CHAPTER 8

Epidemiology and Cycle of Microbial Disease

Topics in This Chapter

Preview

The preceding chapters focused on microbes as a potential threat to the world population and on the biology of microbes and the mechanisms by which they cause disease. Chapters 9, 10, and 11 consider specific microbial diseases and their effects on individuals. This chapter considers microbial diseases in relation to public health and focuses on the factors responsible for infectious diseases in populations. Basic concepts of epidemiology are presented so that the occurrence and prevalence of disease in a particular environment at a particular time can be understood. The existence of microbial disease requires a chain of linked factors that constitute the cycle of disease. These factors are reservoir, transmission, portal of entry, and portal of exit.

In hospitals and in long-term health care facilities, all factors involved in the cycle of infectious diseases are present in a concentrated way. These facilities are hotbeds for the transmission of microbes among hospital personnel and patients.

Concepts of Epidemiology

Epidemiology is an investigative methodology designed to determine the source and the cause of diseases and disorders that produce illness, disability, and death in human populations. Epidemiologists have been dubbed "disease detectives"; they are among the first group to be dispatched by the Centers for Disease Control and Prevention (CDC) when the threat of an outbreak occurs anywhere in the world. Their sleuthing is directed at understanding why an outbreak of a disease is triggered at a particular time and in a particular place. Epidemiologists consider age distribution of the population, sex, race, personal habits, geographical location, seasonal changes, modes of transmission, and others. These parameters are used to design public health strategies for control and prevention of future outbreaks. Historically, epidemiology is based on an understanding of the causes and distribution of infectious diseases, but modern epidemiology has branched out to other public health problems, including alcohol and drug abuse, cancer, mental conditions, "road rage" and other acts of violence, and exposure to lead paint.

Epidemiology dates back to the time of Hippocrates (460–377 B.C.), who questioned the role of eating and drinking habits, the source of drinking water, lifestyle, and seasons of the year as factors related to causality of disease. He was astute enough to realize that the diseases now identified as yellow fever and malaria were associated with swampy environments where mosquitoes bred. The epidemiological studies of Edward Jenner, a country physician in England, proved that cowpox and smallpox were related and led to smallpox immunization in the late 1700s. In the mid-1800s another early epidemiologist-physician, Ignaz Semmelweis, showed that childbed fever resulted from physicians and other attendants who weren't washing their hands after dissecting corpses. They would proceed directly from the autopsy room to the delivery room (**BOX 8.1**).

John Snow was another early epidemiologist who laid the groundwork for modern methodologies of epidemiology. In 1849 a major epidemic of cholera occurred in the Soho district of London, causing about 500 deaths in the span of only ten days. Cholera is a bacterial disease (Chapter 9) manifested by diarrhea so pronounced that life-threatening amounts of water are lost from the body in a short time, causing death from dehydration. Snow's epidemiological detective work showed that most of the cholera victims lived in the Broad Street area and drew their water from the Broad Street pump (**FIGURE 8.1**). Further investigation revealed that the pump was contaminated with raw sewage, and when the pump handle was removed, the cholera epidemic was halted.

A second outbreak of cholera occurred in London in 1854. Snow's sleuthing revealed that most of the cholera victims purchased their drinking water from the Southwark and Vauxhall Company; the company's source of water was the Thames River downstream from the site where raw sewage was discharged into the river.

AUTHOR'S NOTE

The story of Ignaz Semmelweis is one of my favorites. His life was a struggle to convince his colleagues to wash their hands before delivering babies. I visited the Semmelweis Museum in Budapest during the summer of 2006. There is a small garden in the courtyard of the museum displaying a statue of a mother holding her baby in her arms and raising her eyes in gratitude toward Semmelweis.

Author's photo.

BOX 8.1 Semmelweis and Childbed Fever

Ignaz Phillip Semmelweiss (FIGURE 8.B1) (1818–1865) graduated from the Vienna University Medical School in 1844 at the age of 26. He started his medical practice in Austria, specializing in obstetrics at a large maternity hospital. He was not an easy doctor to work with. Dr. Semmelweiss was cantankerous, arrogant and abrasive. What he lacked in personality, he made up for in intelligence and his astute observation skills.

FIGURE 8.B1 Ignaz Semmelweis, sometimes called the "savior of mothers." Before the establishment of microbes as causative agents of disease, Semmelweis realized that childbed fever was transferred from physicians to mothers during delivery. © National Library of Medicine.

The death rate of healthy women from childbed fever was so high that women begged to deliver their babies at home rather than risk a hospital delivery. Semmelweis placed the blame, often with insults, on the doctors' and medical students' unsanitary procedures. He was ridiculed by his colleagues, his hospital privileges were limited, and his academic rank was reduced. "Bad blood" and mysterious forces were thought to be the cause of childbed fever and other diseases; these conditions certainly were not caused by the doctors. Upwards of 30% of women were dying of childbed fever after delivering babies in the hospital whereas women who delivered their babies at home with the aid of a midwife rarely died of childbed fever.

Childbed fever is sometimes called *puerperal fever.* Symptoms of the disease usually began on the second or third day after delivery. The new mothers experienced a violent shivering fit or fever followed by pain in the uterus radiating toward the abdomen that was tender to the touch. The pulse was rapid and the pain became excruciating. Patients complained that the pain was greater than that they suffered during labor. They stopped lactating. As the infection progressed, patients produced cloudy, putrid urine when they could urinate. They produced a foul smelling vaginal discharge. Some vomited and had diarrhea. Their

The Lambeth Company, another water supplier, obtained its water further upstream; the incidence of cholera in the population using Lambeth water was much lower. The cause of the disease was not known and led to conjecture and imagination (FIGURE 8.2). The actual bacterial contaminant in the water in both outbreaks proved to be *Vibrio cholerae.*

Epidemiologists focus on the frequency and distribution of diseases in populations and classify diseases as **sporadic**, **endemic**, **epidemic**, and **pandemic**. Sporadic diseases are those that occur only occasionally and at irregular intervals in a random and unpredictable fashion. Typhoid fever, eastern equine encephalitis, and tetanus are examples. Diseases that are continually present at a steady level in a population and pose little threat to the public health are endemic diseases. The common cold, mumps, and whooping cough are endemic across the United States, whereas Lyme disease is endemic primarily in some New England states,

tongues became white, and the patients became thirsty. As the disease progressed, the pain and agony were unbearable. As the suffering continued, they became confused and delirious. Some doctors ordered frequent bleeding or purging procedures and opium for the pain. This was a time before the role of bacteria in diseases was discovered. Today it is known that childbed fever is an infection of the endometrium following childbirth or an abortion caused by group A hemolytic streptococci.

After a woman died of childbed fever, their bodies were moved to nearby dissection rooms—the "death houses." Physicians and medical students would perform autopsies. They smelled of the death houses. They did not wear gloves. Their hands contained putrid matter from corpses. The bloodier and dirtier their laboratory coats, the prouder they became. The smell and filthy coats represented evidence of their superior skills as physicians and interns.

Dr. Semmelweiss observed that the obstetricians and medical students performing autopsies on the wombs of postpartum women who died of childbed fever went directly to the delivery rooms to perform routine vaginal examinations. He believed they carried "death particles" with them to the birthing rooms. Because of his difficult personality, he used his authority to order all obstetricians and medical students to wash their hands with chloride of lime before entering the maternity ward. The results were dramatic! The doctors and interns no longer smelled of death. The morbidity rates plummeted to less than 2%!

Dr. Semmelweiss was ignored and ridiculed by many in the medical community. He believed that cleanliness was critical in the hospitals; however, he could not handle criticism for his beliefs. He was difficult and dogmatic, retaliating by writing angry letters. His term of appointment at the hospital expired in 1849, and he was dismissed. Thirteen years later, he published his treatise, *The Etiology, Concept, and Prophylaxis of Childbed Fever,* which is dated 1861 but was actually published in 1860. The treatise of over 500 pages contains passages of great clarity interspersed with lengthy, muddled, repetitive, and bellicose passages in which he attacks his critics.

