PART 1

The Challenge

- CHAPTER 1 Identifying the Challenge
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Identifying the Challenge

Topics in This Chapter

- The Challenge
- Factors Responsible for Emerging Infections
  - World Population Growth
  - Urbanization
  - Ecological Disturbances
  - Technological Advances
  - Microbial Evolution and Adaptation
  - Human Behavior and Attitudes

If human civilization lasts, if it continues to spread, infectious diseases will increase in number in every region of the globe. Exchanges and migrations will bring the human and animal diseases of every country. The work is already well advanced; its future is assured.

—Charles Nicolle, *The Destiny of Infectious Diseases, 1932*

Preview

This book is about a challenge—a worldwide challenge—posed by microbes, invisible marauders that inhabit the earth, many of which cause illnesses and death. Classically, there are five distinct kinds of microbes: **bacteria**, **viruses**, **protozoans**, **fungi**, and **unicellular algae**. Most recently, **prions** can now be added to the list, bringing the total of "**infectious agents**" to six. It should be emphasized at the outset that a relatively few members of each of the groups pose the potential for infection. Most microbes are beneficial and many are essential to the cycles of nature without which higher life forms could not exist. In many cases, microbes have been harnessed for the benefit of humankind.

But this book, by intent, has a bias because its theme relates to those few microbes that are disease producers. In the language of medical microbiology, they are referred to as **pathogens** or virulent microbes. Why some of these microbial diseases now represent an increased challenge is the subject matter of this chapter and sets the stage for the remaining chapters.

The flags represent infectious disease outbreaks or hotspots.

The Challenge

The need for this book continues. Forty previously unknown infectious diseases have emerged and others have reemerged in the past two decades: AIDS, Ebola virus, *Escherichia coli,* hantavirus, West Nile virus, *Salmonella,* flesh-eating "strep," and "mad cow disease," to name only a few (**FIGURE 1.1**). Movies, books, and articles about microbial diseases intrigue large numbers of viewers and readers. Popular news magazine programs, including *Dateline*, *60 Minutes*, *Anderson Cooper 360°*, and *20/20*, frequently air segments relating to dangerous microbes; newspaper articles and news broadcasts appear almost daily and further alert the public to threats posed by microbes. The movie "Contagion," based on a deadly viral epidemic, debuted in September 2011, and thrilled theatergoers about a pandemic caused by an airborne **chimeric** (**hybrid**) influenza-Nipah-like virus.

The 1990s were especially eventful. In 1992 tuberculosis (TB), a bacterial disease almost relegated to oblivion, reemerged in New York City, resulting in almost four thousand cases; the tubercle bacillus was developing resistance to a variety of antibiotics that had once stopped the bacteria dead in their tracks. In 1993 an outbreak of cryptosporidiosis, a waterborne protozoan disease characterized by diarrhea, swept through Milwaukee, Wisconsin, causing illness in about 400 thousand people, approximately 25% of that city's population; it was the largest reported waterborne illness in U.S. history. In 1993 hantavirus, the causal agent of a potentially lethal influenza-like respiratory illness, reemerged with deadly results in New Mexico, Utah, Colorado, and Arizona. Ebola hemorrhagic fever, caused by one of the deadliest known viruses, ignited a panic in 1995 when 240 people bled to death during an outbreak that occurred in Kikwit, Zaire (now

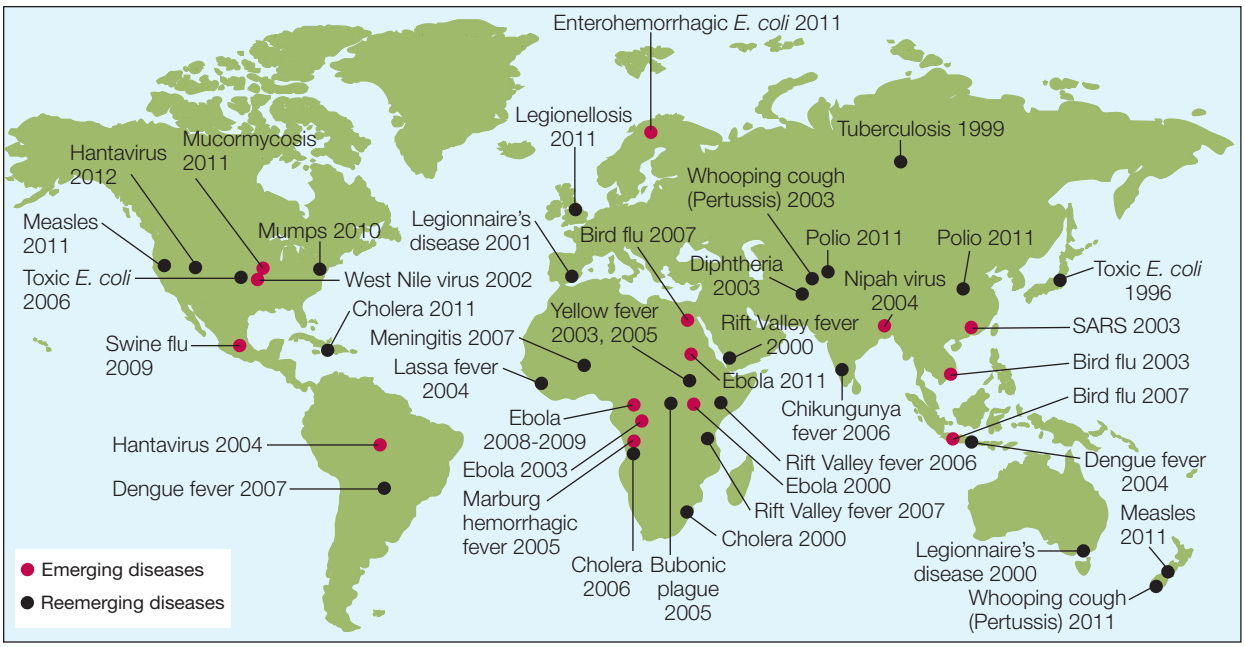


FIGURE 1.1 Emerging and reemerging diseases, 1996–2011. For more recent outbreaks, see HealthMap http://healthmap.org/en/.

the Democratic Republic of Congo). Earlier, in the winter of 1989, scientists working at a primate quarantine facility just outside Washington, DC, were terrified when Ebola virus–infected research monkeys were introduced into the facility. Richard Preston's account of the incident, *The Hot Zone,* inspired the film *Outbreak* in 1998. More recently, Ebola reemerged in the Democratic Republic of Congo in September 2007, resulting in at least 166 deaths.

