland and infected multiple people who were unprotected.

The Vaccination Scare

Fears about the dangers of vaccinations in the late 2000s and early 2010s prompted many people to opt out of vaccinations. One of the reasons that people cited for opting out of immunization protection was the mistaken belief that vaccines cause autism. Autism, or autism spectrum disorder, is a mental condition characterized by difficulty with social skills, behaviors, and communication. Some people were far more afraid of autism than of those diseases that a vaccine protects against.

Because of this scare, the United States began to see a resurgence of diseases such as polio and measles. The lack of herd immunity, stemming from a fear of vaccinations, made it easier for infectious diseases to spread throughout a community, region, or nation. After the loss of herd immunity against several diseases, the Institute of Medicine published a report debunking the idea that vaccinations cause autism. A CDC study followed in 2013 that also proved vaccines do not cause autism. Public health professionals have since embarked on a widespread educational campaign to reiterate the safety of vaccinations and the importance of obtaining herd immunity. Time will tell if herd immunity can be obtained for diseases that should ultimately no longer exist.

Food and Water Supply Protections

One of the priorities of Healthy People is to protect the U.S. food supply. On January 4, 2011, President Obama signed a new law to improve food safety, the Food Safety Modernization Act (FSMA) (U.S. Food and Drug Administration, 2014). The law aims to prevent foodborne illnesses rather than react to them after they occur. It focuses on three main strategies:

1. advancing public health
2. leveraging and collaborating
3. strategic and risk-based industry oversight

First, the law advanced public health by providing the Food and Drug Administration with stronger oversight of the food industry, including implementing additional prevention systems to protect the nation's food supply. This includes increased control of food processing, food allergens, sanitation, and supply chains. In addition, it provides for an improved recall plan in the event of an incident of tainted food. Also, it provides controls to encourage the production of safe foods for animals in the industry, including limitations on excessive use of antibiotics and steroids.

Second, there is significant collaboration between the FDA and national growers as well as food suppliers. This offers both the FDA and stakeholders in the food industry a platform to voice concerns, address issues, and collaborate for the benefit of the entire population. Third, risk-based oversight occurs when an allowable or acceptable level of risk is established. A 0% risk is ideal, but the use of food processing, chemical additives, and preservatives means that there will always be some risk. The approach is to

determine what is acceptable. Research and associated strategies focus on reducing risk in the food supply with strong oversight through the FDA.

Policies and Programs

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Public health departments encourage individuals to receive vaccinations against preventable diseases.

Policies and programs are a key tool for public and community health, and the effort to control infectious disease is no exception (policy will be discussed more in Chapter 5). The range of public health department functions includes the control of sexually transmitted diseases, responding to outbreaks of communicable diseases, maintaining immunization programs, and developing emergency preparedness. Prevention and control of infectious diseases is one of the core functions of public health departments. In addition, public health departments are charged with maintaining emergency preparedness to respond to disease epidemics and bioterrorism incidents. Public health departments sometimes offer testing for tuberculosis and sexually transmitted diseases. Also, they engage in case finding and investigation of outbreaks of diseases such as tuberculosis, foodborne illnesses, and waterborne conditions. An important function of health departments is to encourage citizens to become immunized against vaccine-preventable diseases.

A good example of a prevention program is the Alameda County Public Health Department in California's "Shoo the Flu" program. Through this community-based initiative, the City of Oakland preschool and elementary school children can receive a free flu vaccination every fall (Alameda County Public Health Department, n.d.; Shoo the Flu, n.d.).

In New Jersey, the Public Health Department operates the Perinatal Hepatitis B Prevention Program, primarily to protect newborns. The program helps screen all women for the Hepatitis B surface antigen at each pregnancy and reports positive results. It also ensures all infants born to positive mothers are identified and reported and receive treatment and promotes the HBV vaccination for all infants (New Jersey Department of Health, 2017).

Summary & Resources

Chapter Summary

Globally and in the United States, infectious and communicable diseases continue to be a major cause of morbidity and mortality. In fact, pneumonia and influenza are the eighth leading cause of mortality in the United States. Infectious diseases are communicable—easily transmitted from person to person by touch, breath, bodily fluids, or other paths. The epidemiological triangle is a three-way model for the etiology of an infectious disease that includes agent, host, and environment. A break in any part of the triangle should remove the threat.

Understanding the history of devastating epidemics caused by diseases such as influenza, cholera, and plague can offer insight on current and future outbreaks of disease. For example, the London cholera outbreak provided John Snow the impetus to investigate the cause of the disease and figure out the cure. Today, public health professionals use the same techniques as Snow did. During the 19th century, infectious disease pioneers made great strides in the identification of microbes that caused infectious diseases. The development of efficacious immunizations for conditions such as smallpox in the 19th century and polio in the 20th century was crucial for the control of vaccine-preventable diseases.

Several environmental factors contribute to diseases and outbreaks, including water and sanitation, climate change, and foodborne illnesses. In terms of water improvements, fluoridation of water systems across the United States has been one of the great public health achievements of all time. If the amount of fluoride added to the water is too great, it can significantly affect health through fluorosis. This is one of the key reasons why water monitoring continues today. Several types of climate issues often increase health risks, such as decreased air quality from particulate matter from burning fossil fuels. In worst-case scenarios, adverse health outcomes for humans and animals include lung disease and cancers.

Understanding a disease and its etiology, and monitoring the progression of diseases through surveillance activities, is not the only goal for public health officials. They are also tasked with controlling infectious diseases. The CDC Framework for Preventing Infectious Diseases outlines three critical elements: surveillance, laboratory detection, and epidemiological investigation. Those activities support interventions to stop the spread of diseases and advocate for policies, such as mandatory immunizations, to keep those diseases away from the public.

In the latter part of the 20th century and beginning of the 21st century, the United States experienced the effects of infectious diseases such as HIV/AIDS, syphilis, Lyme disease, and Zika. These diseases are among a large number of new threats. Starting in 1961, the CDC began monitoring and investigating outbreaks of diseases through the National Notifiable Diseases Surveillance System. Ongoing surveillance programs assist in tracking and possibly stopping infectious diseases.

Protection of the community against infectious diseases is one of the most significant functions of public health departments. A cycle of surveillance, interventions, and policies continuously keeps the public safe and healthy.

Critical Thinking and Review Questions

1. Explain the components of the epidemiological triangle and apply them to the etiology of the following infectious diseases: seasonal influenza, tuberculosis, and HIV infections.
2. Discuss possible host responses to infectious disease agents and explain why all persons who are exposed to microbes do not become ill.
3. Define and describe direct and indirect modes of transmission of infectious diseases.
4. Examine the chain of infection for the following diseases: Zika, syphilis, and HIV/AIDS.
5. Describe at least two emerging infectious diseases and explain what public health is doing for mitigation.
6. Explain herd immunity, how to obtain it, and why it is so important to public health.
7. Name four environmental risk factors and at least one disease that is associated with each factor.
8. Research one common foodborne illness and suggest methods for its prevention.
9. Describe the National Notifiable Diseases Surveillance System.
10. Explain the purpose behind the Food Safety Modernization Act.

Additional Resources

HIV/AIDS timeline

https://www.hiv.gov/hiv-basics/overview/history/hiv-and-aids-timeline (https://www.hiv.gov/hiv-basics/overview/history/hiv-and-aids-timeline)

Learn more about the HIV/AIDS epidemic from this timeline. Descriptions provide an overview of events and developments between 1981 and 2016.

The 1918 influenza virus

https://www.cdc.gov/flu/about/qa/1918flupandemic.htm (https://www.cdc.gov/flu/about/qa/1918flupandemic.htm)

Visit this website for more information about the 1918 influenza outbreak, the greatest influenza pandemic the world has ever experienced. It also provides details about how this deadly virus was reconstructed in order to glean more information about it.

History of vaccines

https://www.historyofvaccines.org/timeline#EVT_100315 (https://www.historyofvaccines.org/timeline#EVT_100315)

Visit this website to learn more about the development and use of vaccinations across the globe. This informative timeline includes images, videos, and descriptions about milestones that occurred from 1625 to the present day.

Shoo the Flu

http://shootheflu.org/ (http://shootheflu.org/)

Learn more details about the “Shoo the Flu” campaign. This annual campaign occurs in Oakland, California, to vaccinate children against influenza.

Key Terms

acute infectious disease
: A disease that usually runs its course in a matter of days.

chain of infection
: Sequence of disease transmission that explains how diseases form in the human body.

chronic infectious disease
: A disease that lasts for weeks or months.

communicable disease
: See *infectious disease*.

direct transmission
: The spread of an infectious disease from person to person by physical contact.

disease agent
: See *infectious agent*.

environment
: The third component of the epidemiological triangle, it is the unique niche in which disease agents exist, survive, or originate.

epidemiological triangle
: A model for the etiology of diseases that encompasses three major factors: agent, host, and environment.

germ theory of disease
: A theory that microbes cause diseases in humans. The theory proved to be true.

herd immunity
: The relative immunity a large group or community has against an infectious disease, based on a large number of members of that population having been immunized (through either past exposure or vaccination).

host
: A person or animal infected by a disease agent. It is the second component of the epidemiological triangle.

immunity
: The presence of antibodies (proteins produced by the body) that act against disease-causing microorganisms. Immunity can be either active or passive and either natural or artificial.

incubation period
: The time period between a host’s exposure to an infection and the first appearance of disease symptoms.

indirect transmission
: The spread of infection through intermediary sources known as vehicles, fomites, or vectors.

infectious agent
: Bacterium, virus, parasite, or fungus that can infect human, plant, or animal life.

infectious disease
: Disorder caused by organisms such as bacteria, fungi, viruses, or parasites that can be easily transmitted from person to person by touch, breath, bodily fluids, or other paths. Also called a *communicable disease*.

infectivity
: The potential of an agent to infect and multiply within a host.

pathogenicity
: The capacity of an agent to cause disease in the infected host.

portal of entry
: A location on the body where an agent can infect the host, such as through the mouth or open wound.

portal of exit
: A location where infectious agents may leave the body, such as through sweating or sneezing.

reservoir
: A site where infectious agents survive, such as a human, animal, or insect.

vector
: A living insect or animal that can transmit and cause disease.

vehicle for transmission
: A contaminated, nonmoving object involved in the transmission of disease (such as food and water).

virulence
: Explains the severity of a disease, or how severely it manifests.

4

Chronic Diseases in the Community

Spencer Grant/age fotostock/SuperStock

Learning Outcomes

After reading this chapter, you should be able to

- Describe chronic diseases and their effect on population health.
- Explain the environmental risk factors associated with chronic diseases.
- Summarize the activities intended to address the chronic disease burden in the United States.

Even though people still get sick, individuals are living longer with improved health care. In fact, increasing numbers of people are living with diseases that once would have killed them. Most of the top 10 causes of death in the United States are not spread by an infectious agent and often cannot be prevented or cured. They are illnesses of long duration. In 2012, half of all adults had one or more long-term, or chronic, health conditions in the United States (CDC, 2017c). Cancer and heart disease together accounted for nearly half of all deaths in 2014 (CDC, 2017c). Obesity, arthritis, and diabetes are the other chronic killers.