In 1865 Semmelweiss was committed to an insane asylum. He had become an uncontrollable psychotic—possibly due to tertiary syphilis or Alzheimer's disease. He died at the age of 47, ironically, of a wound infection that may have been caused by the same bacterium that causes childbed fever. A tragic ending for a scientist ahead of his time. Irrespective of his difficult nature, he is credited with the practice of **handwashing,** a simple, standard aseptic technique. It is the single most important procedure in preventing hospital-acquired infections. In his honor, Semmelweiss University, a medical school located in Budapest, Hungary, is named after him.

but can be caught on a year-round basis. A disease is said to be epidemic when there is a sudden increase in the **morbidity** (illness rate) and in the **mortality** (death rate) above the usual, causing a potential public health problem. Throughout history, epidemics have resulted in more deaths than those caused by wars, and they have influenced the course of history. Plague has bedeviled humankind at least since the reign of Emperor Justinian in the sixth century; the fourteenth century epidemic was particularly devastating. Smallpox, cholera, and typhus fever are other examples of past epidemics (Chapters 9, 10, and 11). Epidemics may arise from an explosion of sporadic or endemic diseases or, it would seem, from out of nowhere. Pandemic diseases are those that spread across continents and may be worldwide; AIDS is a pandemic. Cholera has been responsible for pandemics on several occasions over time. In 1918 what was then referred to as swine influenza was perhaps the greatest pandemic of all times. Epidemiologists use a

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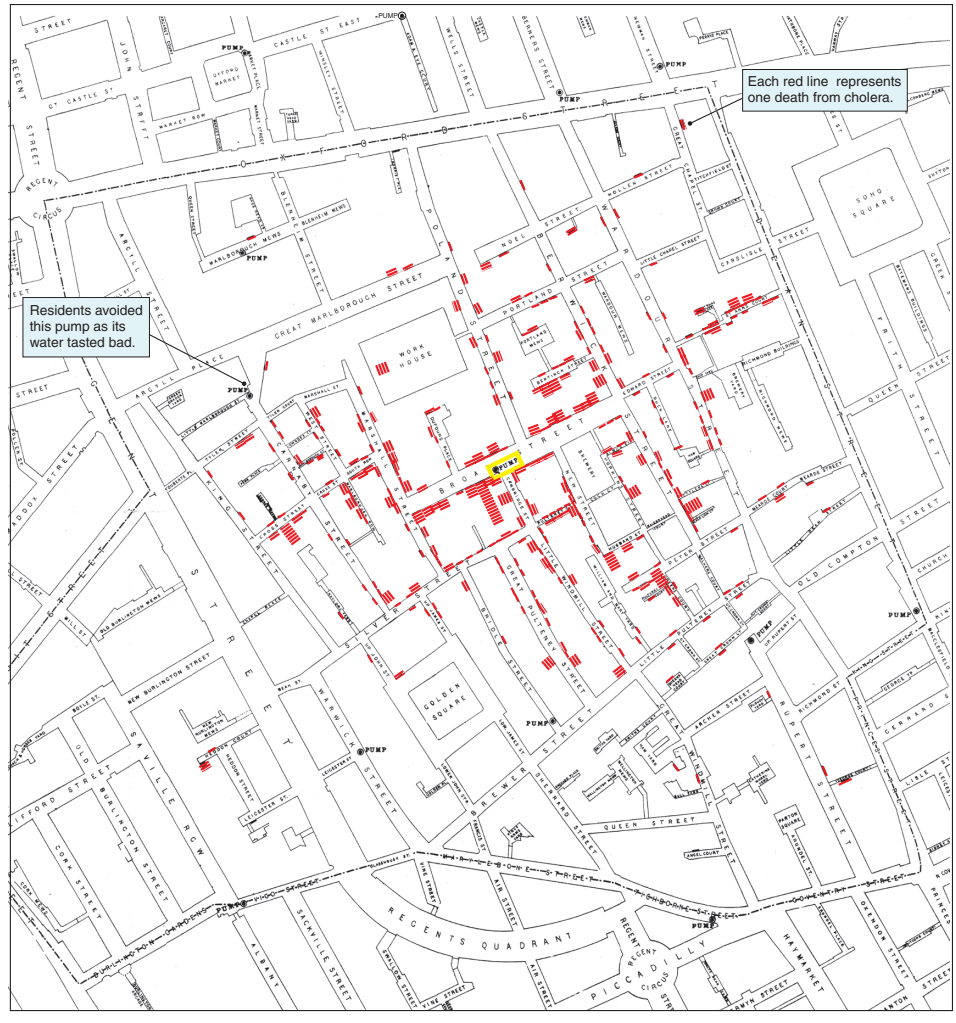

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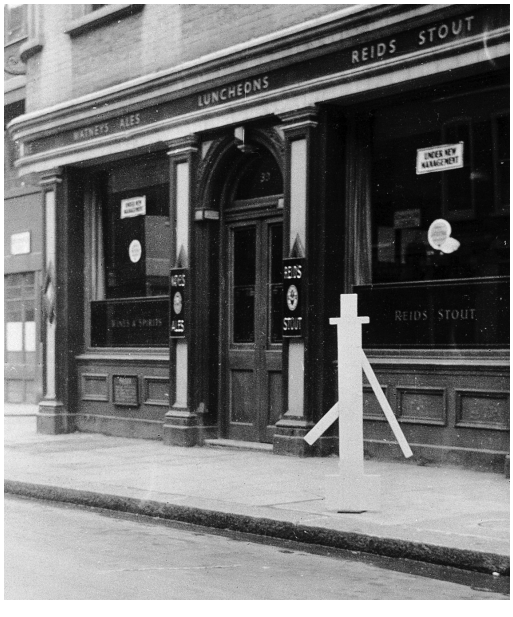


FIGURE 8.1 **(a)** A portion of the map created by Dr. John Snow of the Broad Street area. The lines plot how many people died at each address. Courtesy of Frerichs, R. R. John Snow website: http://www.ph.ucla.edu/epi/snow.html, 2006. **(b)** The John Snow Pub and the "ghost of Broadwick Street" (formerly Broad Street). In the foreground is a replica of the "ghost," the Broad Street pump that was the source of contaminated water causing a major outbreak of cholera. © Wellcome Library, London.

variety of graphs, charts, and maps as tools to illustrate the frequency and distribution of diseases (FIGURE 8.3). The term *epidemic* has been borrowed to indicate a variety of conditions unrelated to infectious diseases that are present beyond the norm. For example, college officials talk of grade inflation as a problem of epidemic proportions, as are school violence, obesity, and cancer.

Epidemiologists have described the source and spread of epidemics as **common-source epidemics** or **propagated epidemics**. Common-source epidemics arise from contact with a single contaminated source and are usually associated with fecally contaminated foods and water. Typically, a large number of people become ill quite suddenly, and the disease peaks rapidly in the population. A propagated epidemic is the result of direct person-to-person contact; the microbe is spread from infected individuals to noninfected susceptible individuals. As compared with common-source epidemics, the number of infected individuals rises more slowly and decreases gradually. Chicken pox, measles,

and mumps are examples of propagated epidemics. FIGURE 8.4 illustrates the courses of common-source and propagated epidemics.

The number of individuals in a population who are immune (nonsusceptible) to a particular disease as compared with those who are nonimmune (susceptible) is an important factor in the occurrence of epidemics. Immunity can be the result of having had a particular infection or of having been immunized. The term ***herd immunity*** (group immunity) refers to the proportion of immunized individuals in a population. Disease can only be spread to susceptible individuals; therefore, the smaller the number of susceptible individuals, the less opportunity for contact between them and infected individuals. Public health officials strive to maintain high levels of herd immunity against communicable diseases to minimize the chances that they will progress to epidemic status. Hence, immunization is required in the elementary grades against a variety of diseases; proof of an up-to-date immunization history is required for college admission.

FIGURE 8.2 "Monster Soup," commonly called Thames Water. A satirical cartoon created by William Heath, c. 1928. © Wellcome Library, London.

AUTHOR'S NOTE

In 1990 I visited the site of the old Broad Street pump. At the site is now a pub called the John Snow Pub in commemoration of the pump. I had a few beers and reminisced about history.