Dengue fever sickened 1.2 million people in 56 countries in 1998. Reports of the bacterium *E. coli* O157:H7 frequent the news, as in 1993 when a cluster of people became ill in Seattle after eating hamburgers at a Jack in the Box fast-food restaurant. Health officials detected the organisms in hamburger patties, resulting in the recall of nearly 22 million pounds of ground beef to avert a nationwide outbreak. Can you imagine a mound of hamburger meat that size? Peanut butter contaminated with *Salmonella* caused over 425 cases of *Salmonella* infection spread over 48 states in February 2007, resulting in recalls of particular brands of the product. (Parents packing peanut butter sandwiches into their children's lunch boxes were dismayed and at a loss to find an appropriate substitute.) In the summer of 2011, a new strain of *E. coli* caused about 4,000 people to become ill and about 45 deaths; the source remains unclear. Multiple state outbreaks of Listeriosis, a serious bacterial infection, started in August 2011, and has been traced to Rocky Ford cantaloupes. It never ends! Lyme disease, severe acute respiratory syndrome (known as SARS), and avian and swine influenza are four more examples from a long list of new, emerging, and re-emerging infectious diseases (TABLE 1.1). No nation can afford to be complacent regarding its vulnerability.

TABLE 1.1 New, Emerging, and Reemerging Infections

Bacterial Diseases
- Lyme disease
- Ehrlichiosis
- Gastroenteritis
- Listeriosis
- Legionnaires' disease
- Salmonellosis
- Tuberculosis

Viral Diseases
- Hantavirus pulmonary syndrome
- Ebola hemorrhagic fever
- Dengue fever
- Rabies
- Severe acute respiratory syndrome (SARS)
- West Nile encephalitis
- HIV/AIDS
- Influenza
- Nipah encephalitis
- Measles

Protozoan Diseases
- Cryptosporidiosis
- Malaria
- Babesiosis

Fungal Diseases
- Coccidioidomycosis
- Cryptococcosis pneumonia
- Pneumocystis *pneumonia*
- "Bat White Nose" syndrome (bats, eastern U.S.)
- Chytridiomycosis (amphibians)

The Institute of Medicine is a branch of the National Academy of Sciences that advises the government on policy matters pertaining to the health of the public. In a 1992 report, *Emerging Infections: Microbial Threats to Health in the United States,* the institute defined emerging infections as "new, reemerging or drug-resistant infections whose incidence in humans has increased within the past two decades or whose incidence threatens to increase in the near future."

Despite the tremendous progress in the latter half of the twentieth century in controlling infectious diseases, including the eradication of smallpox, the introduction of antibiotics in the 1940s, improvement in sanitation, and an increase in the diseases for which immunization is available, the battle against infectious diseases continues (**BOX 1.1**). David Satcher, former director of the U.S. Centers for Disease Control and Prevention (CDC) and later surgeon general of the United States, stated that "our ability to detect, contain, and prevent emerging infectious diseases is in jeopardy."

The International Red Cross warned of the danger of infectious diseases in a report published on June 6, 2000. The report spoke of "the silent tragedy" of deteriorating health services and the death of thirteen million people from preventable diseases, primarily infectious in nature, in the previous year. Further, compared with floods and earthquakes, which grab news headlines and donors' cash, the uncontrolled spread of disease steals far more lives. Over 150 million people have died of AIDS, TB, and malaria alone since 1945, compared with the more than 23 million lives lost in wars. In a recent year, 160 times more people died from AIDS, malaria, respiratory diseases, and diarrhea than were killed in that year's natural disasters, including the massive earthquakes in Turkey, floods in Venezuela, and cyclones in India. Malaria killed 781,000 in 2009, mostly children. According to the World Health Organization (WHO) *World Malaria Report, 2010*, there were 225 million cases of malaria in 2009. TB has been on the upswing in North Korea; statistics from that country reveal that 5 million of its 22 million people are infected.

Infectious diseases are the second leading cause of death worldwide, resulting in 20.7% deaths occurring worldwide each year (**FIGURE 1.2**). Pneumonia and diarrheal diseases are the two largest killers of children under the age of five, causing 18% and 15% of all deaths respectively in 2008. Almost ten million children under the age of five die each year, and their leading killers are infectious diseases: pneumonia, diarrhea, malaria, measles, and HIV. These figures are an underestimate, because surveillance and reporting networks are woefully deficient in many less-developed countries. The leading infectious killers in the world, according to the WHO, include bacterial, viral, protozoan, and worm diseases. Initially, one would attribute these devastating statistics to the poverty associated with developing nations, but, as surprising as it may seem, in the United States infectious diseases remain in the top ten causes of death (**FIGURE 1.3**). No wonder the director-general of WHO stated in a 1996 report, "We stand on the brink of a global crisis in infectious diseases. No country is safe from them. No country can any longer afford to ignore this threat." This statement remains true.

So what's the bottom line? What grade would the world now be awarded in terms of its success in coping with microbial diseases? Certainly, under

BOX 1.1 Quotations Relating to Health and Infectious Disease

He who cures a disease may be the skillfullest, but he that prevents it is the safest physician.

—Thomas Fuller, English clergyman and historian in 1650

Not a single year passes without [which] . . . we can tell the world: here is a new disease!

—Rudolf Virchow, German doctor of medicine in 1867

The ideal way to get rid of any infectious disease would be to shoot instantly every person who comes down with it.

—H. L. Mencken, American writer in 1910

Germs come by stealth
And ruin health
So listen, pard,
Just drop a card
To a man who'll clean up your yard
And that will hit the old germs hard.

—Sinclair Lewis, *Arrowsmith*, 1925

Infectious disease is one of the few genuine adventures left in the world. The dragons are all dead and the lance grows rusty in the chimney corner. . . . About the only sporting proposition that remains unimpaired by the relentless domestication of a once free-living human species is the war against those ferocious little fellow creatures, which lurk in the dark corners and stalk us in the bodies of rats, mice, and all kinds of domestic animals; which fly and crawl with the insects, and waylay us in our food and drink and even in our love.

—Hans Zinsser, *Rats, Lice, and History*, 1935

Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity. . . .

—Constitution of WHO, July 22, 1946

Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family including food, clothing, housing, and medical care. . . .

—Article 25, Universal Declaration of Human Rights, adopted by the General Assembly of the United Nations, December 10, 1948

Ingenuity, knowledge, and organization alter but cannot cancel humanity's vulnerability to invasion by parasitic forms of life. Infectious diseases which antedated the emergence of humankind will last as long as humanity itself and will surely remain, as it has been hitherto, one of the fundamental parameters and determinants of human history.

—William H. McNeill, *Plagues and Peoples,* 1976

The microbe that felled one child in a distant continent yesterday can reach yours today and seed a global pandemic tomorrow. Pitted against microbial genes, we have mainly our wits.

—Joshua Lederberg, 1958 Nobel Prize winner, 1988

Pathogenic microbes can be resilient, dangerous foes. Although it is impossible to predict their individual emergence in time and place, we can be confident that new microbial diseases will emerge.

—Institute of Medicine, *Emerging Infections: Microbial Threats to Health in the United States,* 1992

It is time to strengthen our research efforts . . . so that we can unlock the mysteries behind antibiotic resistance and discover new scientific weapons in the battle to detect and control emerging infectious diseases.

—Albert Gore, former vice president of the United States, June 1996

The world may have only a decade or two to make optimal use of the many medicines presently available to stop infectious diseases. We are literally in a race against time to bring levels of infectious disease down worldwide, before the disease wears the drugs down first.