Unlike infectious diseases, chronic diseases are largely influenced by lifestyle behaviors and choices. Chronic diseases share four common, modifiable risk factors. These include being sedentary, consuming foods high in saturated fats and calories, smoking cigarettes and using other forms of tobacco, and consuming excessive amounts of alcohol. In addition, physical inactivity and poor diet are associated with obesity, an increasingly prevalent long-lasting condition, which is a risk factor for other chronic conditions.

This chapter will focus on the occurrence, distribution, and risk factors for major chronic diseases, including cardiovascular diseases, cancer, diabetes, asthma, and obesity. It will also touch upon oral diseases and mental health—two growing concerns in the nation. Evaluating risk behaviors and environmental factors that are associated with chronic diseases, as well as prevention activities currently underway to quell the growth of such diseases, will provide a better understanding of the current state of chronic disease.

4.1 Types of Chronic Disease

By the mid-1900s, medical professionals, coupled with community and public health specialists, had made a significant dent in the spread of various infectious diseases thanks to the invention of immunizations. This success allowed for a shift in public health focus in the mid-20th century to chronic diseases, which are noncommunicable diseases that last at least 3 months or longer and often cannot be prevented by vaccines or cured by any type of medication or treatment. As chronic diseases became a population health focus, the National Center for Chronic Disease Prevention and Health Promotion at the CDC was created in 1988 (Remington & Brownson, 2011). Since then, most public health efforts have revolved around chronic disease prevention. See *A Closer Look* for examples of chronic disease epidemics in China, the United States, Denmark, and the Cook Islands.

A Closer Look: Chronic Disease Epidemics

Chronic disease has been on the rise for decades. In 1990, chronic diseases caused 40% of all deaths, and it is expected that by 2020, that percentage will rise to nearly 70% (World Health Organization, 2005). While chronic diseases do not function like traditional epidemics of infectious diseases that peak and then end, public health officials have labeled some of these long-term diseases "epidemics" due to their prevalence and growth. Recall that an *epidemic* is defined as an occurrence of a disease in greater numbers than is normally seen in a population. Typically, an epidemic occurs suddenly rather than gradually over time.

Tobacco Use in China

More than 300 million adult men smoke cigarettes in China. Of that number, 160 million adults now have hypertension as a result of their smoking habit (Liu et al., 2016). In fact, China has the largest number of smokers in the world, making it a target for various public health interventions as well as policy development (Au, Su, & Yuan, 2012), though there has been no reduction in smoking rates thus far. A 2015 study suggested that if there is not widespread cessation soon, the annual number of deaths in China caused by tobacco will go from 1 million in 2010 to 2 million in 2030 and 3 million by 2050 (Chen et al., 2015).

Heart Disease in the United States

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Heart disease is the leading killer in the United States. Physical inactivity, poor nutrition, and obesity are some of the risk behaviors associated with heart disease.

Close to 610,000 people die of heart disease in the United States annually (CDC, 2017i). Furthermore, coronary heart disease is the most common type of heart disease, killing more than 370,000 people every year (CDC, 2017i). Heart disease is the leading killer of people of all ethnicities in the nation. It kills 18% of American Indians, 22% of Asians/Pacific Islanders, 24% of non-Hispanic Blacks, and 24% of non-Hispanic Whites (CDC, 2017i). This is another epidemic that will continue to grow if risk behaviors are not modified and reduced. These risk behaviors include overweight/obesity, poor nutrition, physical inactivity, and excessive alcohol use.

Cancers in Denmark

Denmark has the highest rates of all cancers (excluding non-melanoma skin cancer) across the world (World Cancer Research Fund International, 2014). When adjusted for age, Denmark saw a cancer rate of 338 cases per 100,000 people. The most common types are prostate cancer for men and breast cancer for women; the breast cancer incidence for both men and women is the highest in the world (International Agency for Research on Cancer, 2012). The highest mortality rates were due to lung cancer for both men and women. Because of the exceptionally high cancer rates, Denmark has been named "the Cancer Capital of the World" (Czech Society for Oncology, n.d.). Researchers believe that the country is simply getting better at diagnosing various cancers; however, some studies have claimed that the reason is due to smoking and alcohol consumption rates, both of which are increasing among the Danish population. Furthermore, the country is trending toward increased obesity and less physical activity—all of which can contribute to chronic disease.

Obesity in the Cook Islands

While the United States has the greatest number of obese people (109.3 million), the Cook Islands has the highest population percentage considered obese (Renew Bariatrics, 2017). Of the entire U.S. population, 33.7% are considered obese, whereas 50.8% of the Cook Islands population falls into the obese category (Renew Bariatrics, 2017). The Cook Islands, located in the Pacific Ocean about 2,000 miles northeast of New Zealand, has a population of 17,380 people. That means that almost 9,000 people on those islands are obese. While 9,000 obese individuals may seem like a small number, it is significant because it is more than half of the country's population. Obesity exists in almost every country, but the Cook Islands is the only place where it has overtaken more than half the population. Palau and Nauru are second and third highest by percentage at 47.6% and 45.6%, respectively. This has become a significant crisis because obesity rates have been rising for more than three decades, and the rate continues to rise.

Cardiovascular Diseases

Cardiovascular diseases are disorders of the heart and/or blood vessels, including heart diseases and stroke. Mortality due to both heart disease and stroke has declined greatly during the past half-decade (Remington & Brownson, 2011). In fact, between 1960 and 2009, heart disease mortality declined by 68% and stroke mortality by 78%. These declines can be attributed to reductions in smoking and improvements in screening for cardiovascular disease risk factors, as well as treatments for cardiovascular disease. Figure 4.1 shows the distribution of heart disease death rates of adults aged 35 and older across the United States.

Figure 4.1: Heart disease death rates for adults 35 and over, 2011–2013

Heart disease is far more prevalent in the South than in the western states. It is possible that the culture and foods of the Deep South cause the higher mortality rates from heart disease. Southern foods are often deep fried or covered in sauces—both of which contain significant amounts of fat. Consuming a regular diet of these types of foods can lead to heart disease.

Source: Adapted from "Heart Disease Fact Sheet: Division of Heart Disease and Stroke Prevention," by Centers for Disease Control and Prevention, 2017 (**https://www.cdc.gov/dhdsp/data_statistics/fact_sheets/fs_heart_disease.htm (https://www.cdc.gov/dhdsp/data_statistics/fact_sheets/fs_heart_disease.htm)**).

According to the Centers for Disease Control and Prevention, heart disease is the leading cause of death for both men and women in the United States. One in every four Americans is dying from the disease each year. Based on the map, the Deep South has the highest number of deaths and the western states the lowest. What factors could be present in the Deep South that may point to higher numbers of heart disease deaths? This could be due to differences in regional diets, a hotter climate, and a larger population of African Americans, who are often exposed to health disparities (see Chapter 2).

Disorders that comprise cardiovascular diseases are the same regardless of the geography of the individuals who experience them:

- *Coronary heart disease (CHD)*: Disease of the blood vessels supplying the heart muscle
- *Cerebrovascular disease*: Disease of the blood vessels supplying the brain
- *Peripheral arterial disease*: Disease of the blood vessels supplying the arms and legs
- *Rheumatic heart disease*: Damage to the heart muscle and heart cells (cardiac tissue) from rheumatic fever caused by streptococcal bacteria
- *Congenital heart disease*: Malformations of the heart structure existing at birth, which include atrial septal defect (ASD), coarctation of the aorta, patent ductus arteriosus (PDA), and ventricular septal defect (VSD)
- *Deep vein thrombosis (DVT) and pulmonary embolism*: DVT involves the formation of a clot in a deep vein of the body, occurring most often in the femoral and ilia veins, and a pulmonary embolism involves blood clots in the leg veins, which can dislodge and move to the heart and lungs

Coronary heart disease (CHD) is the result of fatty buildup, or *plaque*, in the arteries that supply blood to the heart. Table 4.1 defines important terms related to coronary artery diseases.

Table 4.1: A glossary of terms related to coronary artery diseases

Term	Definition
Angina	Chest pain or discomfort, which is a symptom of coronary artery disease, caused by insufficient blood circulation to the heart
Arrhythmia	Abnormal heart rhythm
Atherosclerosis	Narrowing of the arteries over time, caused by a buildup of plaque
Atrial fibrillation	A type of arrhythmia that can cause rapid, irregular beating in the heart's upper chambers
Coronary artery disease (CAD)	The buildup of plaque in the arteries that supply blood to the heart (called coronary arteries)
Heart failure	Reduced ability of the heart to pump blood normally; sometimes called congestive heart failure
Ischemic heart disease	Reduced blood supply to the heart caused by disease of the blood vessels that supply the heart muscles
Myocardial infarction	Medical term for a heart attack
Plaque	Accumulation of cholesterol deposits in the arteries
Sudden cardiac arrest	Complete stopping of the heart

Sources: Centers for Disease Control and Prevention. (2015). About heart disease. Retrieved from **http://www.cdc.gov/heartdisease/about.htm (http://www.cdc.gov/heartdisease/about.htm)**

American Heart Association. (2017). What is cardiovascular disease (heart disease)? Retrieved from **http://www.heart.org/HEARTORG/Caregiver/Resources/WhatisCardiovascularDisease/What-is-Cardiovascular-Disease_UCM_301852_Article.jsp (http://www.heart.org/HEARTORG/Caregiver/Resources/WhatisCardiovascularDisease/What-is-Cardiovascular-Disease_UCM_301852_Article.jsp)**

Mathers, C., Truelsen, T., Begg, S., & Satoh, T. (2004). Global burden of ischemic heart disease in the year 2000. *Global Burden of Disease 2000*. Geneva, Switzerland.

Normal blood pressure is defined as a systolic blood pressure of less than 120 mmHg and a diastolic pressure of less than 80 mmHg. **Hypertension** is the state of having high blood pressure. There are two stages: Stage 1 is a systolic blood pressure of 130–139 mmHg with a diastolic pressure of 80–89 mmHg; Stage 2 is a systolic blood pressure of 140 mmHg or higher and a diastolic pressure of 90 mmHg or higher (140/90) (CDC, 2015a). *Prehypertension* is a systolic blood pressure in the range of 120–139 mmHg and a diastolic pressure of 80–89 mmHg. Prehypertension is a risk factor for development of hypertension.

Hypertension, which usually has no warning signs or symptoms, raises the probability of having heart disease and stroke. As the pressure increases, the arterial muscles constrict to stem the flow of blood. This constant constriction and expansion increases the muscle thickness in the coronary arteries, which contributes to further blood-flow constriction.

About 32% of U.S. adults have hypertension, a condition that causes nearly 1,100 deaths per day (CDC, 2015a). The medical costs attributed to hypertension are about $48.6 billion per year. During the past decade, the prevalence of hypertension in the United States has tended to remain constant. Although hypertension is a treatable condition, only about half of individuals with hypertension have the condition under control.