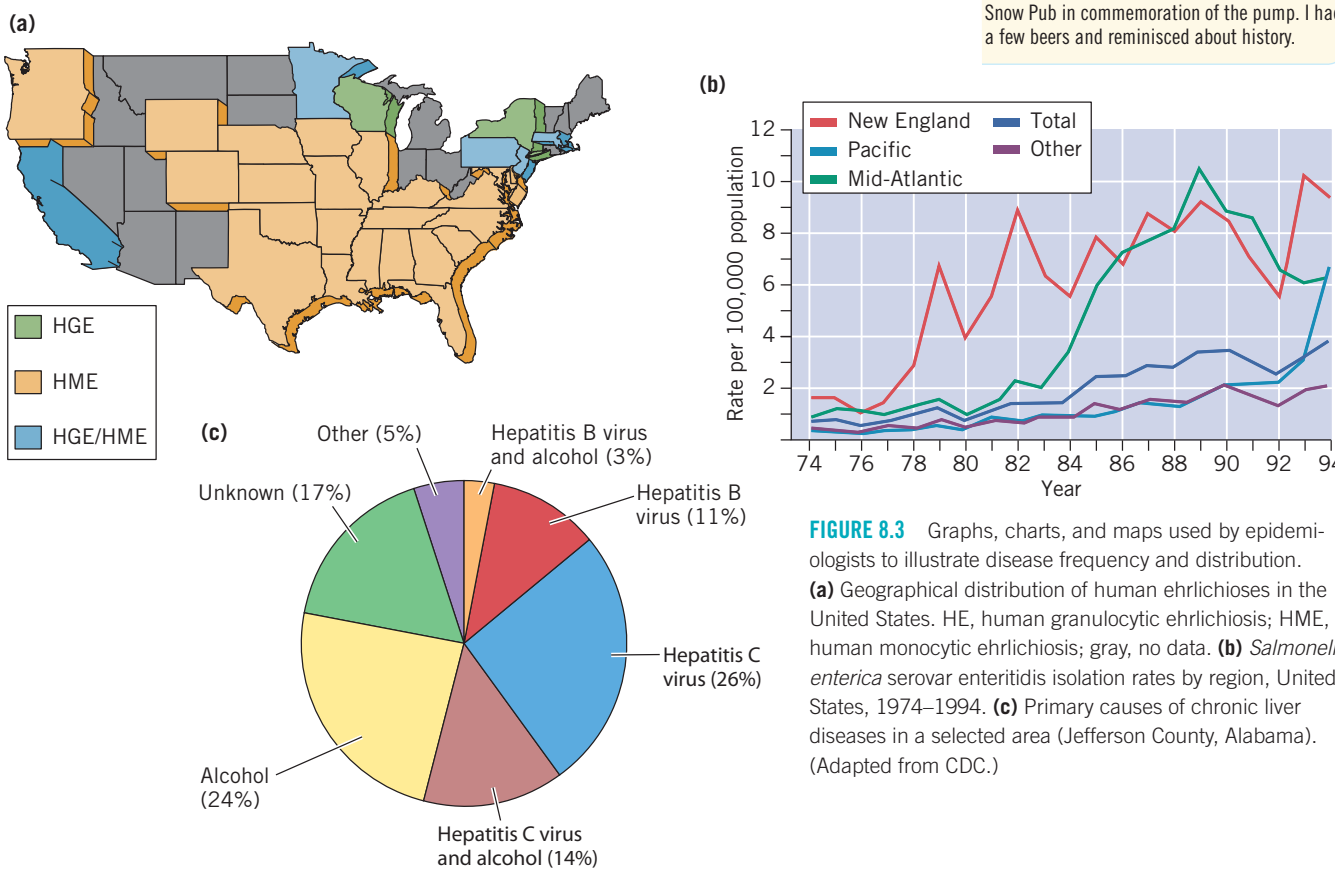


FIGURE 8.3 Graphs, charts, and maps used by epidemiologists to illustrate disease frequency and distribution. **(a)** Geographical distribution of human ehrlichioses in the United States. HE, human granulocytic ehrlichiosis; HME, human monocytic ehrlichiosis; gray, no data. **(b)** *Salmonella enterica* serovar enteritidis isolation rates by region, United States, 1974–1994. **(c)** Primary causes of chronic liver diseases in a selected area (Jefferson County, Alabama). (Adapted from CDC.)

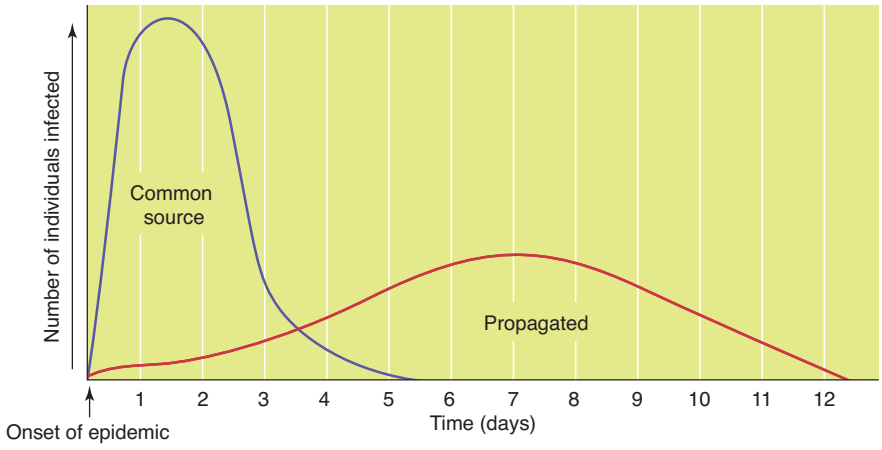


FIGURE 8.4 A comparison of the courses of common-source and propagated epidemics.

A decrease in herd immunity can lead to reemergence of a disease. A case in point is the epidemic of diphtheria that occurred in the newly independent states of the former Soviet Union in the early 1990s. A decline in the public health infrastructure resulted in fewer children receiving diphtheria vaccination and a decline in herd immunity. When the disease was introduced into the population, possibly by returning military personnel, diphtheria reached epidemic proportions.

Smallpox immunization is no longer practiced because of the eradication of this disease, as proclaimed by the World Health Organization (WHO) in 1980. The world population has little herd immunity against smallpox because only children born before smallpox was declared eradicated in 1980 were vaccinated. This is a potential nightmare, because smallpox virus is near the top of the list of potential biological weapons (Chapter 15).

Surveillance of disease outbreaks and of factors that could trigger outbreaks is an important mission of public health organizations throughout the world, including the WHO, the CDC, and agencies at the state and local levels. To keep track of these diseases in the United States, physicians are required to report cases of certain diseases, referred to as notifiable diseases, to their local health departments; these are then reported to the CDC. In 1994 forty-nine diseases were listed as notifiable; sixty-four diseases were reportable in 2008 (**TABLE 8.1**). The specific diseases are decided on at an annual meeting involving state departments of health and the CDC. An increase or a decrease in the number of notifiable diseases does not necessarily reflect a change in the health status but may be the result of reorganization each year. Some of these diseases are discussed in Chapters 9, 10, and 11. To further assist public health and medical personnel, the CDC publishes the journal *Emerging Infectious Diseases* as well as the *Morbidity and Mortality Weekly Report,* which contains data organized by states on morbidity and mortality of particular diseases in the United States and throughout the world.

Cycle of Microbial Disease

For infectious diseases to exist at the community level, a chain of linked factors needs to be present, somewhat reminiscent of a parade of circus elephants linked trunk to tail. These factors are reservoirs, modes of transmission, portals of entry, and portals of exit (**FIGURE 8.5**). An understanding of these factors is imperative to attempt to break the cycle somewhere along the path. For example, if insects are involved in transmission, then controlling their population is a target; for those microbes transmitted by drinking water, providing safe drinking water is a goal. Shrinking the reservoir (where the microbes exist in nature) is a potential target for other diseases. In some instances, a combination of targets is preferable.

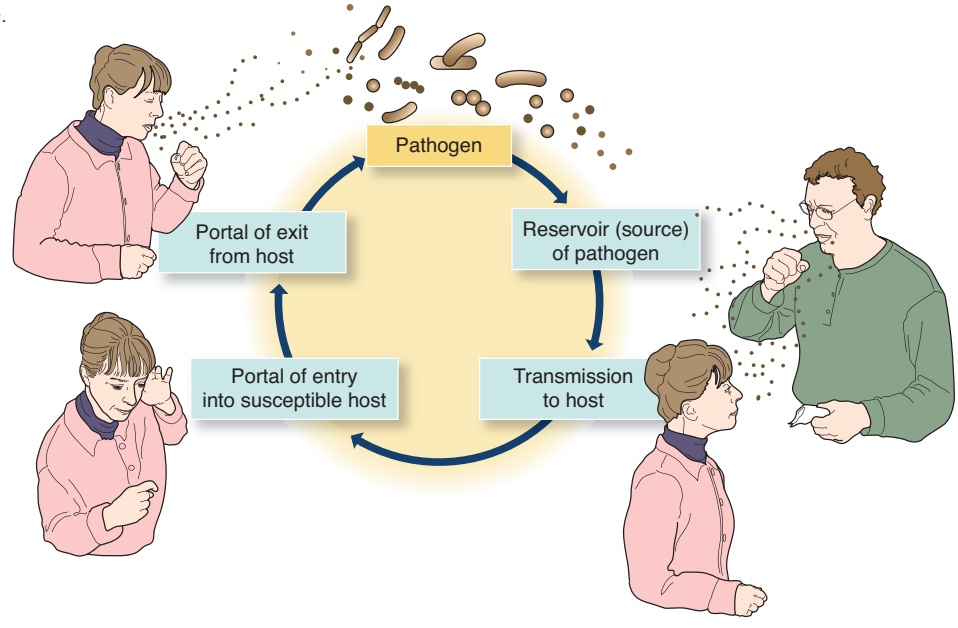
For a particular microbial disease to exist there has to be a pathogen as the caus-