—David Heymann, Executive Director, World Health Organization's Communicable Disease Program, 2000

On a good day, we hold them at bay. On a bad day, they're winning. Our task is a lot like trying to swim against the current of a raging river.

—Michael Osterholm, former Minnesota state epidemiologist and founder of an infectious disease control company, 2000

the leadership of the United Nations, WHO, the CDC, and other organizations, the burden of infectious diseases around the world can be lessened and a higher grade achieved.

In fact, during the 1950s, 1960s, and 1970s microbial diseases appeared to be on their way out. It was a span of years heralded by optimism and progress in public health. The first polio vaccine was introduced by Jonas Salk in the 1950s and ushered in a time of successful mass vaccination campaigns. Fewer than one thousand polio cases occurred in 1967 in western Europe and North America as compared with over seventy-five thousand in 1955. It appeared that malaria would be taken off the list of diseases "of major importance," according to WHO and the Pan-American Sanitary Conference. The times were good; as the economy of nations improved, poverty decreased, and so did the burden of microbial diseases. A 1966 CDC report, in what might be considered an address on the state of the union's health, glowed with the promise of the conquest of microbial diseases. Further, William H. Stewart, surgeon general of the United States in 1967, told a gathering of health officers that it was "time to close the book on infectious diseases and shift all national efforts to chronic diseases." Stewart's optimism was echoed by health officials in other developed nations of the world.

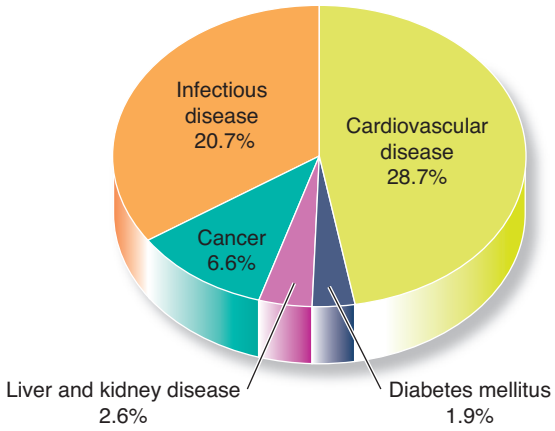


FIGURE 1.2 The five leading causes of death from disease. There were 59.4 million deaths worldwide in 2007. Cancers and cardiovascular, respiratory, and digestive diseases can also be caused by infections, and thus the percentage of deaths due to infectious diseases may be even higher than shown. *Source:* World Health Organization, *World Health Statistics,* 2008.

Fortunately the advice to "close the book" was not heeded nor was the optimism in developing countries—countries that constitute a large part of the world's population. Consider that from 1980 to 1992 alone, the CDC reported a 22% increase in infectious diseases (excluding AIDS). Data presented in a 1996 article published by the *Journal of the American Medical Association* indicated a greater than 50% increase in deaths caused by microbes in the United States since 1980. Despite the tremendous strides in infectious disease control over the past century, data from the U.S. National Center for Health Statistics indicate that microbial disease remains as a leading cause of death in the United States (Figure 1.3) But the scientific community was slow to acknowledge that the bubble of antisepsis and disease control was about to burst.

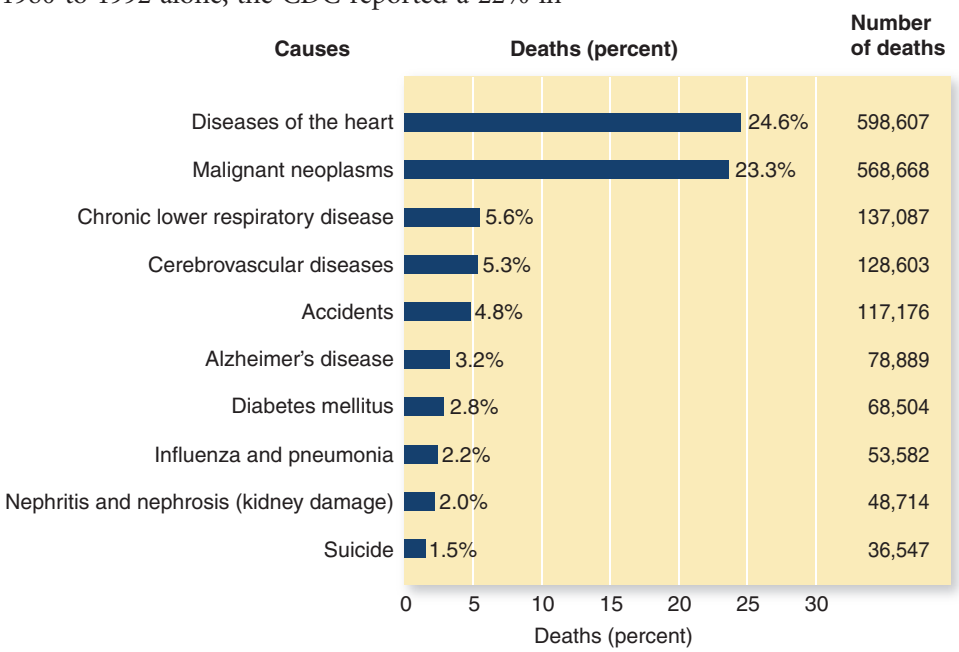


FIGURE 1.3 Leading causes of death in the United States. Data from *Deaths: Final Data for 2009, National Vital Statistics Reports,* Vol. 57, No. 4, March 16, 2011, National Center for Health Statistics/CDC.

Why were new diseases emerging and older ones reemerging with a vengeance, as it sometimes appeared? The 1992 Institute of Medicine's report, *Emerging Infections: Microbial Threats to Health in the United States,* warned that microbes

were winning the battle and that our previous complacency and optimism had weakened our ability to counterattack. Essentially, it appeared that the choreography of adaptation between microbes and humans was beginning to come apart at the seams because of a variety of linked and overlapping factors considered below: world population growth, urbanization, ecological disturbances, technological advances, microbial evolution and adaptation, and human behavior.

Factors Responsible for Emerging Infections

Infections are a part of civilization and actually predate civilization. Microbes and men co-exist and share the same ecosystem. Diseases have threatened since ancient times as evidenced by numerous references in the Old Testament and other sources of antiquity; "pestilence" and "plague" speak of them. Major factors involved in the emergence are discussed in this section (TABLE 1.2).

TABLE 1.2 Factors Responsible for Emerging Diseases

World population growth	Microbial evolution and adaptation
Urbanization	Antimicrobial resistance
Ecological disturbances	Evasive strategies
Deforestation	Human behavior and attitudes
Climatic changes	Complacency
Natural disasters (drought, floods)	Migration
Technological advances	Societal factors
Air travel	
Transfusion of unsafe blood	

World Population Growth

Planet earth is rapidly approaching a population of seven billion people, with a growth rate at 1.092%. The United Nations estimates world population to reach 9.3 billion by 2050 and the latest long-range projection to reach 10.1 billion by 2100 (FIGURE 1.4). To add to the problem of the burgeoning population, 80% of the population is living in less-developed countries (of which 60% are tropical and subtropical areas) with a diminished capacity to cope with population increase. Several factors have been cited for the current crisis of new and emerging infectious diseases, but the population explosion is central to the issue (FIGURE 1.5).