Stroke events reduce or stop the flow of blood to the brain. Other names for stroke are a *cerebrovascular accident (CVA)* and a *brain attack*. They are also classified as cerebrovascular diseases. There are two major types of stroke. **Ischemic strokes**, which account for 87% of all strokes, are further classified as embolic or thrombotic. An *embolic stroke* happens when a blood clot that originates in the brain or some other part of the body dislodges and blocks one of the blood vessels in the brain. A *thrombotic stroke* is caused by the formation of a blood clot in an artery of the brain. The clot develops in an artery that has narrowed due to the accumulation of fat and cholesterol. A **hemorrhagic stroke**, caused by the bursting of a blood vessel in the brain, can be from either an intracerebral hemorrhage, which is the rupture of an artery inside the brain, or a subarachnoid hemorrhage, during which bleeding occurs between the covering of the brain and the brain itself.

Stroke is the fifth leading cause of death and the primary cause of long-term serious disability in the United States (CDC, 2017x). Cerebrovascular diseases are responsible for more than 140,000 deaths annually. The data on stroke occurrences across states show disparities both by state of residence and by demographic characteristics, such as race and education. States with a high prevalence of stroke in 2010 tended to be clustered in the South—for example, Alabama and Mississippi. The "stroke belt" is a collection of states that have higher-than-average mortality rates due to stroke, and they include Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. The factors contributing to the stroke belt states' high incidence of stroke deaths is not clearly understood yet. These states also had a high prevalence of hypertension, which is a major risk factor for stroke. Additionally, American Indians/Alaska Natives and Blacks have a higher prevalence of stroke in comparison with other racial and ethnic groups. Persons who had less than a high school diploma had almost three times the prevalence of stroke compared with persons who had a college degree or higher level of education.

Cancer

Cancer is the leading cause of global mortality. In 2015, cancer was responsible for 8.8 million deaths worldwide, with approximately 70% of those people being from low- to middle-income countries (WHO, 2017b). Table 4.2 lists the top five leading cancer deaths worldwide.

Table 4.2: Types of cancers and deaths

Cancer type	Number of deaths
Lung	1,690,000
Liver	788,000
Colorectal	774,000
Stomach	754,000
Breast	571,000

Source: Data from "Cancer Fact Sheet," by World Health Organization, 2017 (**http://www.who.int/mediacentre/factsheets/fs297/en/ (http://www.who.int/mediacentre/factsheets/fs297/en/)**).

Cancer occurs when abnormal cells divide to form a malignant tumor. (Some tumors are benign, or not cancerous.) Cancerous, or malignant, tumors can grow, causing various stages of cancer (stages 1–4). Cancer stages describe the size of a cancer and how far it has grown. Stage 1 has the least progression, while Stage 4 is the largest and most invasive. These changes in cells occur because of the interaction of a person's genetic makeup and three categories of external agents:

- Physical carcinogens, including ultraviolet and ionizing radiation
- Chemical carcinogens, such as asbestos, tobacco, and arsenic
- Biological carcinogens, which are infections from bacteria or viruses

While cancer cannot typically be predicted in an individual, there are risk factors that may increase the chance of developing it:

- Age
- Tobacco
- Sunlight
- Ionizing radiation
- Certain chemicals and other substances
- Some viruses and bacteria
- Certain hormones
- Family history of cancer
- Alcohol
- Poor diet, lack of physical activity, or being overweight

Lung Cancer

Of the various types of cancer, lung cancer causes the greatest number of deaths among both men and women in the United States (CDC, 2017l). In fact, lung cancer is responsible for more deaths than breast cancer, prostate cancer, and colon cancer combined. The age-adjusted rate of death for lung cancer, based on deaths between 2010 and 2014, is 44.7 per 100,000 men and women per year. A total of 154,050 lung cancer deaths in the United States was projected for 2018 (National Cancer Institute, n.d.-c).

Tracking the incidence of both new cancer cases and deaths attributed to cancer helps researchers determine if progress is being made with screening, diagnosis, and treatment. Data from 1975 through 2009 show that both new cancer case and death rates steadily increased until the mid-1990s, at which point the trend was steadily decreasing (Figure 4.2).

Figure 4.2: New cases, deaths, and 5-year relative survival of cancers

Rates of cancer deaths and new cases of cancer started trending downward in the mid-1990s. Better screening and early detection may be part of the reason for this trend.

SEER 9 incidence & U.S. mortality 1975–2014, all races, both sexes. Rates are age-adjusted.

Source: Adapted from "Cancer Stat Facts: Lung and Bronchus Cancer," by National Cancer Institute, n.d. (**https://seer.cancer.gov/statfacts/html/lungb.html (https://seer.cancer.gov/statfacts/html/lungb.html)**).

Colorectal Cancer

The Surveillance, Epidemiology, and End Results (SEER) program provides information on cancer statistics in an effort to reduce the cancer burden among the U.S. population. According to SEER data, there were more than 1.3 million people living with colorectal (colon or rectum) cancer in the United States in 2015 (National Cancer Institute, n.d.-a). Mortality from colorectal cancer, approximately 50,000 deaths in 2017, increases with age. The median age at diagnosis was 67 and at death was 74. Regardless of racial/ethnic group, the distribution of deaths from 2010 to 2014 showed far more men were affected than women (Figure 4.3).

Figure 4.3: Deaths from colon and rectum cancer by race/ethnicity and sex

Colorectal cancer is far more common in men than women. There are higher rates of this disease among Black and Native American/Alaska Native males. One factor that may explain this trend could be a lack of access to screening among this population. Screening increases early detection.

U.S. 2010–2014, age-adjusted.

Source: Adapted from "Cancer Stat Facts: Colon and Rectum Cancer," by National Cancer Institute, n.d. (**https://seer.cancer.gov/statfacts/html/colorect.html (https://seer.cancer.gov/statfacts/html/colorect.html)**).

If diagnosed before it has spread, colorectal cancer has a high survival rate. When localized to a primary site, colorectal cancer has a 5-year relative survival percentage of almost 90%.

Breast Cancer

Breast cancer starts in the tissues of the breast. There are two main types of breast cancer in women: *ductile carcinoma*, which starts in the tubes (ducts) that move milk from the breast and nipple, and *lobular carcinoma*, which starts in parts of the breasts called lobules that produce milk. Most cancers of the breast are ductile carcinomas. Breast cancer also occurs in men as a ductile carcinoma. Male breast cancer makes up less than 1% of all cancer cases (U.S. National Library of Medicine, n.d.-a).

Compared with other cancers, female breast cancer is fairly common and has an 89.7% 5-year survival rate (National Cancer Institute, n.d.-b). The median age of a woman at diagnosis is 62; however, this cancer does affect women of all ages (Figure 4.4).

Figure 4.4: New cases of female breast cancer by age group

Female breast cancer is common, and the median age at diagnosis is 62. The increase of breast cancer diagnoses could be explained by increased screenings and new technologies that can be used to catch early signs of breast cancer. While men can also suffer from breast cancer, they account for less than 1% of all breast cancer cases in the United States.

SEER 18 2010–2014, all races, females

Source: Adapted from "Cancer Stat Facts: Female Breast Cancer," by National Cancer Institute, n.d. (**https://seer.cancer.gov/statfacts/html/breast.html (https://seer.cancer.gov/statfacts/html/breast.html)**).

According to the National Cancer Institute (n.d.-b), about 12.4% of women will be diagnosed with breast cancer at some point in their lifetime. In 2014, more than 3.3 million women were living with breast cancer in the United States.

Diabetes

Diabetes is a prevalent chronic disease that has steadily been growing. The World Health Organization (2017e) found that only 108 million people had diabetes in 1980, compared with a whopping 422 million in 2014. **Diabetes** occurs when the pancreas does not produce enough insulin or the body cannot use the insulin that is produced. Insulin is a hormone that regulates sugar in the blood. Too much sugar leads to serious damage to various bodily systems.

There are two main types of diabetes: Type 1 and 2. *Type 1* diabetes is characterized by insufficient insulin production in the body. It requires a daily dose of insulin. This type of diabetes is not preventable. *Type 2* is characterized by the body's ineffective use of insulin supplied by the body. Most diabetes worldwide is Type 2. This diabetes type is preventable and is usually associated with excess body weight and physical inactivity.

A third diabetes type is known as *gestational* diabetes and occurs in women during pregnancy. This type of diabetes is hyperglycemia, where blood glucose is high but below

those of types 1 or 2 diabetes. Gestational diabetes increases pregnancy complications.

Approximately 76,488 deaths occurred in 2014 from diabetes, and it is the seventh leading cause of death in the United States (CDC, 2017d). It is more common among non-Whites and is considered a health disparity for many ethnic groups (Figure 4.5).

Figure 4.5: Age-adjusted prevalence of diagnosed diabetes in the U.S. by race/ethnicity

Diabetes is more common in ethnic minorities than in the White population. Non-Hispanic Blacks and Hispanic Americans have the highest prevalence. It is possible that lifestyle, poverty, and culture play a key role in the higher rates of diabetes in minority groups.

Source: Data from "Race/Ethnic Difference in Diabetes and Diabetic Complications," by E. K. Spanakis and S. H. Golden, 2013, *Current Diabetes Reports, 13*(6), 814–823.

Obesity represents the strongest contributor to the development of Type 2 diabetes in all populations (Spanakis & Golden, 2013). Although genetics have been suggested as the difference that leads to the increased incidence and prevalence of diabetes among particular racial and ethnic groups, recent studies have shown that genetics are similar across all races and not a factor that should be considered in the health disparity conversation (Spanakis & Golden, 2013).

Global projections of deaths from diabetes look grim. According to the WHO (2017e), 1,555,609 people died from diabetes in 2015. If no changes are made to decrease the rate of diabetes, by 2030, there will be 2,464,252 deaths worldwide from the disease annually.

Asthma

Asthma is a chronic lung disease that inflames and narrows the passageways to and from the lungs. The disease affects people of all ages, but it often starts in childhood. According to the National Heart, Lung, and Blood Institute (2014), more than 25 million people are living with asthma, and 7 million of those are children.

When we breathe, air flows smoothly through tubes into and out of our lungs. It is almost so natural that we do not notice the process of breathing until there is a problem. Asthma is a serious concern because when those tubes become swollen, it becomes harder to inhale and exhale regularly. In addition, cells in those airways make more mucus than usual and cause further narrowing of the airway. Asthma is not curable at this time, and the disease is not always constant. It can flare up at any time, so managing the disease is the best approach.

Respiratory diseases, which include asthma, are the third leading cause of death in United States (as shown in Chapter 2). In 2014, 3,651 people died from asthma. As Table 4.3 shows, the highest percentage of the population living with asthma clusters around the northeastern section of the United States, with a couple of states in the Midwest (CDC, 2017n). It is difficult to pinpoint a specific cause of asthma because various things trigger asthma differently for each individual. It could be exercise/physical exertion, the environment, or pollution. Why the northeastern portion of the United States has a high population percentage of asthma is still a mystery.