TABLE 8.1 Major Infectious Diseases Designated as Notifiable at the National Level, United States, 2008

AIDS
Anthrax
Arboviral neuroinvasive and nonneuroinvasive diseases
Botulism
Brucellosis
Chancroid
Chlamydia trachomatis, genital infections
Cholera
Coccidioidomycosis
Cryptosporidiosis
Cyclosporiasis
Diphtheria
Ehrlichiosis/anaplasmosis
Giardiasis
Gonorrhea
Haemophilus influenzae, invasive disease
Hansen's disease (Leprosy)
Hantavirus pulmonary syndrome
Hemolytic uremic syndrome, postdiarrheal
Hepatitis viral, acute
Hepatitis virus, chronic
HIV infection
Influenza-associated pediatric mortality
Legionellosis
Listeriosis
Lyme disease
Malaria
Measles
Meningococcal disease
Mumps
Novel influenza A virus infections
Pertussis
Plague
Poliovirus infection, nonparalytic
Poliomyelitis, paralytic
Psittacosis
Q fever
Rabies
Rocky Mountain spotted fever
Rubella
Rubella, congenital syndrome
Salmonellosis
Severe acute respiratory syndrome-associated Coronavirus (SARS-CoV disease)
Shiga toxin-producing *Escherichia coli* (STEC)
Shigellosis
Smallpox
Streptococcal disease, invasive, group A
Streptococcal toxic shock syndrome
Streptococcus pneumoniae, drug-resistant invasive disease
Streptococcus pneumoniae, invasive disease nondrug resistant, in children less than five years of age
Syphilis
Syphilis, congenital
Tetanus
Toxic shock syndrome (other than streptococcal)
Trichinellosis (trichinosis)
Tuberculosis
Tularemia
Typhoid fever
Vancomycin-intermediate *Staphylococcus aureus* (VISA)
Vancomycin-resistant *Staphylococcus aureus* (VRSA)
Varicella (deaths only)
Varicella (morbidity)
Vibriosis
Yellow fever

Reproduced from the CDC. *Summary of Notifiable Diseases*, 2008.

FIGURE 8.5 The cycle of microbial disease.



ative agent and a host in which the pathogen takes up residence. The potential for disease to occur and its outcome are a result of the complex interaction between the number of invading microbes and their virulence (see Chapter 7) and the host immune system (Chapter 12). Communicable diseases are infectious diseases in which the pathogen can be transmitted from its reservoir to the host portal of entry.

Reservoirs of Infection

A **reservoir** is a site in nature in which microbes survive (and possibly multiply) and from which they may be transmitted. All pathogens have one or more reservoirs, without which they could not exist. Knowledge and identification of these reservoirs are important, because the reservoirs are prime targets for preventing, minimizing, and eliminating existing and potential epidemics. The facts that humans are the only reservoir of smallpox and that person-to-person transmission of smallpox takes place were key factors in the eradication of this disease. Additionally, humans are the only known reservoir for gonorrhea, measles, and polio. Animals, as well as plants and nonliving environments, also serve as reservoirs. In some cases the source of the pathogen is distinct from the reservoir and is the immediate location from which the pathogen is transmitted. For example, in typhoid fever the reservoir may be an individual with an active case of the disease who sheds typhoid bacilli in feces; the immediate source would be water or food contaminated with fecal material. On the other hand, in most sexually transmitted diseases the human body serves as both reservoir and source.

Active carriers are those individuals who have a microbial disease, whereas **healthy carriers** have no symptoms and unwittingly pass the disease on to others. **Typhoid Mary**, a cook and healthy lifetime carrier of typhoid fever, was responsible for about ten outbreaks, fifty-three cases, and three deaths due to typhoid fever during her lifetime; her dilemma is revealed in Chapter 9. **Chronic**

carriers are those who harbor a pathogen for long periods after recovery, possibly throughout their lives, without ever again becoming ill with the disease. In the case of chronic (and healthy) carriers of typhoid fever, removal of the gallbladder may be effective in eliminating the carrier state; intensive therapy with antibiotics works in other cases. Tuberculosis is another disease in which carriers play a significant role. Depending on the particular infection, carriers discharge microbes via portals of exit, including respiratory secretions, feces, urine, and vaginal and penile discharges.

Domestic and wild animals serve as reservoirs for about 150 species of pathogenic microbes that can affect humans. These diseases are referred to as **zoonoses** (TABLE 8.2). Microbes of animals that are most closely related to humans have the greatest chance of making the "species leap" to humans or as having erased the species barrier. Consider, for example, the AIDS virus, which is thought to have a reservoir in chimpanzees and is now a human pathogen. Prions cause both mad cow disease and its human counterpart variant, Creutzfeldt-Jakob disease (Chapter 16); prions jumped from cattle to humans. Monkeys are reservoirs for the microbes that cause malaria, yellow fever, and numerous other diseases. The reservoirs for the bacteria that cause Lyme disease, a major problem in the northeastern United States, are deer and mice. Hantavirus pulmonary syndrome, a relatively new disease in the United States, uses a variety of rodent species, particularly the deer mouse, as reservoirs. Many mammals, including dogs, cats, raccoons, skunks, foxes, and bats, serve as reservoirs for rabies.

TABLE 8.2 Selected Zoonotic Diseases

Transmission by arthropod bites	Transmission via food, water, or animal bites
Bacteria	Bacteria
Ehrlichiosis	Undulant fever
Relapsing fever	Leptospirosis
Lyme disease	Anthrax
Rocky Mountain spotted fever	Cat scratch fever
Plague	Tularemia
Typhus fever	Viruses
Viruses	Rabies
Yellow fever	Hantavirus disease
Eastern equine encephalitis	Viral gastroenteritis
West Nile virus disease	Protozoans
Rift Valley fever	Giardiasis
Dengue fever	*Cyclospora* infection
Protozoans	Toxoplasmosis
Babesiosis	
Sleeping sickness	
Malaria	
American trypanosomiasis	
Leishmaniasis	

Eradication of zoonotic diseases is particularly challenging and difficult because it is, ultimately, dependent on eradicating the reservoirs. Malaria is a protozoal disease transmitted by mosquitoes. Intensive spraying with the pesticide DDT (dichlorodiphenyltrichloroethane) in the 1940s markedly reduced the mosquito population and the number of malaria cases. The mosquitoes developed resistance to DDT eventually, leading to a reemergence of malaria.

Nonliving Reservoirs

Some organisms are able to survive and multiply in nonliving environments. Soil and water are the major nonliving reservoirs of infectious diseases. The tetanus bacillus and the botulinum bacillus, both members of the same bacterial group *Clostridium,* are spore formers and thus can survive for many years in soil. These organisms are part of the normal flora of horses and cattle and are deposited in their feces onto the soil. The use of animal fertilizers contributes to their distribution. Certain helminth (worm) parasites (for example, hookworms) deposit their eggs onto the soil, establishing a reservoir for human infection (FIGURE 8.6).

FIGURE 8.6 Soil can be a reservoir for microbes and helminth eggs. This child is at increased risk for infection. © Bernardo Erti/Dreamstime.com.

Contaminated drinking water and foods are major reservoirs for many microbes that cause gastrointestinal tract disease, ranging from mild to severe to fatal. The list includes bacteria, viruses, and protozoa (TABLE 8.3). Many of these diseases are discussed in Chapters 9, 10, and 11. Because of the potential for an outbreak of waterborne and foodborne illnesses, local departments of public health devote considerable attention to sanitary measures designed to minimize risks; their activities include monitoring food service establishments, beaches, swimming pools, and certification of food handlers.

TABLE 8.3 Water and Food as Reservoirs of Infection

Type of Microbe	Examples of Water- and Foodborne Infections
Bacteria	Salmonellosis, cholera, *E. coli*
Viruses	Hepatitis A, poliomyelitis, viral gastroenteritis
Protozoa	Giardiasis, amebiasis, cryptosporidiosis
Worms	Ascariasis, trichinellosis, *Trichuris* infection

Transmission

The next link in the cycle of disease is **transmission**, the bridge between reservoir and portal of entry (Figure 8.5). Transmission is the mechanism by which an infectious agent is spread through the environment to another person. More simply put, transmission answers the question "How do you get the disease?" There are several modes of transmission, and they can be grouped into two major pathways, direct and indirect. Each of these, in turn, can be subgrouped into three categories (TABLE 8.4).