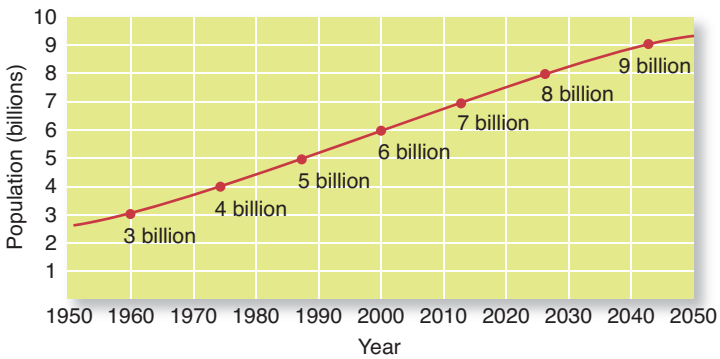


FIGURE 1.4 World population, 1950–2050. Projections are based on an estimated annual growth rate of 1.092%. *Source:* United Nations. *World Population Prospects: The 2010 Revision.*

Thomas Malthus' (1776–1834) *An Essay on the Principle of Population as It Affects the Future Improvement of Society* warned of the negative influence that unchecked population growth could have on societies,

primarily because of inadequate supplies of food. (Charles Darwin's insights into evolution and the process of natural selection were strongly influenced by Malthus.) It appears that Malthus was right, as evidenced by famine in Africa and in other parts of the world over the past 100 or more years. But there is another negative consequence of overpopulation: transmission of infectious diseases. The total population of a country or a region, in itself, is not as crucial as its population density—the number of people per square kilometer in a defined area. Microbe-caused diseases can be transmitted by person-to-person contact, by **biological vectors**, including mosquitoes, ticks, lice, and flies, and by animal to human contact (**zoonotic diseases**) but whatever the mode of transmission, population density is a significant factor. Consider, for example, a classroom with fixed dimensions and assume that one person in the class has a cold, but there are only ten other students randomly spaced throughout the room; on the other hand, consider the same classroom with sixty students. Clearly, the chain of transmission is fostered in the larger population, simply because respiratory droplets are able to traverse the shorter distance from contact to contact when the population density is higher.

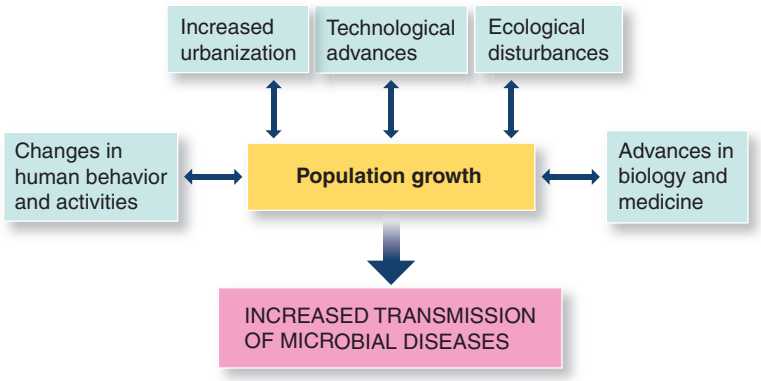


FIGURE 1.5 Population explosion: the "hub" of the problem.

The age distribution of the population is also of considerable significance in terms of the risk factors. For example, in the United States people over age sixty-five constituted 38.6% of the population in 2010. Elderly populations are more susceptible to microbial diseases, presumably because the strength of their immune system has declined. They serve as an increasing source of infection for family and community members. The point is that predictors of infectious disease need to take into account not only the total population and population density but also the demographics of age distribution in that population.

As the world population increases, there are a number of consequences that foster an increase in infectious diseases (**TABLE 1.3**). For example, Dhaka, the capital city of Bangladesh, has many slum areas. Bangladesh is one of the world's most populous countries, with approximately 150 million people. Population control is Bangladesh's most urgent problem, along with the attendant low per capita income. As would be expected, high levels of malnutrition exist, with much of the population getting less than one-third of the normal food intake because agricultural production has not been able to keep pace with population growth. The consequences in terms of infectious diseases, particularly diarrhea, due to poverty and poverty-related conditions are dramatic.

Urbanization

At an international conference Gerard Piel, an authoritative scientific journalist, stated that "the world's poor once huddled largely in rural areas. In the modern world they have gravitated to the cities." The following story is indicative of the depth of despair suffered by many in the world: Zaynab Begum lives in Bangladesh in a Dhaka slum, along with her husband and three children in a primitive hut, less than six square meters in size, constructed of bamboo and makeshift materials.

TABLE 1.3 Potential Effects of World Population Growth on Variables Related to Emerging and Reemerging Infections

Increased potential for person-to-person disease spread
Greater likelihood of global warming
Larger numbers of travelers
More frequent wars
Increased numbers of refugees and internally displaced persons
Increased hunger and malnutrition[a]
More crowding in urban slums
Increased numbers of people living in poverty
Inadequate potable water supply[a]
More large dam construction and irrigation projects

[a]New technologies could prevent or minimize these effects.
Reprinted from D. B. Louria, in *Emerging Infections 1*, W. M. Scheld, D. Armstrong, and J. M. Hughes (ed.), 1998, ASM Press, Washington, DC, with permission.

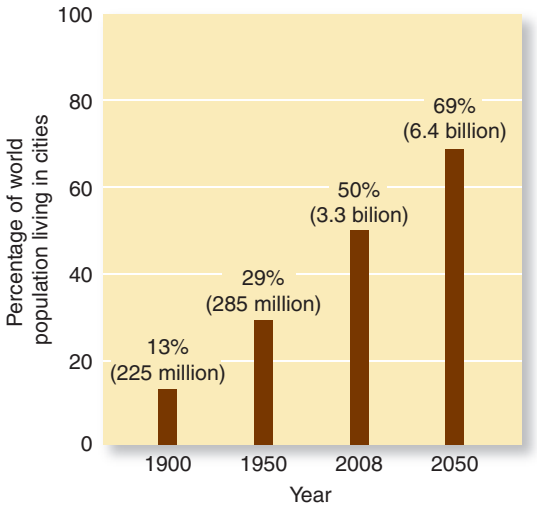


FIGURE 1.6 Progressive urbanization of our planet. Adapted from United Nations, Department of Economic and Social Affairs/Population Division, *World Urbanization Prospects: The 2009 Revision* (2010).

There is no electricity, running water, or toilet, and an open sewer runs outside the hut. Zaynab's husband is a rickshaw puller; her fate is shared by millions of others who have left their villages and migrated to the cities in search of work and a better life. It's a cruel realization that many who migrate to cities in search of a better life now live in urban poverty characterized by crowded and substandard housing lacking safe drinking water, inadequate toilets, and tenant's rights.