Table 4.3: Top 10 states with the highest percentage of asthma cases

State	Number with asthma	Percentage with asthma
Massachusetts	636,176	12.0%
Kentucky	402,690	11.9%
Maine	122,881	11.6%
District of Columbia	62,346	11.5%
Vermont	56,644	11.3%
West Virginia	161,534	11.0%
Michigan	831,656	10.9%
Rhode Island	89,462	10.8%
Indiana	532,909	10.7%
New York	1,642,598	10.7%

Source: Data from "Most Recent Asthma State or Territory Data," by Centers for Disease Control and Prevention, 2017 (**https://www.cdc.gov/asthma/most_recent_data_states.htm** (**https://www.cdc.gov/asthma/most_recent_data_states.htm**)).

Obesity

Obesity is the condition of having a BMI (body mass index) of 30 and above. Overweight means having a BMI between 25 and 30; normal is 18.5 to 25. *Body mass index* is a person's weight in kilograms divided by the square of the height in meters. A high BMI can be an indicator of how much fat a body contains.

By mid-2017, adult obesity had exceeded 35% of the population in five states, 30% in 25 states, and 25% of the population in 46 states (Robert Wood Johnson Foundation, 2017). Three states and the District of Columbia are below 25%, but they are all still above 20% (Robert Wood Johnson Foundation, 2017). Figure 4.6 shows the ranking and rate for every state as of the end of 2016. Obesity rates—both adult and child—are significantly higher than they were a generation ago. Tracking for obesity since 1990 shows that the rate for the nation was well below 20% at one point. In fact, the highest rate of obesity in 1990 was in Mississippi at 15%, with the lowest being Colorado at 6.9% (Robert Wood Johnson Foundation, 2017). Colorado's obesity rate today, while still the lowest in the United States, is still much higher than it was a few decades ago.

Figure 4.6: State rank and obesity rates for 2016

The causes of obesity rates are complex—different individual, social, and environmental factors can contribute to obesity. In the United States, southern states bear the largest burden of obesity. The five states with the highest rates of obesity include West Virginia (37.7%), Mississippi (37.3%), Alabama (35.7%), Arkansas (35.7%), and Louisiana (35.5%).

Source: "Adult Obesity in the United States," by Trust for America's Health and Robert Wood Johnson Foundation, 2017 (**https://stateofobesity.org/adult-obesity/ (https://stateofobesity.org/adult-obesity/)**). Copyright 2017, Robert Wood Johnson Foundation. Adapted with permission from the Robert Wood Johnson Foundation.

Many of the deaths that occur from chronic diseases are linked to obesity, especially diabetes and cardiovascular disease. Lifestyle trends have a direct impact on the obesity rate in the United States. The American environment is generally sedentary. People sit in a car to go from place to place, and many sit at a desk for work. The daily exercise of simply walking to work or physically moving at one's job is rare for most Americans. Daily life just doesn't involve routine movement, which means people need to consciously think about physical activity and exercise to maintain good health.

In addition, food is abundant in the United States. Americans are constantly eating or drinking something because it is readily available through fast food chains and convenience stores. Furthermore, food portions are excessive. People tend to eat two to three times the amount of food required for fuel. The body doesn't need it, so it becomes stored as fat. These environmental changes and personal lifestyle modifications over time have created the obesity epidemic of today.

Other Chronic Diseases

Beyond the commonly known chronic diseases such as cancer, cardiovascular disease, and obesity, other diseases are causing significant health issues across the nation and worldwide. Two of these diseases are oral diseases and mental health.

Oral Diseases

Oral health is the health of the teeth, gums, and entire oral-facial system, which allows people to speak, chew, and smile (CDC, 2016h). Diseases that affect oral health include tooth decay, gum disease, and oral cancer.

Mike Watson Images/moodboard/Thinkstock

Oral diseases cause significant issues across the nation. Tooth decay, gum disease, and oral cancer are some of the diseases that affect oral health.

Worldwide, between 60% and 90% of children and nearly all adults have dental cavities (WHO, 2012). Dental cavities in the United States are largely prevented thanks to the addition of fluoride in many water systems; however, that is not the case globally. In 2000, the first-ever *Oral Health in America: A Report of the Surgeon General* was released, in an effort to stress the importance of oral hygiene and the subsequent reduction of linked diseases (U.S. Department of Health and Human Services, 2000).

In the report, it was noted that more than one third of the U.S. population was lacking water fluoridation. This means there are more than 100 million people at risk of dental cavities and other oral diseases due to lack of prevention through fluoride. The report also shed light on other existing issues of oral health:

- More than 50% of children ages 5–9 years old have at least one cavity or filling, and that number increases to 78% among 17-year-olds. While water fluoridation has helped with this, these rates could still be improved.
- Low-income children suffer twice as much with oral health issues compared with their richer counterparts, indicating a significant disparity.
- Tobacco-related oral health concerns are prevalent in adolescents who use smokeless tobacco products.
- More than 51 million school hours and more than 164 million hours of work are lost each day from dental-related issues.
- A little less than two thirds of adults reported having visited a dentist in the past 12 months.
- Elderly Americans living in long-term care facilities receive little to no dental care.
- Oral and throat cancers are diagnosed in about 30,000 Americans annually, with 8,000 of those dying from the disease every year. The survival rate for these types of cancers is 56% for White patients but only 34% for Black patients.
- Most Americans take some type of medication—prescription and/or over the counter—which can cause additional oral side effects, including the risk for diseases.

While oral health conditions are considered separate from chronic diseases, they are interrelated. Preventing risk behaviors that lead to oral diseases is the best approach to reduce such conditions.

Depression and Mental Health

While not always considered a chronic disease, depression and various mental health issues are growing concerns worldwide. According to the WHO (2017d), more than 300 million people of various ages suffer from **depression**, a serious mood disorder, around the world. It is the leading cause of disability and a major contributor to the global burden of disease.

Mental health status is connected closely to physical health. Positive mental health status contributes to one's ability to lead a fulfilling and productive life. The WHO (2016a) has defined *mental health* as a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively, and is able to make a contribution to his or her community. In this positive sense, mental health is the foundation for individual well-being and the effective functioning of the community.

Mental disorders, particularly serious ones, are linked to disability, stigmatization, homelessness, and incarceration. (See *A Closer Look* for information about the roles of biological, psychological, social, and environmental causes.) In fact, the National Alliance on Mental Illness (NAMI) (2017) has estimated that 26% of homeless adults staying in shelters on any given day have a serious mental illness. Furthermore, almost half of the homeless live with a severe mental illness and/or substance abuse. Among those incarcerated, approximately 20% in the state prison system and 21% in local jails have a history of mental illness. In addition, 70% of youth in the juvenile justice system also live with at least one mental health condition.

People with severe mental illnesses may be unable to perform the essential tasks of everyday life. This loss of functional capacity, plus the lessened ability to maintain gainful employment, is among the causes of homelessness and criminal behaviors.

Another group struggling with mental disorders are military veterans who return to the country with serious issues such as posttraumatic stress disorder (PTSD), major depression, and anxiety, as well as substance abuse issues (U.S. National Library of Medicine, 2017). One of the consequences of mental illnesses among returning veterans is an increased suicide rate. Many veterans are forced to cope with long-term unemployment, which can add to their sense of distress and hopelessness.

A Closer Look: The Etiology of Mental Disorders

The precise cause of mental disorders in most cases is unknown. Most likely, mental disorders stem from a combination of biological and psychological influences that are affected by influences from the physical environment, society, and culture. Mental illness is hypothesized to result from an interaction among inherited characteristics, *in utero* environmental influences, adverse life events, and chemicals in the brain. Three key elements affect the onset of mental health disorders:

- *Genetic*: Some mental disorders (for example, bipolar disorder and schizophrenia), appear to have an inherited basis. Consequently, family history is a potential indicator for the occurrence of these two disorders.
- *Environmental*: Environmental toxins such as chemicals and pesticides can disturb the normal function of the human brain and lead to other mental health changes.
- *Emotional/psychological*: Stress and other emotional states can also lead to mental health disorders. Many people are under stress because they are unable to afford basic necessities such as housing and health care. Some researchers posit that the consequences of these societal and economic stresses are increases in suicide rates, levels of psychological depression, family dysfunction, interpersonal violence, and criminality.

4.2 Environmental Risk Factors

The physical environment is one of the most crucial dimensions of the health of communities globally and in the United States when it comes to the infectious diseases discussed in Chapter 3 and chronic diseases that are examined in this chapter. Environmental hazards associated with the home setting, recreation, and work or commuting to work affect the health of almost all human beings and demonstrate ecological principles in operation. Chemicals/toxins, air pollution, the built environment, and lifestyle choices have had a significant impact on the incidence and prevalence of chronic diseases. This section will look at a few factors that have helped contribute to chronic disease and affected the United States' struggle to reduce its burden.

Toxic Chemicals

The negative consequences of exposure to toxic chemicals are a major concern of environmental professionals. Because toxic chemicals are essential to many vital industrial processes and are used commonly in the home, humans have many occasions for exposure to them. However, toxic chemicals can be used with appropriate safeguards in order to prevent adverse effects for human health and the environment.

Some examples of chemicals that represent potential health and environmental hazards are solvents, PCBs, dioxins, and chemicals used for the manufacture of plastics. Across the United States, chemicals that are also leaking from inadequate storage sites endanger the environment. Among the hazards associated with some toxic chemicals are biological accumulation, biological amplification, carcinogenicity, persistence in the environment, and ability to mimic sex hormones. These terms are explained in Table 4.4.

Table 4.4: Chemical hazards in the environment

Term	Definition
Biological accumulation (bioaccumulation)	The uptake and storage of chemicals (e.g., DDT, PCBs) from the environment by animals and plants. Uptake can occur through feeding or direct absorption from water or sediments.
Biological amplification (also called bioamplification, biomagnification, or bioconcentration)	The concentration of a substance as it "moves up" the food chain from one consumer to another. The concentration of chemical contaminants (e.g., DDT, PCBs, methyl mercury) progressively increases from the bottom of the food chain (e.g., phytoplankton, zooplankton) to the top of the food chain (e.g., fish-eating birds such as cormorants).
Carcinogenic chemical	Chemical that causes cancer
Dioxin—TCDD (2, 3, 7, 8-tetrachlorodibenzo-p-dioxin)	Toxic chemical produced as a byproduct of industrial processes
DDT (dichloro-diphenyl-trichloroethane)	Synthetic pesticide developed in the 1940s
Endocrine disruptor	Chemical that mimics sex hormones and thereby interferes with reproductive processes. Endocrine disruptors have the potential to impair development, the immune system, reproduction, and neurological functioning in both humans and animals. When present in lakes and rivers, they could affect aquatic animals. In addition to being persistent organic pollutants (POPs), DDT, dioxins, and PCBs are also endocrine disruptors.
Persistent organic pollutant (POP)	Chemical that remains in the environment for long periods (e.g., DDT, dioxins, and PCBs)
Polychlorinated biphenyl (PCBs)	Toxic synthetic chemical with many applications (e.g., in electrical devices and coatings)
Solvent	Liquid that can dissolve other substances
Toxic chemical	Poisonous chemical (e.g., synthetic organic chemicals such as PCBs and DDT)

Source: The definitions of biological accumulation and biological amplification are adapted and reprinted from *Volunteer Estuary Monitoring: A Methods Manual* (EPA-842-B-06-003, 2nd ed., pp. 12–13), by United States Environmental Protection Agency, 2006 (**https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual (https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual)**).