TABLE 8.4 Modes of Transmission

Direct	Indirect
Contact (e.g., kissing, sneezing, coughing, singing, sexual contact)	Vehicles (fomites, e.g., doorknobs, eating utensils, toys)
Animal bites	Airborne (via aerosols created by, e.g., shaking bedsheets, sweeping, mopping)
Transplacental	Vectors (e.g., mosquitoes, ticks, flies)

Direct Transmission

The most common type of **direct transmission** is person-to-person contact, in which the infectious agent is directly and immediately transferred from a portal of exit to a portal of entry. Sexual contact, kissing, and touching are the most common examples. Transmission is facilitated by contact of the warm, moist mucous membranes of one individual with the warm, moist mucous membranes of another, as occurs in sexually transmitted diseases. Sexual contact is an example of **horizontal transmission** (i.e., transmission from one person to another). Droplet transmission is also direct and horizontal and involves the projection of infected spray from coughing, sneezing, talking, and laughing onto the conjunctivae of the eyes or onto the mucous membranes of the nose or mouth. Influenza, whooping cough, and measles are spread by droplets. Droplets are about 10 micrometers or greater in diameter and travel less than 1 meter; as many as twenty thousand droplets may be produced in a sneeze (FIGURE 8.7). Think about that the next time you cough or sneeze directly into the crowded environment of the classroom and be certain to "spray" into the crook of your elbow and not into your hand.

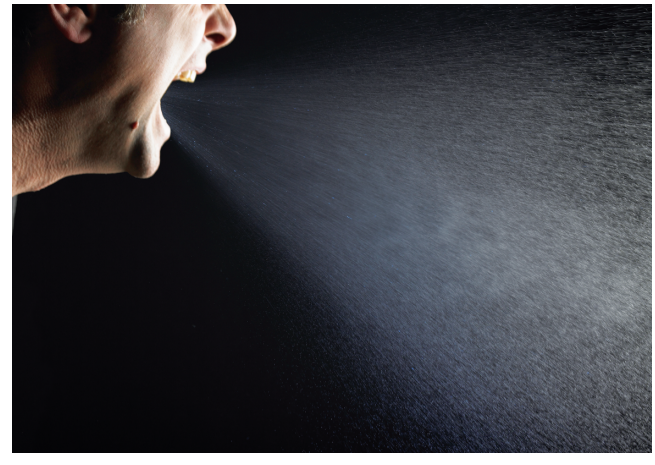


FIGURE 8.7 Droplet transmission. As many as twenty thousand droplets may be produced during a sneeze. It is important to carry a handkerchief or tissue and to cover your nose and mouth when sneezing. © James Klotz/ShutterStock, Inc.

A second type of direct and horizontal transmission involves animal bites, rabies being the most common example. The virus is directly transmitted from the saliva of the rabid animal onto the skin and underlying tissues. Finally, transplacental transmission is an example of **vertical transmission**, in which the pathogens are passed from mother to offspring across the placenta (AIDS, measles, and chicken pox), in breast milk, or in the birth canal (syphilis and gonorrhea). Notice there are no intermediaries in all these categories of direct transmission. Microbes are transferred by the contact of portals of exit with portals of entry. These portals are described later in this chapter.

Indirect Transmission

Indirect transmission involves the passage of infectious material from a reservoir or source to an intermediate agent and then to a host. The intermediate agent can be living or nonliving. Vehicleborne transmission is accomplished by food, water, biological products (organs, blood, blood products), and **fomites** (inanimate objects) as, for example, desk surfaces, doorknobs, or escalator rails.

Waterborne transmission is a serious problem throughout the world and is a major cause of death in many developing countries as a result of fecal–oral passage, in which pathogens are transmitted from the feces of one individual to another by hand-to-mouth transfer. Public, semiprivate, and private water supplies must all be carefully monitored for the presence of fecal pathogens.

Water and food can serve as both a reservoir and a transmitter of infectious agents. Because of the potential for an outbreak of waterborne and foodborne illnesses, local departments of public health devote considerable attention to sanitary measures designed to minimize risks; their activities include monitoring food packaging industries, food service establishments, beaches, swimming pools, and certification of food handlers.

Fomites play a significant role in the transmission of infectious agents. The list of fomites is seemingly endless and includes objects in common use, such as doorknobs, telephones, faucets, computer keyboards, and exercise equipment. Toys are fomites and contribute to illness in children wherever the toys are shared. Surgical instruments, medical equipment (for example, catheters, intravenous equipment, and syringes), bedding, and soiled clothing are also fomites. An interesting study involving soiled saris as fomites, conducted in fifty-one slum areas in Dhaka, Bangladesh, revealed a positive correlation between the number of misuses of dirty saris and episodes of childhood diarrhea.

FIGURE 8.8 Exercise machines can be reservoirs for microbes. You may be exercising to maintain good health, but poor personal hygiene may place others at risk. Wipe down exercise machines after use.

The list of fomites and their role may cause you some concern, but there is at least a partial solution to the problem. The simple act of frequent hand washing has been shown to markedly reduce hand-to-mouth (and nose and eye) infection. Frequent wiping of tabletops and counters with disinfectants is effective and a sign of good hygiene in a sanitation-conscious restaurant. In health and exercise clubs it has become a widespread practice to wipe down exercise equipment after use; it is a sign of bad manners not to do so (FIGURE 8.8).

Airborne transmission by **aerosols** is the second type of indirect transmission. Aerosols are suspensions of tiny water particles and fine dust in the air; they are distinct from droplet nuclei, as they are smaller than 4 micrometers, travel more than 1 meter, and are small enough to remain airborne for extended periods. Aerosols cause outbreaks of Q fever, Legionnaires' disease, and psittacosis (from infected birds). The microbes in aerosols may not come directly from humans or animals but may be present in dust particles where they can survive for months. Most hantavirus pulmonary syndrome infections can be traced back to when the victim cleaned out mouse droppings from a dusty place such as a summer cabin. Bacteria and viruses can be disseminated by changing bed linens, sweeping, mopping, and other activities. Hospital personnel are keenly aware of this, as reflected in the practice of using wet mops and damp cloths to wipe surfaces.

The third type of indirect transmission is by vectors, living organisms that transmit microbes from one host to another. The term *vector* is sometimes more

TABLE 8.5 The Phylum Arthropoda

- Subphylum Chelicerata
  - Scorpions
  - Chiggers
  - Spiders
  - Daddy longlegs
  - Mites[a]
  - Horseshoe crabs
  - Ticks[a]
- Subphylum Crustacea
  - Water fleas
  - Isopods
  - Fairy shrimp
  - Crabs
  - Copepods[a]
  - Lobsters
  - Barnacles
  - Shrimp
- Subphylum Hexapodia
  - Insects (many subgroups)
    - Flies[a]
    - Fleas[a]
    - Mosquitoes[a]
    - Lice[a]
- Subphylum Myriapodia
  - Centipedes
  - Millipedes

[a]Vectors of human disease.

broadly used to cover any object that transfers microbes, but this is, strictly speaking, incorrect usage. Ticks, flies, mosquitoes, lice, and fleas are the most common vectors, and they belong to the same biological phylum, the **Arthropoda**, along with lobsters and crabs. (It may be difficult to understand what flies, fleas, ticks, and lobsters have in common—but the edibility of lobsters certainly sets them apart!) Arthropods are invertebrate animals with jointed appendages (*arthro* means joint, as in "arthritis" [inflammation of joints], and *pod* means foot, as in "podiatrist" [foot doctor]). Further, they all have segmented bodies and a hardened exoskeleton. The arthropods are members of the largest phylum and consist of many diverse species that are divided into three subphyla (TABLE 8.5). They are considered to be the most successful of all living animals in terms of the huge number of species and their distribution.

Spiders, ticks, and mites hatch from eggs as six-legged larvae and undergo metamorphosis to eight-legged adults with two body segments and mouth parts adapted for the sucking of blood. Ticks transmit a variety of infectious diseases, including Lyme disease, Rocky Mountain spotted fever, babesiosis, and ehrlichiosis. These diseases are described in Chapter 9. In addition to their role as vectors, some ticks are important reservoirs because they exhibit **transovarial transmission** (the passage of microbes into their eggs).