The trend to urbanization dates back to early in the twentieth century. In 1900 just 13% of the world's population lived in urban areas. According to the 2009 UN *World Urbanization Prospects* report, the percentage has increased to 50.1% in 2009, and is expected to climb to 68.7% by 2050 (**FIGURE 1.6**). The world's ten largest urban areas are listed in **TABLE 1.4**; about half of these megacities are in developing countries. The magnitude of the effect of urbanization on communicable diseases varies dramatically in developed and developing countries, as a function of the economy and the public health infrastructure necessary to cope with the stress of increasing population density. The challenge of maintaining acceptable standards of sanitation and hygiene is far more difficult in

TABLE 1.4 World's Ten Largest Urban Agglomerations in 2011*

1. Tokyo, Japan	6. Mumbai, India
2. Delhi, India	7. New York City, NY-NJ-CT (USA)
3. Seoul, South Korea	8. São Paulo, Brazil
4. Jakarta, Indonesia	9. Mexico City, Mexico
5. Manila, Philippines	10. Shanghai, China

*The rankings vary depending on definition of urban agglomerations and yearly estimates of current population.
Source: Demographia World Urban Areas (World Agglomerations), 7th Annual Edition, April 2011.

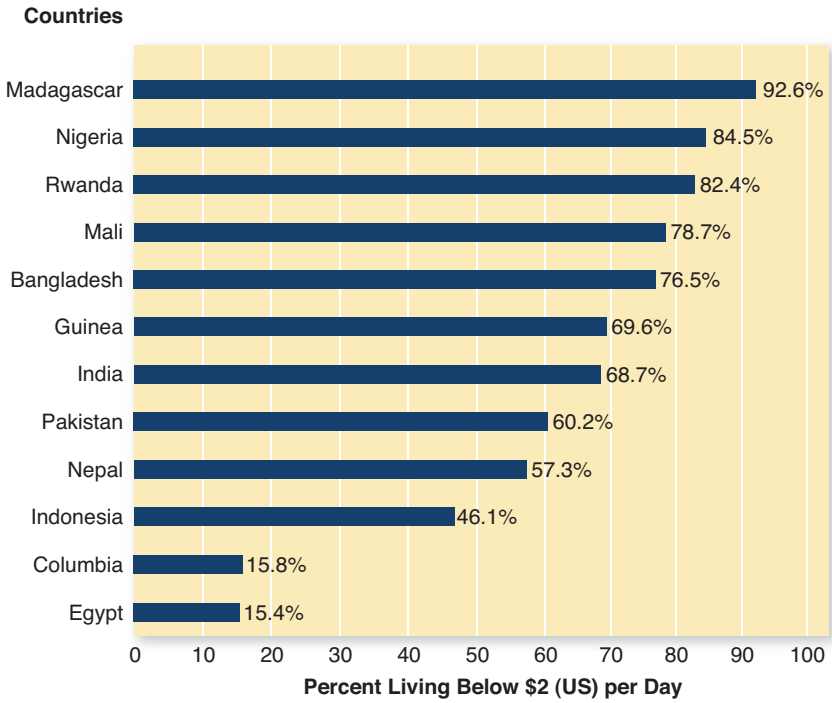


FIGURE 1.7 World's poorest countries. Poverty is especially serious where rapid population growth occurs. *Source: World Bank, 2011 World Development Indicators* (2011).

developing countries, but it is also important to keep in mind that pockets of poverty and despair also exist in the United States and other developed nations (**FIGURE 1.7**).

Urbanization frequently leads to poverty and together set up a cycle of infectious disease (**FIGURE 1.8**). In July 2000 at a meeting of the Group of 8 (G-8) countries (the top seven industrialized countries, plus Russia) in Okinawa, the nations pledged to break the vicious circle of poverty suffered by citizens of developing countries. Sub-Saharan Africa is home to 68% of the world's 33.2 million people living with HIV (**FIGURE 1.9**) because of a variety of factors, an important one of which is poverty-associated urbanization. The drain on natural resources, including safe drinking water, is excessive, whereas at the same time problems of pollution, including human waste disposal and sanitation, are magnified. Untreated human wastes are dumped by the tons into the rivers, streams, and oceans. Ultimately, slums and shantytowns develop. The United Nations estimates half of the population on the African continent—482 million people—live in slums. People live in filth and squalor (**FIGURE 1.10**). Rodent populations increase as sanitation decreases, and the cycle of disease is perpetuated. Rodents may harbor fleas, which transmit a variety of diseases, including the Black Death of fourteenth century Europe, now known simply as the Plague.

AUTHOR'S NOTE (RIK)

I have been to Japan on a few occasions, the first being during my service as a young military officer in the U.S. Army stationed just outside of Japan. I am always impressed with its cleanliness, despite the ever-present crowds.

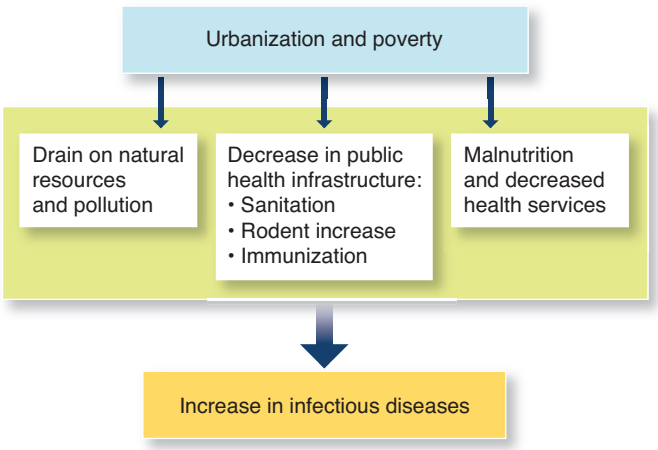


FIGURE 1.8 Relationships among poverty, urbanization, and infectious disease.