As noted in Table 4.4, one hazard associated with toxic chemicals is **biological amplification**, in which the chemical concentration increases at successive levels of the food chain. A small amount of a chemical in the water has a much greater effect on a fish-eating bird than a large fish, for example, because of the amount of the chemical the bird ingests and stores when it eats the large fish (Figure 4.7).

Figure 4.7: Biological amplification

One hazard associated with toxic chemicals is biological amplification, in which the chemical concentration increases at successive levels of the food chain. A small amount of the chemical in the water has a much greater effect on a fish-eating bird than on a larger fish, for example, because of the amount of the chemical the bird ingests and stores when it eats the large fish.

Source: Adapted from *Volunteer Estuary Monitoring: A Methods Manual* (EPA-842-B-06-003, 2nd ed., pp. 12–13), by United States Environmental Protection Agency, 2006 (**https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual** (https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual)). © 2002 the Ocean Conservancy.

DDT

Everett Collection/SuperStock

DDT is a synthetic pesticide. It was originally developed in the 1940s to control insects that carried diseases, damaged crops, invaded homes, and destroyed buildings.

A *pesticide* is any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Pests are living organisms that occur where they are not wanted or that cause damage to crops, humans, or other animals. Examples include insects, mites, unwanted plants (weeds), fungi, and microorganisms such as bacteria and viruses (U.S. Environmental Protection Agency, 2017c). **DDT (dichloro-diphenyl-trichloroethane)** was one of the first modern synthetic pesticides. It was developed in the 1940s as an effective way to control insects that carried human and animal diseases (malaria and typhus). It was also a way to keep insects from damaging crops, invading homes, and destroying buildings.

Among the numerous products available for household and industrial uses are insect baits, rat poisons, pesticides applied to pets (e.g., flea and tick sprays), and aerosol pesticides used inside and outside the home. There is actually no "safe" pesticide, although there are pesticides that are safer than others depending on the individual's exposure to the chemical and the toxicity of the chemical itself (i.e., how poisonous it is). Currently, DDT is probably considered one of the worst pesticides in terms of risk to human health. But that was not always the case.

DDT was promoted after World War II as a "wonder chemical" because it killed harmful bugs that damaged crops and carried infectious diseases (Pesticide Action Network, n.d.). While DDT was intended to kill infectious disease-carrying insects as well as assist with agricultural practices, it ended up causing far more harm to human health than good. Human health harms included the following:

- Breast and other cancers
- Male infertility
- Miscarriages and low birth weight
- Developmental delay
- Nervous system and liver damage

The advocacy work of environmentalist Rachel Carson finally pushed the United States to ban the substance in the 1970s. Rachel Carson's groundbreaking book *Silent Spring* helped to focus the public's attention on the harmful effects of pesticides and encouraged improved controls over pesticide use (Carson, 1962). See *Spotlight on Public Health Figures* for more about Carson's work.

DDT also became linked to adverse environmental effects, including harm to wildlife and long-term environmental persistence—especially its tendency to build up in fatty tissues of the body. Despite the ban on DDT, humans are still carrying a lasting burden from the short period of time it was in use. According to the Pesticide Action Network, DDT is still in the food supply, as well as the human body (Table 4.5). Levels of DDT continue to be monitored regularly through the CDC (see CDC, 2017s).

Table 4.5: DDT byproducts found in 2017

Product	Percentage testing positive for DDT
Heavy cream	60
Kale	42
Carrots	28
Blood	99

Sources: Centers for Disease Control and Prevention. (2017). National report on human exposure to environmental chemicals. Retrieved from **https://www.cdc.gov/exposurereport** (https://www.cdc.gov/exposurereport)

Pesticide Action Network. (n.d.). The DDT story. Retrieved from **http://www.panna.org/resources/ddt-story** (http://www.panna.org/resources/ddt-story)

Although no longer in use in this country, DDT can now be sprayed indoors in some countries or regions (for example, sub-Saharan Africa) that have malaria outbreaks or where endemic transmission of malaria is taking place. In 2006, the World Health Organization stated that indoor spraying of DDT could quickly reduce malaria infections and that DDT, if used properly, did not present a health risk (WHO, 2017l). In 2011, it re-evaluated the use of DDT and continued to support its use in protecting against malaria (WHO,

2011).

Spotlight on Public Health Figures: Rachel Carson (1907–1964)

Everett Collection/SuperStock

Rachel Carson discouraged the use of synthetic pesticides such as DDT, warning that these products could have harmful effects on humans and the environment.

Click each of the questions provided to learn more about Rachel Carson.

Who is Rachel Carson?

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Rachel Carson was born after the turn of the 20th century in the rural community of Springdale, Pennsylvania. Her mother was a nature lover and passed on that love to her daughter. As a result, Carson studied marine biology at the Pennsylvania College for Women (now known as Chatham University in Pittsburgh) and earned a master's in zoology from Johns Hopkins University. She was a conservationist and wrote numerous articles on nature and natural resources throughout her life. Her first book, *Under the Sea-Wind*, was a study of the ocean published in 1941. She later wrote more books that focused on ocean life. Her most famous book was *Silent Spring*, which warned the public about the use of toxic pesticides in farming practices after World War II.

What was the political climate at the time?

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Carson's childhood was fairly calm despite the political climate of the time. She grew up in a stable home where her mother had a significant influence on her life and career. After she went to college, the Great Depression hit the nation, and she maintained an income by writing radio scripts for the U.S. Bureau of Fisheries as well as articles on natural history for the *Baltimore Sun*. At the end of the Great Depression, the United States entered World War II. It wasn't until after World War II that Carson made a name for herself on the national stage.

What was her contribution to public health?

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Carson provided the impetus for the nation to ban the use of DDT as an agricultural practice. She found that synthetic pesticides that had become commonplace after World War II were causing long-term health effects for not only human beings, but also the overall environment. She fought numerous battles with the chemical industry and was considered a nuisance among government entities because she spoke out against the use of chemicals. In 1963, she testified before Congress and called for new policies to protect the environment and human and animal life.

What motivated her?

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Her mother guided her career toward nature and the natural sciences. From there, Carson was adamant about protecting the environment as well as human, animal, and plant life. She dedicated her career to voicing her strong concerns about the use of toxic chemicals. She died before she saw the use of DDT banned, which occurred in 1972, 8 years after Carson's death.

Source: Lear, L. (2015). Rachel Carson: The life and legacy of Rachel Carson. **www.rachelcarson.org (http://www.rachelcarson.org)**

Lead

Lead is an element that is found naturally in Earth's crust. It can affect multiple body systems but is particularly harmful to young children, and, according to the WHO (2017i), there is no known "safe" level of exposure for humans. Before its phaseout was completed in 1996, lead from gasoline was disseminated widely into the environment by the combustion of motor fuels. Other lead exposure sources are lead-based paints, colorful painted ceramics and pottery, plumbing fixtures, lead-acid batteries, solder, and candy wrappers used in some countries. In addition, lead can be released into the air from metal smelters and can be present in air, water, and soil near metal refineries.

Today, human exposure from lead-based paints can occur in homes that were constructed before the 1978 ban on use of lead in household paints was adopted. Young children in older homes may risk exposure to lead when they eat paint chips peeling from walls. According to the CDC (2016e), levels of lead exposure in children have declined since the national ban; however, older homes and especially those in low-income communities still contain lead paint. Figure 4.8 shows the significant drop since 1997 and a slower reduction since the 21st century began.

Figure 4.8: Blood lead surveillance totals in the United States, 1997–2015

Human exposure from lead-based paints was a major issue until the 1978 ban on the use of lead in paints. Since then, there has been a significant decline in exposure as tracked from 1997 through 2015.

BLL is an acronym for blood lead levels.

Source: Adapted from "Lead. CDC's National Surveillance Data (1997–2017)," by Centers for Disease Control and Prevention, 2016 (**https://www.cdc.gov/nceh/lead/data/national.htm** (https://www.cdc.gov/nceh/lead/data/national.htm)).

Not only can lead in paint pose risks for home occupants and their children, but lead-contaminated chipping and peeling paint in older homes can also endanger house cleaners and remodelers. The use of personal protective equipment reduces dust inhalation; a damp sponge during cleaning reduces dust creation.

The health effects of lead exposure can be severe for children, pregnant women, and adults. Among children, lead ingestion can cause permanent brain damage, learning and behavior problems, growth retardation, and anemia. As a result of lead exposure, pregnant women can experience miscarriages and fetal growth retardation. Adults who are exposed to lead may experience adverse effects to the nervous system and cardiovascular system. For example, one of the adverse cardiovascular effects of lead exposure is increased blood pressure.

Mercury

Mercury is a toxic heavy metal that is found in nature. The organic form of mercury is methylmercury, which is created by the action of microorganisms that convert airborne mercury compounds deposited in water and on land into methylmercury (Bernhoft, 2012). Fish that consume these contaminated microorganisms develop elevated mercury levels. Birds and mammals that eat the fish further concentrate levels of methylmercury. In turn, top predators that eat these animals can develop high mercury levels. Most human exposure to methylmercury is through consumption of fish and shellfish. The levels of methylmercury are higher in some species of fish than in others, such as tuna, shark, and swordfish (Bernhoft, 2012); adults should minimize consumption of these species, and pregnant women and children should avoid them.

While small doses of mercury are not harmful to human health, larger exposures can be fatal. Most human exposure occurs from fish consumption as well as dental amalgam (cavity fillings) (Bernhoft, 2012). Severe poisoning has occurred, including a profound outbreak that began in the early 1900s (see *Case Study: Minamata Disease*).

At one time, medicines that contained mercury were used for treatment of syphilis and other diseases. Coal, oil, and wood burning are currently the largest human-caused sources of mercury emissions in the United States (U.S. EPA, 2017b).

Health effects associated with exposure to elemental mercury include tremors, emotional changes, insomnia, and neurologic effects. Exposure can occur when vapors from elemental mercury are inhaled during occupational exposures that involve the use of mercury. The human health effects of methylmercury can be severe. Among pregnant women, consumption of high levels of methylmercury endangers the developing nervous systems of their fetuses. Infants and children exposed to methylmercury can experience neurological impairment (U.S. EPA, 2017e). Although methylmercury exposure among persons of all ages (including adults) can be deleterious, the developing nervous system of the fetus is at greater risk of harmful effects than is the nervous system of an adult.

Case Study: Minamata Disease

Minamata disease is a neurological disease caused by daily intake of fish and shellfish that has been highly contaminated with methylmercury. The disease was discovered when it broke out in the Yatsushiro Sea coastal area, particularly around Minamata Bay. It was reported in May 1956, and by the end of that year, 52 people were diagnosed with the disease and 17 had already died from it.