Insects are an extremely large group of arthropods with well over one million species. You may think of them as pests because (depending on the species) they bite, eat our crops, are bizarre-looking, or are disgusting because they are associated with uncleanliness. Insects have three body segments (the head, the thorax,

and the abdomen) and six legs; some have one or two pairs of wings. Some have mouth parts adapted for puncturing the skin and sucking blood. "Kissing bugs" suck blood from their hosts and are vectors of Chagas disease, endemic in Central and South America (Chapter 11).

Because many arthropods play a significant role in the cycle of infectious diseases, officials at public health departments know that arthropod control can lead to disease control. Mosquito abatement programs have been carried out on numerous occasions to control malaria. All the lower forty-eight states are threatened by West Nile virus, a mosquito-borne virus, resulting in insecticide spraying to control the mosquito population. Several other viruses that cause encephalitis (brain swelling and other neurological damage) belong to a group called arboviruses and are so named because they are arthropodborne (shortened to "arbo").

Arthropods can be either **mechanical vectors** or **biological vectors**. Mechanical vectors transmit microbes passively on their feet and other body parts; the microbes do not invade, multiply, or develop in the vector. Houseflies, for example, feed on exposed human and animal fecal material and then transfer microbes on their feet to food and eating utensils. Typhoid fever and other gastrointestinal diseases characterized by diarrhea or dysentery may be spread in this way. Covering of human and animal waste to avoid exposure to flies is an obvious answer, but this is not always possible in poverty-stricken areas, under wartime conditions, in refugee camps, and in other circumstances involving large groups of people when it is difficult to maintain good sanitation. Even in the best of circumstances, flies have access to dog feces and can mechanically transmit microbes to kitchen areas. It is disturbing to think that a fly that has just lunched on dog feces in your backyard or in a neighboring park may walk across the chicken salad that you prepare for a picnic. Cockroaches also serve as mechanical vectors; remember this when you see them marching across a kitchen counter. In December 2000 Chinese newspapers reported that Beijing was in the grip of a roach menace. Roaches were invading restaurants, hotels and motels, and even hospitals. Roaches carry more than forty kinds of bacteria, some of which are pathogens. Cheap rundown motels are sometimes referred to as "roach motels."

Biological vectors, unlike mechanical vectors, are necessary components in the life cycles of many infectious disease agents and are required for the multiplication and development of the pathogen; transmission by biological vectors is an active process. As an example, when a mosquito picks up the malaria plasmodium parasite while taking a blood meal from an infected person, the parasites are not at an infective stage. Further development in the mosquito's body results in parasites that are now infective for hosts. Depending on the particular vector, parasites may be carried in the saliva and injected into the tissue while biting; other vectors have the nasty habit of regurgitating infectious secretions into and around the bite, and others defecate infectious material onto the bite area. Itching usually results, and scratching facilitates entry of the parasite. Mosquitoes, fleas, lice, and ticks are common biological vectors.

Mosquitoes can rightly be considered as "public health enemy number one" based on their transmission of bacterial, viral, protozoal, and worm diseases (TABLE 8.6). Ticks are not only significant vectors of disease but also are a direct

TABLE 8.6 Human Mosquito-borne Disease

Disease	Genus of Mosquito	Genus of Microbe
Caused by viruses		
Eastern equine encephalitis	*Culex, Coquillettidia, Aedes*	Alphavirus
Japanese encephalitis	*Culex*	Flavivirus
La Crosse encephalitis	*Ochlerotatus*	Orthobunyaviridae
St. Louis encephalitis	*Culex*	Flavivirus
West Nile virus	*Culex*	Flavivirus (enveloped, icosahedral nucleocapsid ssRNA)
Western equine encephalitis	*Aedes*	Alphavirus
Dengue fever	*Aedes aegypti*	Flavivirus (dengue virus DEN-1, DEN-2, DEN-3, DEN-4)
Rift Valley fever	*Aedes*	Phlebovirus
Yellow fever	*Aedes*	Flavivirus
Chikungunya fever	*Aedes*	Alphavirus
O'nyong-nyong fever	*Anopheles*	Flavivirus
Ross River Virus	*Culex, Aedes*	Alphavirus
Venezuelan Encephalitis	*Culex, Aedes*	Flavivirus
Murrey Valley encephalitis	*Culex*	Flavivirus
Barman Forest	*Culex, Aedes*	Alphavirus
Australian encephalitis	*Culex*	Flavivirus
California encephalitis	*Aedes*	Orthobunyaviridae
Caused by a protozoan		
Malaria	*Anopheles*	Protozoa *Plasmodium vivax, P. falciparum, P. malariae, P. ovale*
Caused by a worm		
Elephantiasis	*Culex, Anopheles, Aedes, Mansonia, Coquillettidia*	*Wuchereria bancrofti, Brugia malayi*

source of disease. Tick paralysis is an example and is characterized by ascending flaccid paralysis resulting from a toxin in tick saliva; the paralysis usually disappears within several days. A 2006 CDC report cited and described a cluster of four cases in Colorado during May 26–31, 2006. Ticks populations depend largely on the number of deer in the area; more deer per square mile means more ticks.

Fleas are the biological vectors of the *Yersinia pestis* bacterium, and rats are the reservoirs (Chapter 9). Rats are important reservoirs for other microbial diseases, including Lassa fever and, in the southeastern United States, hantavirus pulmonary syndrome.

TABLE 8.7 Diseases Transmitted by Arthropod Bites

Disease	Distribution	Vector
Protozoal and helminthic diseases		
Filariasis	Central and South America, Africa, Indian subcontinent and other parts of Asia	Mosquitoes
Babesiosis	United States, Europe	Ticks
American trypanosomiasis	South and Central America	Kissing bug
Onchocerciasis	Central America, tropical South America, Africa	Black flies
African trypanosomiasis (sleeping sickness)	West, Central, and East Africa	Tsetse flies
Leishmaniasis	Central and South America, Africa, Indian subcontinent and other parts of Asia, Europe	Sand flies
Viral diseases		
Yellow fever	Tropical South America, Africa	Mosquitoes
Colorado tick fever	United States (Rocky Mountains)	Mosquitoes
Rift Valley fever	Eastern and southern Africa, sub-Saharan Africa, Madagascar	Mosquitoes
West Nile virus disease	Asia, Africa, United States	Mosquitoes
Dengue fever	India, Southeast Asia, Pacific, South America, Caribbean	Mosquitoes
Bacterial diseases		
Plague	Southeast Asia, Central Asia, South America, western North America	Fleas
Relapsing fever	South America, Africa, Asia, western North America	Lice or ticks
Lyme disease	Europe, United States, Australia, Japan	Ticks
Typhus fever (endemic)	Worldwide	Fleas
Typhus fever (epidemic)	Eastern Europe, Asia, Africa, South America	Lice

From U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Infectious Diseases, Division of Quarantine. 1997. *Health Information for International Travel 1996–97.* http://wonder.cdc.gov/wonder/prevguid/p0000475/p0000475.asp.

Vectorborne infectious diseases are as numerous and varied as are their vectors, and they are emerging and reemerging throughout the world (TABLE 8.7 and FIGURE 8.9). Factors responsible include genetic changes in both vectors and pathogens resulting in resistance to insecticides and drugs, public health policy, funding directed toward emergency response, and societal changes. In the first half of the twentieth century, considerable progress was made in the fight against vectorborne diseases. Most of these diseases were brought under control, and by the 1960s their threat, except in Africa, was greatly diminished (TABLE 8.8). In fact, ma-

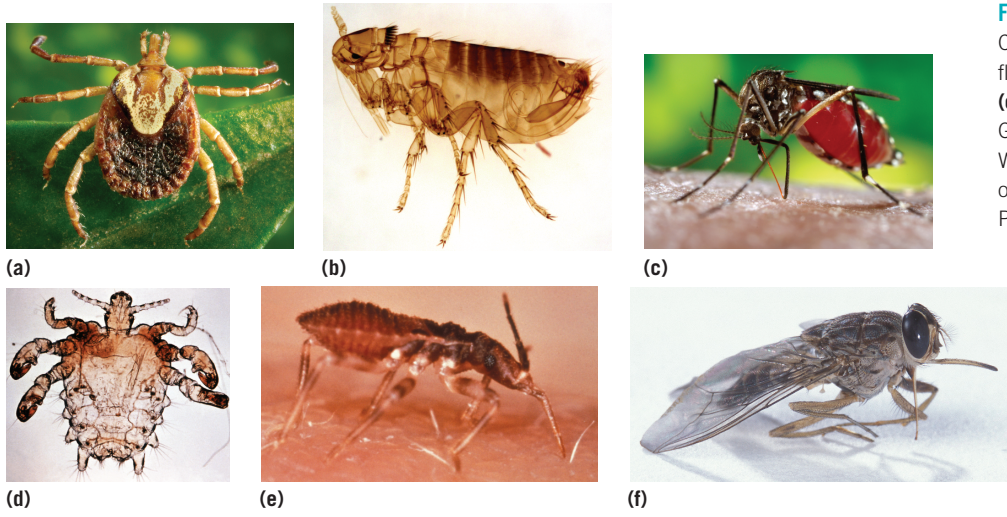


FIGURE 8.9 A "bug" parade: **(a)** tick. Courtesy of James Gathany/CDC. **(b)** flea. Courtesy of John Montenieri/CDC. **(c)** mosquito. Courtesy of James Gathany/CDC. **(d)** louse. Courtesy of WHO/CDC. **(e)** kissing bug. Courtesy of WHO/CDC. **(f)** tsetse fly. Courtesy of Peggy Greb/USDA ARS.

laria was eliminated from many countries of the world. However, no country is immune to the potential threat and spread of vectorborne microbial diseases. A case in point is West Nile virus, which emerged in 1999 in the state of New York. This was the first appearance of the virus in the United States; it had been previously reported only in Africa and Asia.