Numerous studies have concluded that city dwellers get sick more often than their rural counterparts and that people living in poverty are sick more often. Upton Sinclair's 1906 novel, *The Jungle,* portrayed the unsanitary practices and working conditions, especially for

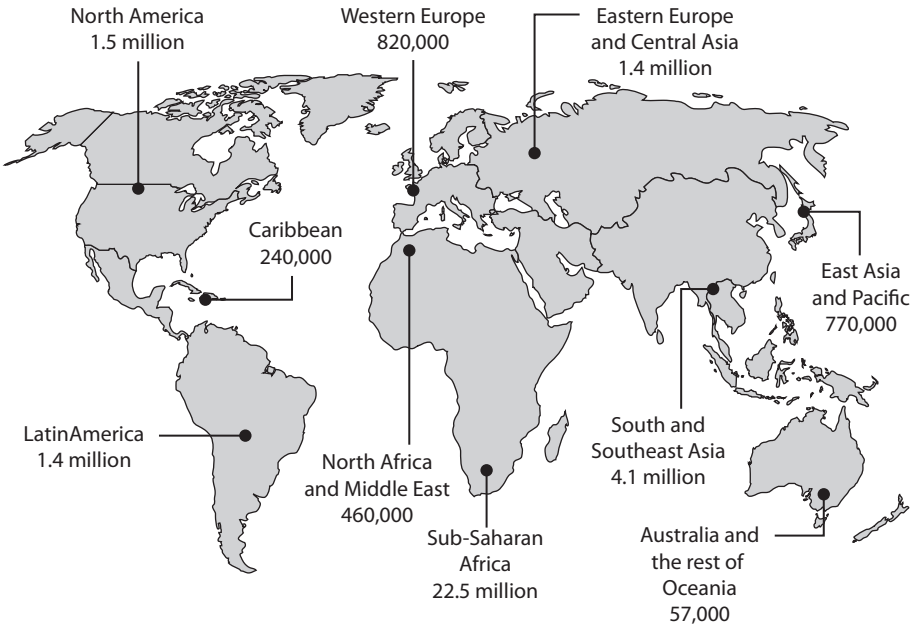


FIGURE 1.9 Global distribution of HIV in 2009. Data from UNAIDS.

(b)

(a)

(c)

FIGURE 1.10. Slums and shantytowns. Poverty is associated with a lack of sanitary facilities, an increase in rodent populations, a lack of safe drinking water, and other circumstances that contribute to infectious diseases. **(a)** A shack in rural Panama. Author's photo (RIK). **(b)** A shanty town in Karachi, Pakistan. © Reuters/Athar Hussain/Landov. **(c)** Individuals walking in the mud of a Nairobi slum, Kenya (October, 2011). © meunierd/ShutterStock, Inc.

BOX 1.2 An Excerpt from *The Jungle*, Upton Sinclair

The Jungle was originally published as a story in a socialist newspaper in 1906 and later republished as a novel. It chronicles immigrants working in a Chicago meatpacking factory.

> *There was another interesting set of statistics that a person might have gathered in Packingtown—those of the various afflictions of the workers. . . . There were the men in the pickle-rooms, for instance, where old Antanas had gotten his death; scarce a one of these that had not some spot of horror on his person. Let a man so much as scrape his finger pushing a truck in the pickle-rooms, and he might have a sore that would put him out of the world; all the joints in his fingers might be eaten by the acid, one by one. Of the butchers and floorsmen, the beef-boners and trimmers, and all those who used knives, you could scarcely find a person who had the use of his thumb; time and time again the base of it had been slashed, till it was a mere lump of flesh against which the man pressed the knife to hold it. The hands of these men would be criss-crossed with cuts, until you could no longer pretend to count them or to trace them. They would have no nails—they had worn them off pulling hides; their knuckles were swollen so that their fingers spread out like a fan. There were men who worked in the cooking-rooms, in the midst of steam and sickening odors, by artificial light; in these rooms the germs of tuberculosis might live for two years, but the supply was renewed every hour. There were the beef luggers, who carried two-hundred-pound quarters into the refrigerator cars; a fearful kind of work, that began at four o'clock in the morning, and that wore out the most powerful men in a few years. There were those who worked in the chilling-rooms, and whose special disease was rheumatism; the time-limit that a man could work in the chilling-rooms was said to be five years. There were the woolpluckers, whose hands went to pieces even sooner than the hands of the pickle-men; for the pelts of the sheep had to be painted with acid to loosen the wool, and then the pluckers had to pull out this wool with their bare hands, till the acid had eaten their fingers off. There were those who made the tins for the canned meat; and their hands, too, were a maze of cuts, and each cut represented a chance for blood poisoning.*

the workers, in the Chicago meatpacking industry (BOX 1.2). Prevention of communicable diseases is a major component of public health and is more problematic in cities than in rural areas and wide-open spaces.

On the other hand, it does not necessarily follow that disease runs rampant in the megacities. Consider, for example, the Tokyo-Yokohama area, ranked as the world's largest urban area (Table 1.4), which is hardly poverty stricken or disease ridden. In fact, population statistics indicate that the Japanese people enjoy the longest life expectancy. The country's economy and public health infrastructure make it possible for them to cope with urbanization. By contrast, in most developing countries the crush of humanity and the tide of urbanization are overwhelming and beyond the financial resources necessary to construct sewage systems and to develop and maintain a public health infrastructure. Laura Garrett, in *The Coming Plague,* refers to cities as "microbe magnets" and "microbe heavens." "Graveyards of mankind" is a term used by British biologist John Cairns.

Ecological Disturbances

Deforestation

Almost half of the earth's forests either no longer exist or have been damaged, possibly to the point of no return, as a result of agriculture, settlement, logging,

FIGURE 1.11 Deforestation. As people move into areas that were formerly forests, there is increased contact with animals, including insects that harbor infectious microbes. Further, the displaced animals return to neighborhoods that were once their lands in search of food. Author's photo (RIK).

and mining over the past 8,000 years. The driving force ultimately, is deliberate and financial—to make money—although wildfires and other natural phenomenon play a significant role.

Deforestation is a major factor in the eruption of emerging and reemerging diseases. Wilderness habitats serve as reservoirs for a large variety of insects and other animals that harbor infectious agents. When the village or town becomes too crowded, whether it is in a poor and developing country or in a developed country, expansion occurs into the surrounding areas for tracts of land on which to build. Generally, the first event to give notice that construction is about to take place is the whine of the chain saws signaling deforestation followed by bulldozers moving in to uproot the tree stumps (**FIGURE 1.11**). Every time a tree is felled or a bulldozer digs up the soil to create another shopping or housing development, microbes and other organisms are displaced. Fungi and bacteria and their spores are released into the environment and may alight and colonize on a human or animal and possibly give rise to a new or reemerging disease. Examples of outbreaks of certain fungal diseases have been reported in construction workers, particularly in the southwest. Perhaps this is what Louis Pasteur was referring to 150 years ago when he advised, "the microbe is nothing; the terrain is everything."

Deforestation favors human intrusion into the environment and fosters contact with wildlife and with insects and plays a major role in the migration of these displaced species into villages, communities, and backyards in search of food. An example is the rise of rabies in the eastern part of the United States as a result of rabies-infected raccoons foraging for food in the garbage cans of suburban and rural communities. Chagas disease is a protozoan disease carried by beetles, commonly called kissing bugs, because they bite on the face and lips where the skin is thin. They are particularly prevalent in Brazil and other areas of South America. In the early 1900s construction of the Central Railroad in Brazil was undertaken through the heavily forested tropical wilderness, a project that necessitated large-scale deforestation. You can guess the outcome—the indigenous mammals were displaced, as were the beetles that fed on them for their blood meal. Humans and their domesticated animals took up the slack and became infected, as did rodents; the latter conveyed the disease to species of beetles that inhabit housing in urban populations.