During the investigation, it was determined that the Chisso Corporation, a chemical factory located along the bay, had been releasing methylmercury-infested industrial wastewater into the bay waters. This toxin was then consumed by the fish and later by humans. Although deaths continued over the next three decades, neither the government nor the company did anything to prevent the pollution. According to data collected from the Boston University Sustainability Program (n.d.), as of 2001, 2,265 victims had been identified as having Minamata disease, and 1,784 of those had died. By 2004, the company was ordered to pay for cleanup efforts and compensate more than 10,000 victims. Lawsuits and compensation claims are ongoing.

Today, certain fish born in hatcheries can often be contaminated with too much mercury. It is important that public health officials continue to protect the population through all means necessary—even if it means monitoring agricultural practices as well as behavioral choices.

Sources: Boston University Sustainability Program. (n.d.). Minamata disease. Retrieved from **http://www.bu.edu/sustainability/minamata-disease/** (http://www.bu.edu/sustainability/minamata-disease/)

Ministry of the Environment. (2014). Outline of Minamata disease: Cause and damage of Minamata disease. Retrieved from **http://www.nimd.go.jp/archives/english/tenji/a_corner/a01.html** (http://www.nimd.go.jp/archives/english/tenji/a_corner/a01.html)

Air Pollution

Air pollution—a stew of chemicals, gases, and particles in the air we breathe—can be a potentially deadly threat to the health of the residents of cities and other geographic areas where the pollution drifts. In the developed world, progress has been made in controlling sources of air pollution through legislation and regulation. However, many of the rapidly growing and industrializing cities of the developing world urgently need to come to grips with the causes of highly polluted air. China is an example of a rapidly industrializing country that has experienced continuing air pollution disasters.

Polluted air has been researched extensively as a risk factor for heart disease and related cardiovascular conditions, cancer, stroke, respiratory diseases, and mortality. Air pollution is associated with increased risk of heart attacks. Fine particles (invisible particles in air pollution) can bypass the body's filtering mechanisms and penetrate deeply. Some types of fine particles can circulate in the bloodstream and even gain access to the human brain.

Historical Air Pollution Episodes

Kydpl Kyodo/Associated Press

The government in China made efforts to reduce the high air pollution levels prior to the 2008 Summer Olympics in Beijing. Though reduced, the levels were still relatively high when guests and athletes from around the world attended the games.

Since the early 1930s, cities across the world have suffered from notorious and deadly episodes of extreme air pollution. At one time, many American cities were faced with disastrous levels of air contamination. These incidents increased the public's awareness of the harmful effects of air pollution and stimulated efforts to reduce air pollution levels.

- *Meuse Valley, Belgium (December 1930)*: The Meuse Valley air pollution episode occurred in a highly industrialized region near Liege, Belgium. Levels of sulfuric acid mists, sulfur dioxide, and fluoride rose to toxic levels during the first week of December 1930. The high pollution levels were believed to be related to the deaths of more than 60 persons.
- *Donora, Pennsylvania (October 1948)*: In this small town, emissions from various sources that used fossil fuels, such as steel mills and home heating stoves, caused very severe air pollution. The event caused illnesses among half of the town's 14,000 residents, and 20 deaths were associated with it.
- *London, England (December 1952)*: A thick "pea-souper" fog enveloped London from December 5 to December 9, 1952. Following this lethal occurrence of air pollution, authorities reported an excess of 3,000 deaths above normal.
- *Beijing, China (August 2008)*: In the years before the Summer Olympics in Beijing, China, commenced, people around the world expressed concerns about the dangers of breathing in the polluted air. Reports found that China's Olympics atmosphere contained twice the levels of soot as Athens, three times the levels of Atlanta, and 3.5 times that of Sydney. The Chinese government worked diligently to reduce the pollution by closing factories, restricting car use, and reducing construction. It is too early to know if the millions who attended or participated in the Olympics will experience any long-term effects.

Components of Outdoor Air Pollution

The components of outdoor air pollution include particles and toxic or dangerous gases such as carbon monoxide, sulfur dioxide, and ozone, one of the molecular forms of oxygen. These components can be either visible or invisible, as in the case of gases and very fine particles. Some air pollutants interact with one another, especially during high temperatures, and produce visible clouds of pollutants known as smog. **Criteria air pollutants** are six common air pollutants regulated by the EPA: ozone, nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, and lead. The six criteria air pollutants, their sources, and health effects are shown in Table 4.6.

Table 4.6: Criteria air pollutants

Name of pollutant	Source	Potential health effects
Ozone	Combustion of fossil fuels, in combination with chemicals such as solvents	Respiratory difficulties, eye irritation
Nitrogen oxides	Combustion of fossil fuels such as gasoline	Harm to respiratory system
Carbon monoxide	Incomplete burning of fuels	Aggravation of circulatory and respiratory diseases; causes death in high concentrations
Particulate matter	Diesel exhaust, smoke from combustion	Fine particles (smaller than 2.5 micrometers) can be inhaled deeply into the lungs, causing damage to the lungs and other parts of the body
Sulfur dioxide	Combustion of fossil fuels contaminated with sulfur; can form sulfuric acid	Lung irritation, exacerbation of asthma
Lead	Refining of metal ores that contain lead	Neurological deficits

Source: From "Criteria Air Pollutants," by Environmental Protection Agency, n.d. (**https://www.epa.gov/criteria-air-pollutants (https://www.epa.gov/criteria-air-pollutants)**).

The Built Environment and Lifestyle

The **built environment** is a term used to describe man-made surroundings that provide the setting for human activity. It includes buildings, parks, roads, electric poles, and anything that is not part of the natural environment. Many people blame the Industrial Revolution (1760–1840), which ushered in the age of machines and technology, for the poorer health outcomes today. While the built environment does not have to stymie physical activity and good nutrition, it, along with associated lifestyles, has increased the incidence and prevalence of chronic diseases.

Community Walkability

Trekandshoot/iStock/Thinkstock

In many cities, the availability of and reliance on cars has affected communities, environments, and personal behaviors.

A staggering 263.6 million cars were registered in the United States in 2015, and the number of cars sold in 2016 was 7.1 million (Statista, 2017). Because of the influx of motorized transportation, people have moved further away from their places of work. In fact, they drive everywhere. Because of that, it can actually be unsafe to travel without the use of a car. According to a study of the built environment in 2003, people have adapted to traveling by car "to virtually all of their destinations, because they have no practical transportation alternates" (Jackson, 2003, para. 1). As motorized transportation became more popular, communities began to focus on routes of motorized transportation at the expense of other transportation modes. As a result, there are now fewer sidewalks, open spaces, or bicycle paths. People just drive to and from their homes for everything. As people have adapted remarkably well to the shape of modernization, they have begun to lose some of the healthier habits that historically were taken for granted. People move less and sit more. There are fewer spaces to stretch out, run, and play. People have become, thanks in part to the built environment that was once labeled "progress," more sedentary—which leads to obesity and many related disorders.

Beyond the lack of exercise, the built environment has created pollution from motor vehicle traffic. The air is now littered with particulates from the exhaust of cars, trucks, and public transportation. Particulates are solid and liquid particles that are suspended in the air, many of which are hazardous, such as those mixed in with car and truck emissions and industry smoke. The built environment also removes plant life to make room for paved surfaces such as roads and sidewalks, creating less room for natural plant life to thrive. Plant life is strongly connected to the ecosystem, which helps maintain human health through biodiversity (WHO, 2017a). Changes in the ecosystem, such as the building of a city, influence how plants and animals function together for the benefit of good health (WHO, 2017a).

Beyond the obvious health effects, the built environment—particularly the urban corridor—includes tall buildings that block the sun. Bright sunshine provides vitamin D to boost the body's immune system (Mead, 2008). At least 1,000 different genes in virtually every tissue in the body are regulated through vitamin D (Mead, 2008). Lack of sun is also strongly linked to depression and other mental health conditions. Tall buildings that line miles of city streets can also lead to significant noise pollution. Noise pollution refers to unwanted sounds that can interfere with normal activities such as sleeping and has been known to diminish one's quality of life (U.S. EPA, 2017s).

Healthy Foods Access

Both urban and rural communities struggle to obtain healthy foods. It seems odd that rural areas would suffer because they are often the agricultural communities of the nation. However, access to healthy and affordable foods is challenging mainly because of economic, not geographical, factors. *Food deserts*, areas where there is limited availability of fresh and affordable foods, are common for those who reside hundreds of miles from any major metropolitan area (Rural Health Information Hub, 2015). Because of the low numbers of residents, major grocers do not find it financially feasible to operate a store in those areas. As a result, rural residents rely on the less nutritious options offered at convenience stores. The only other option is to spend several hours driving to a city with a grocery store. In some cases, people in rural areas do not have reliable transportation to make such a journey.

Urban areas struggle to obtain healthy foods for similar economic reasons, such as a simple lack of money. Food deserts exist in various urban neighborhoods mostly composed of low-income families who cannot afford fresh fruits, vegetables, and meats. Like their rural counterparts, they rely on the local convenience store to feed their families. These stores mainly carry high-fat, high-sugar prepackaged foods, which contribute to poor diets and ultimately obesity and associated diseases (Weisbecker, 2010). According to the USDA, 23.5 million people live in low-income areas identified as food deserts. See *Spotlight on Public Health Figures* to learn about the work of Sara Josephine Baker, who strived to promote health and wellness among the poor during her lifetime.

Spotlight on Public Health Figures: Sara Josephine Baker (1873–1945)

Bettmann/Getty Images

Sara Josephine Baker was director of the New York Bureau of Child Hygiene and the first woman to earn a public health doctorate from New York University.

Click each of the questions provided to learn more about Sara Josephine Baker.

Who is Sara Josephine Baker?

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Baker was born in 1873 in Poughkeepsie, New York, to a prominent lawyer. She had a happy childhood with a solid and positive relationship with her parents. Early in her life, Baker became the financial caretaker of her mother and herself after the deaths of her father and brother. Later, she enrolled in medical school, one of the first women to do so. She had a passion for making connections between poverty and health, which led her to advocating for child and maternal well-being. She spent her life with her partner, Ida Wylie, a novelist, until her death in 1945.

What was the political climate at the time?

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During Baker's lifetime, the United States had established itself as a world power, and the continent became settled from coast to coast. Oil wells dotted the countryside, and the United States supplied much of the world's petroleum. Industrial growth was booming, with telephones now widely used, and electricity covered nearly every corner of the nation. But despite the industrial and economic growth, the United States was still socially stagnant. Gays and lesbians were still "in the closet," and women were considered a lesser class than men. For Baker, the fact that she was a lesbian was not her main concern. Rather, she rebelled at the constraints of being a female in a male-dominated world. Men dominated the public health realm, and Baker faced gender discrimination in a world that still denied women the right to vote. Furthermore, the public health world was still focused on the prevention of infectious diseases, while Baker was more interested in the social climate and how it affected health outcomes, particularly among the poor.

What was her contribution to public health?

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Baker was the first to focus on preventive health concerns in a social environment—typically low-income and poverty environments. She was the first director of the New York Bureau of Child Hygiene, a new department within the city formed in 1908. A year later, she founded the American Child Hygiene Association and was the first woman to earn a public health doctorate degree from New York University. Because of her work on disease prevention and education—especially with those in poverty and children—she was able to focus her work on programs for those living in poor neighborhoods. She developed baby health stations that distributed milk and provided training for midwives in those neighborhoods. By the time Baker retired in 1923, the city had the lowest infant mortality rate compared with other major cities in the nation.