In 1989, in response to the growing problem of vectorborne diseases, the CDC established what is now known as the Division of Vectorborne Infectious Diseases,

TABLE 8.8 Successful Vectorborne Disease Control

Disease	Location	Year(s)
Yellow fever	Cuba	1900–1901
Yellow fever	Panama	1904
Yellow fever	Brazil	1932
Anopheles gambiae infestation	Brazil	1938
Anopheles gambiae infestation	Egypt	1942
Louseborne typhus	Italy	1942
Malaria	Sardinia	1946
Yellow fever	Americas	1947–1970
Yellow fever	West Africa	1950–1970
Malaria	Americas	1954–1975
Malaria	Global	1955–1975
Onchocerciasis	West Africa	1974–present
Bancroftian filariasis	South Pacific	1970s
Chagas disease	South America	1991–present

Reproduced from Duane J. Gubler and CDC, *Emerging Infectious Diseases,* 4 (1998): 442–450.

presently located in Fort Collins, Colorado. The Division is responsible for information, surveillance, prevention, and control of vectorborne diseases. The division is charged with the investigation of national and international epidemics of bacterial and viral diseases transmitted to humans by arthropods, primarily mosquitoes, ticks, and fleas. To prevent and control these diseases, biologists in the division work with the three populations involved: the pathogen, the host, and the vector.

Portals of Entry

The next step in the cycle of disease involves access into (or onto) the body through **portals of entry**. Some microbes have a single portal, but others have more than one. Body orifices (openings to the outside), including the mouth, nose, ears, eyes, anus, urethra, and vagina, and penetration of the skin make it possible for microbes to gain access. To some extent, human behavior influences the portal of entry. The most common site of entry for sexually transmitted diseases is the urethra in males and the vagina in females, but the throat and the rectum may also serve for entry. The portal of entry is an important consideration in the outcome of host–parasite interactions. Bubonic plague results from the bite of a plague-infected flea, but if the *Y. pestis* bacteria gains entry into the lungs through the respiratory tract, the result is the more lethal pneumonic plague. Anthrax, also a bacterial disease, is another example. There are three varieties of anthrax: Cutaneous anthrax results when the skin is the portal of entry, gastrointestinal anthrax occurs as the result of oral ingestion of the bacteria, and inhalation anthrax is the result of the organisms' entering through the respiratory tract. TABLE 8.9 and FIGURE 8.10 summarize the portals of entry by anatomical sites.

Portals of Exit

Once microbes have gained access into the body, whether or not disease results is determined by the interaction between the number of pathogens and their virulence (see Chapter 7) and the immune system of the host (Chapter 12). To complete the cycle of infectious disease and to allow the spread of disease into the community, pathogens require a **portal of exit** (Table 8.9 and Figure 8.10). In some cases the portal of exit relates to the area of the body that is infected. This is particularly true for organisms that cause diseases of the respiratory tract (such as colds and influenza). On the other hand, this is not always the case. For example, the spirochete that causes syphilis uses the urogenital tract as the portal of exit but can invade the skin and nervous system. The eggs of some disease-producing worms exit the body in fecal material, survive in soil, and remain infectious for long periods of time. HIV exits the body through semen and vaginal discharges as well as through the blood. Arthropodborne diseases enter the body through the bites of insects, and these insects also serve as avenues of exit. A mosquito biting an individual with malaria will pick up the parasite.

Nosocomial (Hospital-Acquired) Infections

People are hospitalized because they are ill and require treatment beyond what home care can provide. Ironically, while in the hospital they have a 5% to 15%

increased risk for contracting an infectious disease. **Nosocomial infections** are infections acquired by patients during their hospital stay or during their confinement in other long-term health care facilities; infections acquired by hospital personnel are also considered nosocomial. Based on the number of hospital admissions, estimates are that two million to four million cases of nosocomial infections, resulting in twenty thousand to forty thousand deaths, occur each year in the United States. The infections account for about 50% of all the major complications of hospitalization.

Hospital Environment as a Source of Nosocomial Infections

What are the factors unique to the hospital environment that place patients and hospital staff at an increased risk for acquiring infections? To begin with, the patient population consists of ill individuals who may have a compromised (weakened) immune system. A weak immune system increases a patient's susceptibility to pathogens and opportunistic microbes, including their own normal flora. Antibiotics are heavily used, but also misused, in hospitals to treat or to prevent infections, fostering the development of antibiotic-resistant strains of bacteria.

TABLE 8.9 Infectious Disease Cycle: Portals of Entry and Exit

	Examples of Disease or Microbe
Portals of entry	
Mucous membranes	
Respiratory tract	*Streptococcus pneumoniae,* tuberculosis, Legionnaires' disease, influenza, hantavirus, common cold
Gastrointestinal tract	Cholera, salmonellosis, *E. coli,* rotavirus, poliomyelitis, guinea worm disease, giardiasis
Urogenital tract	Gonorrhea, chlamydia, AIDS, genital warts
Skin (hair follicles, sebaceous glands, wounds, arthropod bites)	Boils, abscesses, cutaneous anthrax, rabies, warts, hookworm, schistosomiasis, malaria
Blood (transfusion, blood products, arthropod bites, placental transfer)	Congenital syphilis, AIDS, German measles, toxoplasmosis, Chagas disease
Portals of exit	
Respiratory tract	Tuberculosis, Legionnaires' disease, influenza, common cold
Gastrointestinal tract	Cholera, salmonellosis, rotavirus, poliomyelitis, hookworm, guinea worm disease
Urogenital tract	Gonorrhea, chlamydia, HIV, schistosomiasis, genital herpes
Skin	Impetigo, boils, abscesses, warts, cold scores, fever blisters, guinea worm disease
Blood (transfusion, blood products, Arthropod bites, placental transfer)	Congenital syphilis, toxoplasmosis, HIV, Rubella, malaria

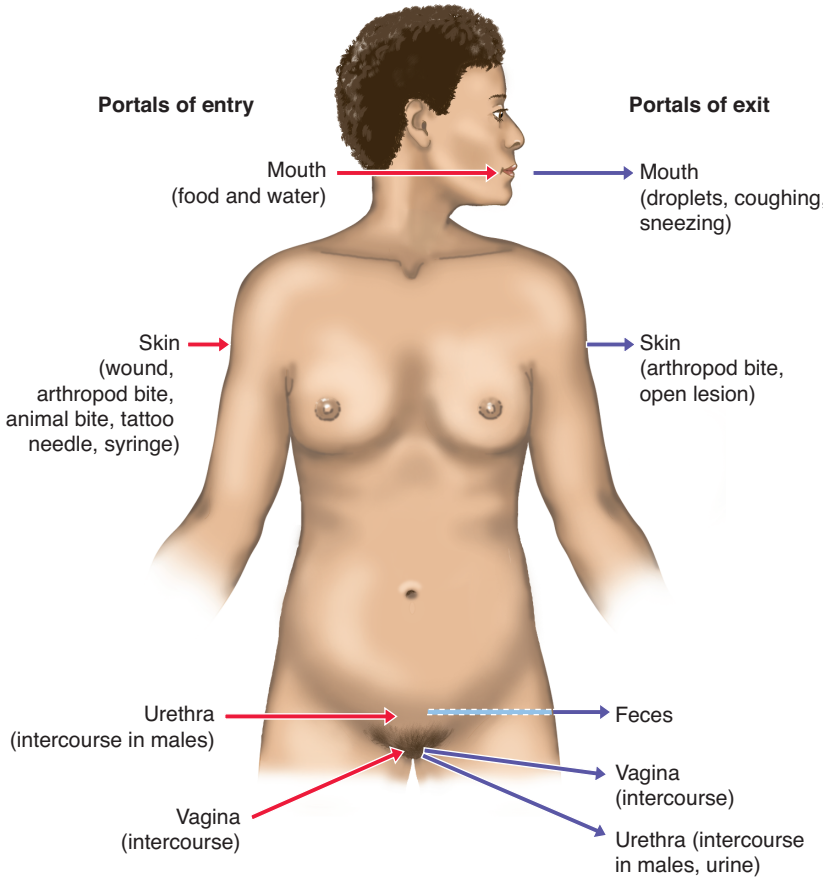


FIGURE 8.10 Portals of entry and portals of exit.