In 1998 and 1999 a new and deadly virus, named "Nipah," killed more than 100 people in Malaysia after first showing up on a pig farm. It is speculated that the pigs ate dropped fruits infected with the virus, which was then spread to farm workers. Fruit bats, also known as "flying foxes," are the world's largest bats and have been identified as the natural reservoir. In the years preceding the outbreak, massive deforestation took place and scores of fruit trees were destroyed causing the bats to forage elsewhere, including that remote pig farm surrounded by fruit trees.

(a)

(b)

FIGURE 1.12 Leishmaniasis is a protozoan infection transmitted by infected sand flies. **(a)** A leishmaniasis skin ulcer on the hand of a Central American villager. Courtesy of Dr. D. S. Martin/CDC. **(b)** Primitive living conditions in a village in Central America. It occupies an area that was formerly a forest and is encircled by a perimeter of trees. Sand flies are poor fliers but can traverse the short distance from their forest habitat. Author's photo (RIK).

Leishmaniasis, a protozoan disease carried by infected sand flies, is a striking example of the consequence of deforestation and the emergence of urban disease. The disease, once limited to mammals of the forest, is now urban, primarily as a result of deforestation. The circumstances are similar to those described for Chagas disease (**FIGURE 1.12**)

Although it can be an attempt to relieve suffering and death, the intrusion of humans into ecosystems can backfire. Inadequate assessment of the public health impact can inadvertently increase microbial disease. This was the case in the construction of Egypt's one billion dollar Aswan High Dam, a ten-year project completed in 1970. The dam harnessed the uncontrolled Nile River by creating Lake Nasser. (Gamal Abdel Nasser was the Egyptian president from 1956 to 1970.) Unfortunately, the walls of the dam served as a new and convenient habitat for snails. The population of snails boomed, resulting in an increase in the incidence of schistosomiasis, a disease caused by a parasitic worm with a complicated life cycle requiring snails for its completion.

Rift valley fever, a viral hemorrhagic disease carried by mosquitoes, is another example of the downside of the Aswan High Dam project. An epidemic of this viral disease occurred close to the dam area, resulting in illness in 200 thousand people and over 500 deaths. The epidemic was the result of a thriving mosquito population in the flood lands created by the dam.

The most contemporary example of the potential consequences of humans' intrusion into the forest is that of AIDS. Most scientists agree that the origin of human AIDS is the result of the simian immunodeficiency virus (SIV) that made the species leap from infected chimpanzees and sooty mangabeys to humans (**FIGURE 1.13**).

Climactic Changes

What about the effect of climate on the emergence of microbial diseases? There is ample evidence that global warming and climatic changes cause ecological disturbances that affect the incidence and distribution of infectious diseases (**TABLE 1.5**). The twentieth century witnessed an increase in average global temperature attributed largely to the burning of fuels and forests, resulting in an

AUTHOR'S NOTE (RIK)

In the spring of 1999, I spent six weeks in Salvador, Brazil at the Institute for Tropical Medicine in completion of the requirements of the M.P.H. degree at the Harvard School of Public Health to study tropical diseases in the natural context of their host. The last week of my stay was in the Amazon and included a visit to a small village with a high incidence of leishmaniasis. It was readily apparent why this was the case; the village bordered a heavy forest (Figure 1.12). Trees had been felled to allow for the construction of primitive dwellings and yet, less than a mile away, leishmaniasis was not prevalent. The reason—sand flies are poor fliers and could not fly far from the forest. As a result of the deforestation, the village habitants and their dogs provided a blood meal for the sand flies. The old expression, "You can't see the forest because of the trees" has its virtues. Wangari Maathai died on September 25, 2011, at the age of 71. She won the Nobel Peace Prize in 2004 for her work on environmental strategies (and other accomplishments). She founded the Green Belt Movement in Kenya that resulted in the planting of 45 million trees by 900 thousand poor women who received a few shillings for the work.

FIGURE 1.13 The interspecies leap. AIDS, which originated in Africa, is presumed to have jumped the species barrier from infected chimpanzee or sooty mangabeys to humans. Other infectious diseases of humans have made a leap from animals to humans. © Jan van der Hoeven/ShutterStock, Inc.

increase in carbon dioxide and other heat-trapping greenhouse gases. The effects are seen not only in human health but also in the disruption of ecosystems and the resulting interference with food productivity. A meeting of world leaders was held in Kyoto, Japan in 1997 to develop countermeasures against the impending threat; these talks resulted in the Kyoto Protocol.

The following year, 1998, was the warmest year worldwide since 1880 when fairly accurate recordings began. The first two months were dominated by a record-breaking El Niño-influenced weather pattern, with wetter than normal conditions across much of the southern third of the United States and warmer than normal conditions across much of the northern two-thirds of the country. The increasingly high temperature exacerbated the extreme regional weather and climate anomalies associated with El Niño. That year brought into focus what scientists had long hypothesized, namely, that global warming could favor outbreaks of a variety of infectious diseases. Furthermore, seven of the eight warmest years on record have occurred since 2001.

In the case of vector-borne diseases, the vector or the microbe, or both, may be influenced by the temperature. **TABLE 1.6** summarizes data on tropical diseases and indicates the likelihood of alteration in their distribution as a result of climate change. Malaria, a protozoan disease transmitted by mosquitoes, is at the top of the list; an increase in both temperature and rainfall extends habitats favorable to mosquitoes. (On the other hand, increased temperature and decreased rainfall favor the distribution of sand flies, the vectors responsible for transmission of leishmaniasis, a protozoan disease.) Estimates are that an increase in mean ambient temperature in central Africa by 2°C would extend the range of the vectors of sleeping sickness, filariasis, and leishmaniasis, allowing for these diseases of the tropics to invade marginal temperature zones. Further, higher temperatures may push malaria transmission to higher altitudes, causing epidemics, as has

TABLE 1.5 Infectious Diseases Linked to Climatic Changes

Disease	Biological Agent	Transmission
Malaria[a]	Protozoan	Mosquitoes
Rift valley fever[a]	Virus	Mosquitoes
Hantavirus[a]	Virus	Mice
Cholera[a]	Bacterium	Waterborne
E. coli infection	Bacterium	Waterborne
Cryptosporidiosis	Protozoan	Waterborne
Hepatitis	Virus	Waterborne
Leptospirosis	Bacterium	Waterborne
Lyme disease	Bacterium	Ticks
Dengue (breakbone) fever	Virus	Mosquitoes
West Nile encephalitis	Virus	Mosquitoes

[a]Directly related to El Niño.

TABLE 1.6 Status of Major Vector-Borne Diseases and Predicted Sensitivity to Climate Change

Disease	Vector	Population at Risk, in Millions[a]	Prevalence of Infection	Present Distribution	Possible Change of Distribution as a Result of Climatic Change
Malaria	Mosquito	2,400	300–350 million	Tropics, subtropics	Highly likely
Dengue	Mosquito	1,800	10–30 million	All tropical countries	Very likely
Schistosomiasis	Water snail	600	200 million	Tropics, subtropics	Very likely
Onchocerciasis	Black fly	123	17.5 million	Africa, Latin America	Very likely
Lymphatic filariasis	Mosquito	1,100	117 million	Tropics, subtropics	Likely
Yellow fever	Mosquito	450	More than 5,000 cases	Tropics, S. America, Africa	Likely
Leishmaniasis	Sand fly	350	12 million infected, 500,000 new cases per year	Asia, southern Europe, Africa, Americas	Likely
African trypanosomiasis	Tsetse fly	55	250,000–300,000	Tropical Africa	Likely

[a]Based on a world population estimate of six billion.