What motivated her?

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Her supportive family guided her work from the moment she had to delay college to support herself and her family. She learned early that she wanted to help others, particularly

in the field of public health. She was raised with the expectation that she would attend college, which she eventually did. During her tenure at school, she met some influential women who moved her to continue toward her goal of population well-being. She knew she had several hurdles to overcome, given that public health was a male-dominated field. Her experiences, role models, and family gave her the motivation to become a leader and instrumental force for child and maternal health.

Sources: Library of Congress. (n.d.). America at the turn of the century: A look at the historical context. Retrieved from **https://www.loc.gov/collections/early-films-of-new-york-1898-to-1906/articles-and-essays/america-at-the-turn-of-the-century-a-look-at-the-historical-context/ (https://www.loc.gov/collections/early-films-of-new-york-1898-to-1906/articles-and-essays/america-at-the-turn-of-the-century-a-look-at-the-historical-context/)**

Parry, M. S. (2006). Sara Josephine Baker (1873–1945). *American Journal of Public Health, 96*(4), 620–621.

Lifestyle Factors

Tobacco and Public Health: A Case Study

Dr. Novotny describes a recent research project focused on global cigarette smoking. He explains some of the epidemiological issues involved in the project, and some of the findings.

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Critical Thinking Questions

Dr. Novotny brings up several important public health issues describing his case study. What environmental conditions does he discuss? What assessment tools did his study use? What are some of the conclusions that can be drawn from the research?

Lifestyle refers to the characteristics and behaviors people display and engage in during their daily career, leisure, and diet activities (Farhud, 2015). Poor lifestyle factors include malnutrition, unhealthy diet, smoking, alcohol and drug use, excessive stress, and sedentary behaviors. Here are some examples of behaviors that have an impact on physical and mental health outcomes:

- *Diet and nutrition*: Consuming high fats and sugars daily contributes to obesity, which in turn is associated with diabetes and cardiovascular disease.
- *Sedentary behavior*: The more people sit, watch television, play games on electronic devices, and so on, the more likely they are to become obese. Regular exercise helps maintain the body's ideal weight.
- *Sleep*: As individuals add more and more activities to their daily lives, they typically cut something out to make room. In many cases, the activity that is removed is sleep time. Lack of sleep has a clear influence on physical and mental health. Adults require between 7 and 9 hours of sleep a night. Teens require between 8 and 10 hours, children 10 to 14, and newborns 14 to 17 to function at an optimal level (National Sleep Foundation, 2017).
- *Substance abuse*: Addictions of various types—tobacco, alcohol, illicit drugs, and prescription medications—decrease the quality of life and cause various cancers, injuries, and other diseases.
- *Study*: This area focuses on utilizing the brain regularly with mind games (crossword puzzles), reading, or perhaps going to formal classes. Study is a factor that leads to improved physical and mental health and can slow the process of dementia.

4.3 Prevention

Preventing chronic diseases is a main focus of public health today. Although some infectious diseases are still a concern, the largest burden comes from chronic diseases. The economic impact is also great. In 2003, the economic costs of chronic diseases, in terms of treatment expenses and lost productivity, totaled $1.3 billion (Milken Institute, 2007). The projected costs in 2023 will be $4.1 billion (Milken Institute, 2007). Due to those costs and the significant number of deaths, public health professionals are fully focused on preventing chronic diseases.

Preventing Heart Disease

Heart disease is the leading cause of death for both men and women, with about 630,000 Americans dying from the disease annually (CDC, 2017i). Efforts to prevent this disease are both large scale and small scale, taking place both nationally and locally. Probably the most visible campaign to prevent heart disease in women stems from the American Heart Association (AHA). The AHA's Go Red for Women campaign began in 2004 after research showed that cardiovascular disease is a "silent killer" of women (American Heart Association, 2017b). It was discovered that nearly 500,000 women annually were dying of the disease simply because they did not realize they had it (American Heart Association, 2017b). Women tended to dismiss any symptoms as stress or the result of other life events and claimed heart disease was an old man's disease. Women who "Go Red" follow an exercise routine, eat a healthier diet, visit their doctor regularly, and influence others by talking about heart health.

Getty Images/Stringer

The Go Red for Women campaign promotes heart disease awareness and prevention efforts among women.

The campaign's goal is simple: build awareness of heart disease in women with the desire to save lives. This ongoing campaign set a lofty 2010 strategic goal to reduce death and disability from the disease by 20% and improve the health of all Americans by 20% by the year 2020 (American Heart Association, 2017b). More than 2 million women have vowed to "Go Red" since the campaign's inception. More than 200,000 health care providers have received critical patient information on their female patients' heart disease status. Furthermore, the American Heart Association (2017b) has reported the following findings since the beginning of the campaign:

- 91% of women in the campaign have visited their doctor within the past year
- 64% follow a regular exercise regimen
- 84% have talked to their friends about heart health
- 90% have had their blood pressure checked within the past year
- 75% have had their cholesterol checked within the past year

There are numerous other national and local campaigns that focus on heart disease, including the Million Hearts and WISEWOMAN campaigns. The Million Hearts campaign was launched in 2012. It has 120 official partners across the states, along with 20 federal agencies (Million Hearts, n.d.). Its priorities include optimizing care by health care providers; keeping people healthy through efforts that promote low-sodium diets, increasing physical activity, and decreasing tobacco use; and improving outcomes for populations that have a significant disparity in cardiovascular disease rates (Million Hearts, n.d.).

WISEWOMAN stands for Well-Integrated Screening and Evaluation for WOMen Across the Nation and is an effort similar to the Go Red campaign. It focuses on women's health and preventing heart disease and stroke by providing services early and regularly. This is an effort coordinated under the CDC's Division for Heart Disease and Stroke Prevention (CDC, 2017aa).

Preventing Oral Disease

Most of the oral health prevention efforts are taking place at the state level with assistance from the CDC. Three efforts currently underway include expanding sealant delivery, increasing the prevalence of water system fluoridation, and improving the delivery of targeted clinical services.

Dental sealant is a plastic coating that is placed on the chewing surfaces of permanent back teeth such as molars and premolars to protect against tooth decay. Sealant programs are highly effective in preventing tooth decay in schoolchildren and have been shown to decrease dental caries (CDC, 2015i). To implement the program, dentists visit schools to apply the sealant to students' teeth. It has been shown to be very effective in the states that have implemented this intervention.

Water fluoridation is an ongoing effort within the United States. While larger cities and many smaller communities have already taken this action, there are still many areas that do not have fluoride in their water. It is one of the objectives of Healthy People 2020 to have 76.9% of the population using community water systems containing added fluoride for improved dental health (CDC, 2015h).

The final area of action is to improve clinical services. This effort includes collaborating with Medicaid providers to increase access to and use pediatric oral health services for children. Efforts are also underway to integrate clinical services at the school and community levels, especially among people with significant health disparities in oral health, such as those who live in rural areas, members of certain ethnic groups, older adults, and low-income residents (CDC, 2015k).

Reducing Air and Noise Pollution

The issues of air quality standards and control of air pollution are extensive and have evolved over many decades. Internationally and domestically, public health workers, government officials, and members of the community have been involved with the development of policies and other initiatives to improve air quality. For the United States, two methods for protection of the public against the hazards of air pollution are the Clean Air Act and the Air Quality Index. In the past few years, a policy known as "cap and trade" has also been introduced to control emissions of air pollution.

The Clean Air Act

The evolution of several laws has made air pollution control in the United States possible. The first was the Air Pollution Control Act of 1955. Subsequently, the Clean Air Act of 1963 and the Air Quality Act of 1967 were introduced. One of the most important legislative acts for control of air pollution was the **Clean Air Act of 1970**, which empowered the federal government to take steps to control air pollution through various regulatory policies and agencies. The United States Environmental Protection Agency was established around the same time to implement the new requirements.

The Clean Air Act of 1970 was revised in 1990. Congress reauthorized the Clean Air Act as part of the Clean Air Act Amendments (CAAA) of 1990. An important feature of the CAAA was the U.S. SO_2 (sulfur dioxide) Allowance Trading Program. This program is an example of **cap and trade**, a policy tool for reducing the levels of greenhouse gases such as sulfur dioxide. A limit, or cap, on total emissions is set for a group of sources, which are given "allowances" that they must surrender to cover their emissions. A financial incentive is offered for reducing emissions, and sources with low emissions are allowed to sell their allowances to others (U.S. Environmental Protection Agency, 2003).

Beginning in 1995, as part of its Acid Rain Program, the EPA limited (capped) emissions of SO_2 from the highest-polluting electric power plants in the Midwest, Appalachia, and Northeast states (U.S. Environmental Protection Agency, 2007). The EPA distributed SO_2 emissions allowances to each power plant; each allowance was valued at one ton of SO_2. Each facility was required to release no more emissions than permitted by the EPA's allowances and would be fined for exceeding emission limits. However, power plants that released more emissions than allowed could trade (purchase) allowances with more efficient plants (that is, plants that had achieved reductions in emissions and had more allowances than needed). In order to document compliance with the program, power plants were required to monitor emissions on a continuous basis. According to environmental assessments, the SO_2 Allowance Trading Program was effective in reducing total SO_2 emissions by 85% between 1990 and 2016 (U.S. EPA, 2017f).

Air Quality Index

The United States Environmental Protection Agency developed the **Air Quality Index (AQI)** for reporting the quality of air in specific geographic areas of the United States (U.S. EPA, 2009). It indicates whether air quality is good, moderate, or unhealthy. The AQI (which can range from 0 to 500) takes into account four major air pollutants regulated by the Clean Air Act: ozone, particles, carbon monoxide, and sulfur dioxide. Low index values suggest that air quality is good; as index values increase, air quality decreases (i.e., it becomes less and less healthy). For example, the maximum index range (301 to 500) denotes hazardous air quality (Figure 4.9).

Figure 4.9: The Air Quality Index

The AQI provides an easily accessible measure and analysis of air quality for the consumer.

Source: Adapted from *Air Quality Index* (EPA-456/F-09-002, p. 2), by United States Environmental Protection Agency, 2009, Research Triangle Park, NC: Office of Air Quality Planning and Standards, Outreach and Information Division.

Noise Pollution

Noise pollution is included in Title IV of the Clean Air Act. In a 1990 amendment to this act, it was recognized that noise pollution adversely affects human health and has become a regulated element under the Clean Air Act (U.S. EPA, 2017d). **Noise pollution** is an unwanted or disturbing sound that interferes with normal activities, including sleeping and other aspects, which may reduce the quality of life. Noise actually affects human health through added stress, high blood pressure, speech interference, hearing loss, sleep disruption, and lost productivity (U.S. EPA, 2017d). Under the Clean Air Act, the EPA developed the Office of Noise Abatement and Control to investigate noise and its public health effects. Regulations are now in place for the decibel levels of railroads, motor vehicles, and construction equipment. This office is also responsible for the labeling of hearing protection devices such as earplugs, earmuffs, and canal caps.