Drugs to purposely suppress the immune system (as in cancer therapy and organ transplantation), prolonged bed rest, and restrictive diets are necessary components of treatment but are traumatic to the body and counterproductive to the maintenance of a healthy immune system.

Diagnostic and treatment protocols frequently involve extensive surgery and the use of invasive procedures, including the insertion of catheters into the urethra, swallowing of tubes, insertion of needles into veins for intravenous therapy, and insertion of nasal tubes. Thermometers, bedpans, urinals, eating utensils, and night table surfaces are only a few of the many fomites that pose potential risk. Hence, the equipment and devices involved in patient care contribute to transmission. The hospital staff, including physicians, nurses, laboratory technicians, and maintenance workers, may unwittingly (and carelessly) transmit microbes from patient to patient; some may be healthy carriers.

All the factors involved in the cycle of infectious diseases are present in a concentrated way in hospitals and in long-term health care facilities, establishing these environments as reservoirs of pathogens. A relatively small number of bacterial species are responsible for most nosocomial infections, but these are species common to the environment. Some sites in the body are more prone to nosocomial infections than others; the urinary tract is the most susceptible, followed by surgical sites and the respiratory tract (TABLE 8.10). Despite the risk of nosocomial infection, be assured that the advances in medicine far outweigh the risks of hospitalization.

TABLE 8.10 Body Site Distribution of Nosocomial Infections

Site	Percent of all Nosocomial Infections
Urinary tract (urinary catheterization)	~50
Surgical site (intestinal surgery, joint replacement surgery)	~25
Lower respiratory tract (respirators and other breathing aids)	~12
Bacteremia (blood infection)	~6
Other (including skin)	~7

Control Measures

Nosocomial infections are a serious problem in hospitals and other medical facilities in terms of mortality, morbidity, and financial burden, and every hospital has strategies of prevention and control. The fact that the frequency and spectrum of antibiotic-resistant organisms are on the rise contributes to the problem. All hospitals are required to have an infection control officer and an infection control committee to maintain accreditation by the American Hospital Association. Hospitals spend considerable time and money to minimize the possibility of microbial contamination in all aspects of the hospital environment. The infection control officer is responsible for training of hospital personnel in basic infection control procedures including isolation procedures, proper techniques of disinfection and sterilization, and the surveillance and reporting of cases of infectious diseases in both patients and staff. The infection control officer and the infection control committee are also responsible for insect control, good housekeeping, and safe practices for the disposal of feces, urine, bandages, dressings, and other potentially contaminated materials.

Education emphasizing the importance of the simple act of hand washing is vital. (Semmelweis talked about hand washing 160 years ago!) Numerous studies have demonstrated that this single simple procedure is the most important practice in minimizing nosocomial infections. In some studies shockingly low rates (well under 50%) of hand washing by health care workers, including physicians and nurses, have been revealed.

Epidemiology of Fear

The fear of epidemics can reach epidemic proportions, but the threat of infectious disease, according to some experts, is out of proportion. *Escherichia coli* outbreaks, avian flu, severe acute respiratory syndrome (i.e., SARS), and West Nile virus have captured the public's attention and led to an explosion of television programs and popular books. The threat of infectious disease, according to some experts, is out of proportion. West Nile virus emerged in the Western Hemisphere for the first time in the summer of 1999 in New York State and caused illness in more than sixty people and the death of seven. By the summer of 2000, infected birds were detected in Massachusetts, Connecticut, and Rhode Island, generating concern among public health officials about an epidemic of fear. As a Massachusetts Department of Health spokeswoman stated, "The message we're trying to get out is to stop people from panicking. West Nile virus is not a major public health threat. It's something people should be aware of, and take precautions, but not let it interrupt their summer."

In his first inaugural address, on March 4, 1933, President Franklin Delano Roosevelt spoke eloquently of the danger of fear. His often quoted words were, "So first of all let me assert my firm belief that the only thing we have to fear is fear itself—nameless, unreasoning, unjustified terror which paralyzes needed efforts to convert retreat into advance." The take-home message is that awareness, surveillance, common sense precautions, and calmness are paramount. Fear can be paralyzing.

Overview

Epidemiologists classify disease as sporadic, endemic, epidemic, or pandemic, depending on its frequency and distribution. These categories are not absolute; a particular disease can slide from one classification to another. Common-source epidemics arise from contact with a single contaminant, resulting in a large number of people becoming ill suddenly; the disease peaks rapidly. Propagated epidemics are characterized by direct person-to-person (horizontal) transmission, a gradual rise in the number of infected individuals, and a slow decline.

A chain of linked factors is required for infectious diseases to exist and to spread through a population. These factors are reservoirs of disease, transmission, portals of entry, and portals of exit. Understanding the characteristics of microbes and the diseases they cause is necessary to break the cycle somewhere along its path. The reservoir is the site where microbes exist in nature and from which they can be spread. Active carriers, healthy carriers, and chronic carriers are reservoirs, as are wild and domestic animals. Nonliving reservoirs include contaminated water, food, and soil.

Transmission is the bridge between reservoir and portal of entry. Person-to-person contact is the most common type of horizontal direct transmission and allows for the immediate transfer of microbes. Vertical transmission is another type of direct transmission and is categorized by the passage of pathogens from mother to offspring across the placenta, in the birth canal during delivery, or in breast milk. In direct transmission there are no intermediaries. Indirect transmission involves the passage of materials from a reservoir or source to an intermediate agent and then to a host. The intermediate agent can be nonliving or living. Water, food, fomites, and aerosols are significant nonliving vehicles of indirect transmission. Vectors are living organisms that transmit microbes from one host to another. Mechanical vectors passively transfer microbes on their feet or other body parts, whereas biological vectors are required for the multiplication and development of the pathogen within the vector.

Portals of entry are the next consideration in the cycle of disease. Some microbes have a single preferred portal of entry into the body, whereas others have more than one. Body orifices, including the mouth, nose, ears, eyes, anus, urethra, and vagina, are portals of entry; the skin can be penetrated and is another portal of entry.

For the cycle of disease to continue in a population, microbes must exit from the body. In many cases the portals of entry and the portals of exit are the same.

Hospitals and long-term health care facilities are hotbeds of infection for patients. Hospital-acquired infections are called nosocomial infections and account for about 50% of all the major complications of hospitalization.

The public should not be paralyzed by the fear of infection. Awareness, surveillance, common sense precautions, and calmness are the best preventive measures.

Self-Evaluation

PART I: Choose the single best answer.

1. The breakup of the Soviet Union ushered in an unusually high number of cases of diphtheria from about 1990 to1995. Which term best characterized the situation?
   a. endemic **b.** epidemic **c.** pandemic **d.** herd
2. A common-source outbreak would most likely be attributed to
   a. airborne source **b.** change in vector distribution **c.** person-to-person contact **d.** water supply
3. Chicken pox in the United States is best described as
   a. sporadic **b.** endemic **c.** zoonotic **d.** pandemic
4. Which one of the following is not an insect?
   a. fly **b.** tick **c.** flea **d.** mosquito
5. Vertical transmission is possible except in the case of
   a. gonorrhea **b.** AIDS **c.** influenza **d.** chicken pox

PART II: Fill in the blank.

1. A worldwide outbreak of a disease is called a _____ .
2. Name a disease transmitted by an arthropod vector, and name the vector.
   _____
3. Only one disease has been eradicated. Name this disease.
   _____
4. Give an example of indirect contact transmission (fomites) of disease.
   _____
5. Which body site is most susceptible to nosocomial infection?
   _____

PART III: Answer the following.

1. Distinguish between vertical and horizontal transmission. Give examples of each.
2. What is meant by zoonoses? What is a common zoonosis in the northeastern United States? Give three examples of zoonoses.
3. Distinguish between biological vectors and mechanical vectors. Give two examples of each.