Creating Clean Water Systems

In the United States, clean water is often taken for granted simply because it is more available than it is in many other countries. On July 28, 2010, the United Nations General Assembly passed a resolution to provide financial and human resources to help countries build and maintain clean water systems (United Nations, 2014). In doing so, it is acknowledging the right to safe, clean, accessible, and affordable drinking water and sanitation for every human being.

While situations like the Flint, Michigan, water crisis (see *Case Study: Water Crisis in Flint, Michigan* in Chapter 2) do occur, the United States takes clean water very seriously. The **Clean Water Act of 1972** was passed to establish the basic structure for regulating discharges into the waters of the United States (U.S. EPA, 2017g). This law was a considerably revised version of the 1948 Federal Water Pollution Control Act. This CWA is very detailed and covers all areas of wastewater management, including oil spills, toxic waste disposal, and pollutant discharges that may affect the nation's water supply. Furthermore, the CWA added extensive monitoring of all water supplies, especially those used for drinking. All public drinking water must meet health-based federal standards for contaminants. Water systems do contain hundreds of various chemicals, most of which are not harmful to human health. Some chemicals are in the system naturally and others incidentally enter from industrial or household waste. An example of household waste would include a significant number of people flushing expired medications down the toilet and into the wastewater system. While these chemicals are largely extracted through the wastewater treatment systems now in place, some levels of exposure still occur. If those levels exceed acceptable points as outlined by the EPA, they could cause either acute or chronic issues in human health. Table 4.7 is a small sample of common chemicals that incidentally wind up in the water supply.

Table 4.7: Common chemicals found in the water supply

Chemical/element name	Description	Excessive exposure health risk
Acetaminophen	Over-the-counter medication	Acute illness
Acrylamide	Natural chemical found in raw foods	Cancer
Carbon tetrachloride	Cleaning agent	Cancer
Ethyl ether	Solvent	Chronic illness
Isopropylbenzene	Crude oil	Chronic illness

n-Nitrosodiphenylamine	Rubber products	Cancer
Pentachlorophenol	Disinfectant	Cancer
Phenol	Disinfectant	Chronic illness
Polychlorinated biphenyls	Coolants	Cancer
Xylenes	Solvent	Short-term illness

Source: From "Comparison of State Water Guidance and Federal Drinking Water Standards," by Minnesota Department of Health, 2017 (**http://www.health.state.mn.us/divs/eh/risk/guidance/waterguidance.html** (http://www.health.state.mn.us/divs/eh/risk/guidance/waterguidance.html)).

Building Walkable Communities

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Residents in walkable neighborhoods should be able to easily and safely walk or bike to and from schools, workplaces, and public centers.

The Industrial Revolution, including the advent of the motor vehicle, has had a significant impact on physical activity. Prior to the Industrial Revolution, routines involved regular physical activity, although it was not thought of as exercise. As a result of industrialization, communities were built to focus on motor vehicle transportation with little concern for pedestrian movement. Unfortunately, society has become more sedentary. People tend to sit all day—driving, at work, and at home. Adding an element of walking to communities can bring routine physical activity back into daily living. To improve walkability, communities typically develop partnerships with various entities within their town, such as local legislators, business partners, schools, and other leaders, to develop a means by which to create a walkable city (see *Case Study: Walkable Cities in Florida* for examples).

There is a specific protocol to become a formal "walkable neighborhood," a designation developed by the company Walk Score, which provides walkability services through its website and mobile applications (Walk Score, 2017a). Walk Score creates a specific numerical score for any address in the United States, Canada, and Australia. This score, or index, is a measure of how easy or hard it would be to walk to places throughout the community rather than use a motor vehicle (Walk Score, 2017a). A higher score (on a scale of 0–100) equals a more walkable community. Criteria for walkable neighborhoods as outlined by Walk Score (2017b) are the following:

- *A center*: Walkable neighborhoods have a center, whether it's a main street or a public space.
- *People*: There are enough people for businesses to flourish and for public transit to run frequently.
- *Mixed income, mixed use*: Affordable housing is located near businesses.
- *Parks and public space*: There are plenty of public places to gather and play.
- *Pedestrian design*: Buildings are close to the street, and parking lots are relegated to the back.
- *Schools and workplaces*: These are close enough that most residents can walk from their homes.
- *Complete streets*: Streets are designed for bicyclists, pedestrians, and transit.

Case Study: Walkable Cities in Florida

The state of Florida was one of the early adopters of walkability. It developed Walkable Communities in 1996 (Walkable Communities, Inc., 2008), which is a collaboration of elected officials, developers, neighborhood associations, planning and zoning agencies, bicycle- and pedestrian-focused organizations, and the general public. Walkable Communities seeks to help communities become less reliant upon motor vehicle transportation and more supportive of physical movement and activity. As a result, numerous Florida cities are now ranked high on the Walk Score index.

The following Florida communities have greatly improved their walkability and have become far more attractive to those who desire less motor vehicle traffic and more pedestrian/bicycle access:

1. Flamingo Park, Miami Beach, has a 94.6 Walk Score mainly because of its proximity to the beach, clubs, nightlife, shopping, work, and entertainment (Bean, 2016).
2. Lake Eola, Orlando, has a 92.6 Walk Score. It boasts a low-key neighborhood that has all the amenities within a few city blocks (Bean, 2016).
3. Fort Lauderdale (downtown) is a more modern city that claims a car-free lifestyle because everything is within close proximity. It has a Walk Score of 90 (Bean, 2016).
4. Rosemary District, Sarasota, is one of the oldest communities in Sarasota and has added more sidewalks and pathways for pedestrian transportation. It boasts a shopping mall that is easily accessible without a car. Its Walk Score is 86.9 (Bean, 2016).

Summary & Resources

Chapter Summary

Chronic diseases are a significant burden in the United States today, with about half of all adults currently living with at least one chronic disease. The economic impact of this human burden was more than $1.3 billion in 2003. That money includes the costs of treatment as well as lost productivity. It is projected that this number will rise to $4.1 billion by 2023. The list of chronic diseases is long, but it includes major diseases such as cardiovascular diseases, cancer, diabetes, asthma, and obesity.

How people live has a significant effect on human health. Environmental forces such as air quality, water quality, and lifestyle greatly affect one's ability to live a healthy life. Diseases such as cancer, asthma, and heart disease are largely associated with these elements. While these environmental factors have significantly improved, the United States has identified more work that must be completed in order to further reduce the burden of chronic diseases. The largest issue may be lifestyle choices: nutrition, physical activity, and the built environment. As a whole, people in the United States are more sedentary and lack the proper nutrition to fuel the body appropriately and maintain good health.

To address these issues, public health professionals have implemented an abundance of interventions. These include addressing the diseases directly, such as with cardiovascular disease and oral health diseases, but they also focus on reducing environmental risks associated with a number of chronic diseases. Laws to monitor and regulate air and water quality as well as the built environment have addressed some of the links that lead to poor health outcomes. Additionally, a nationwide effort to improve the walkability of communities and influence people to move more is a good example of an intervention that can improve public health. Chronic diseases share common and modifiable behaviors that, when addressed, can reduce and perhaps eliminate the burden of chronic disease. Public health professionals seek to help people live not only longer but also healthier.

Critical Thinking and Review Questions

1. State why chronic diseases are often referred to as diseases of lifestyle and explain your answer.
2. Based on your reading of the material in this chapter, what aspects of your current lifestyle, environment, and genetics might put you more or less at risk for disease?
3. Explain why DDT was considered so toxic and how Rachel Carson got involved with its removal from the market.
4. Describe prehypertension and hypertension and why they are both dangerous for human health.
5. Research the characteristics of your city and determine if you have more noise pollution issues or air pollution issues. Is your city worse or better off than the United States as a whole in these areas?
6. Describe the three types of diabetes and explain why a person might suffer from one of them.
7. Review the elements that make up a walkable community and determine for yourself your community's Walk Score. Does your community's Walk Score place it among the nation's top walkable communities?
8. What are food deserts, and what do you think the United States can do to eliminate them?
9. Explain biological amplification and its connection to human health.
10. Describe at least two critical efforts of prevention of chronic diseases that have been implemented in the United States. Do you think they are making a difference in reducing overall chronic disease?

Additional Resources

USDA Food Environment Atlas

https://www.ers.usda.gov/data-products/food-environment-atlas/go-to-the-atlas/ (https://www.ers.usda.gov/data-products/food-environment-atlas/go-to-the-atlas/)

This government website is focused on determining the prevalence of types of foods and prices in relation to diet across the country. It offers statistics on food choices and quality of diet in communities and provides an overview of a given community's access to nutritious food.

Go Red for Women

https://www.goredforwomen.org/ (https://www.goredforwomen.org/)

Visit this website to learn more about the prevalence of heart disease in women and the national campaign to raise awareness.

Key Terms

air pollution
: A stew of chemicals, gases, and particles in the air we breathe.

Air Quality Index (AQI)
: The national indicator of air quality being good, moderate, unhealthy, or hazardous.

asthma
: A chronic lung disease that inflames and narrows the passageways to and from the lungs.

biological amplification
: The concentration of a substance as it "moves up" the food chain from one consumer to another.

built environment
: Man-made surroundings that provide the setting for human activity. It includes buildings, parks, roads, electric poles, and anything that is not part of the natural environment.

cancer
: Abnormal cells that divide to form a malignant tumor.

cap and trade

A policy tool for reducing the levels of greenhouse gases such as sulfur dioxide.

cardiovascular diseases
: Disorders of the heart and/or blood vessels, including heart diseases and stroke.

Clean Air Act of 1970
: One of the most important legislative acts for controlling air pollution, which is still valid and followed today.

Clean Water Act of 1972
: Legislation passed to establish the basic structure for regulating discharges into the waters of the United States.

coronary heart disease (CHD)
: Result of fatty buildup, or *plaque*, in the arteries that supply blood to the heart.

criteria air pollutants
: Six common air pollutants regulated by the EPA: ozone, nitrogen dioxide, carbon monoxide, sulfur dioxide, particulate matter, and lead.

DDT (dichloro-diphenyl-trichloroethane)
: A synthetic pesticide developed in the 1940s.

depression
: A serious mood disorder that is the leading cause of disability and a major contributor to the global burden of disease.

diabetes
: A chronic disease that occurs when the pancreas does not produce enough insulin or the body cannot use the insulin that is produced.

hemorrhagic stroke
: A stroke caused by the bursting of a blood vessel in the brain.

hypertension
: High blood pressure.

ischemic stroke
: A stroke that occurs because of a blockage within a blood vessel supplying blood to the brain; accounts for 87% of all strokes.

noise pollution
: Unwanted or disturbing sound that interferes with normal activities, including sleeping and other aspects, that may reduce the quality of life.

obesity
: Chronic disease characterized by having a BMI (body mass index) of 30 and above.

oral health
: The health of the teeth, gums, and entire oral-facial system that allows people to speak, chew, and smile.

stroke
: Cardiovascular event that reduces or stops the flow of blood to the brain.