Adapted from Vital Climate Change Graphics. UN Environment Programme (UNEP) and GRID-Arendal 2000.

occurred in the highlands of Ethiopia and Madagascar. In Rwanda in late 1987, malaria incidence increased by 337% over the previous three-year period as a result of increases in temperature and rainfall. In the last decade the reported cases of malaria (the form of malaria with the highest fatality rate) in the North-West Frontier Province of Pakistan rose from a few hundred in 1983 to more than twenty-five thousand in 1990. This dramatic rise is attributed to unusually high temperatures at the end of the normal malaria season that extended the season. Malaria, tickborne encephalitis, and leishmaniasis (carried by sand flies) are on the upswing in Italy as a result of climate change according to an Italian environmental organization.

In hantavirus, the cause of a potentially fatal disease emerged in the Four Corners area of the United States (where New Mexico, Utah, Colorado, and Arizona meet). The disease is transmitted by deer mice, the principal animal hosts of the virus, which feed on pine kernels. Higher than normal humidity favored an abundant crop of the pine kernels, which, in turn, led to a tenfold increase in the deer mouse population between 1992 and 1993. This is an excellent example of a climatic condition triggering a chain of events resulting in the emergence of an infectious agent. It can happen again.

Diseases in which infectious agents cycle through invertebrates to complete their development are particularly sensitive to subtle climate variations compared with diseases spread from human to human. Hence, it is imperative that consideration be given to and appropriate measures be enacted regarding the influence of global warming and other climatic changes on microbes and their vectors.

Natural Disasters

Floods, hurricanes, earthquakes, drought, landslides, tsunamis, and volcanoes are environmental disturbances that place populations at risk of an increased burden of infectious diseases. In March and April of 2000 severe floods put the people of Mozambique and other southern African countries at risk for several diseases, particularly malaria and cholera. Up to 250 thousand people in Mozambique alone were endangered by these two diseases. According to a WHO press release, "The threat of a malaria epidemic in the country is increasing and will be at its most dangerous in around three to six weeks time as flood waters gradually subside, the rain stops, and warm temperatures return—ideal breeding conditions for mosquitoes. . . . Before the floods, there were between six and ten cholera cases a week; since the floods it has increased to 120 cases per week." Myanmar (formerly Burma) was hit by tropical cyclone Nargis on May 2, 2008 resulting in over 100 thousand deaths because of heavy rains and 12-foot water surges unleashed by the storm. Mudslides were triggered, contaminating wells that were a source of drinking water and blocking latrines, raising pubic health concerns as a result of a breakdown in sanitation.

The news and the photographs from Somalia are truly devastating, particularly those featuring the terribly malnourished and dehydrated. There is little doubt that most, perhaps all, of the population harbors at least one species of worms. Drought is related to increased famine and an increase in infectious diseases, as has been witnessed in eastern Africa since early 1999, placing at least sixteen million people at risk. In Ethiopia alone, about eight million people are affected. The country is the fifth poorest in the world, with an average life expectancy of fifty-seven years, the fifth lowest in the world.

On December 6, 2004, the world was shocked to witness mountains of water cascading on the northwest coast of the island of Sumatra, Indonesia triggered by an earthquake measuring 9.2 (out of 10) on the Richter scale. Natives and tourists ran to high ground for their lives, but an estimated 230 thousand didn't make it and died. Half a million people were displaced from their homes, and thousands remain unaccounted for. The rapid response and level of relief measures from the international community was unprecedented. Almost immediately, groups worked to prevent infectious disease epidemics by providing "clean" water and bed-nets, initiating a measles vaccination program, and working to prevent and treat soil-transmitted worm infections. Although gaps in the public health infrastructure of the area and in the management of catastrophic events were uncovered, no large-scale outbreaks of infectious disease occurred, and mortality from disease was lower than anticipated.

Another natural disaster occurred when Hurricanes Katrina and Rita inundated large sections of New Orleans and surrounding parishes within a month of each other, August 29 and September 24, 2005, respectively (**FIGURE 1.14**). The pictures on television and in the newspapers and magazines were horrific; thousands of desperate people crowded into the New Orleans Convention Center, whereas others clung atop trees and roof tops hoping for rescue from the swirling waters. Surprisingly, there were no major outbreaks of infectious disease, although there were cases of wound and gastrointestinal infection primarily due to exposure to contaminated flood waters. The major microbial

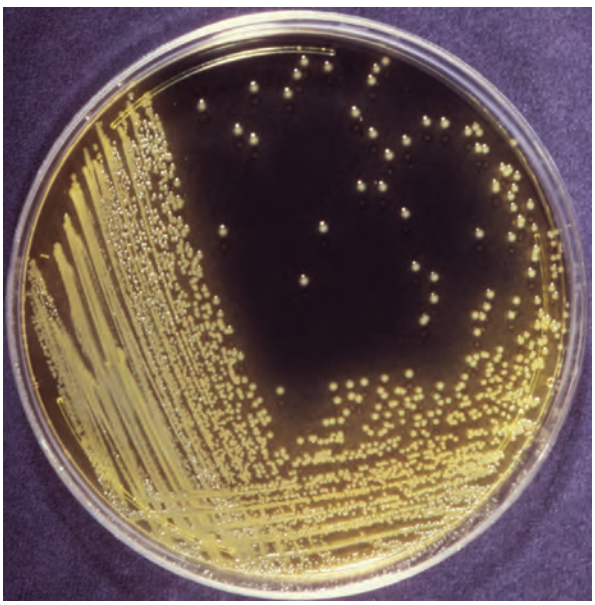
(a)

(b)

FIGURE 1.14 **(a)** A flooded neighborhood in New Orleans as a result of Hurricane Katrina. Courtesy of Jocelyn Augustino/FEMA. **(b)** A New Orleans resident inspects mold damage. Courtesy of Andrea Booher/FEMA.

culprit was mold. As the waters receded, mold thrived and grew in the high humidity and excess moisture. Anyone exposed risked respiratory infections. Further, the CDC reported the occurrence of eighteen cases of wound-associated illness caused by two species of *Vibrio,* five of which resulted in deaths (**FIGURE 1.15**). These infections generally result when open wounds are exposed to warm seawater containing specific vibrios; those with weakened immune systems and the elderly are particularly at risk. More recently, in 2011, wildfires in Texas and Arizona devastated the lives of scores of people and increased the potential for microbial diseases, as did Hurricane Irene. Joplin, Missouri was hit by a tornado in 2011, which ripped through the city. In the aftermath, an unusual

(a)



(b)

FIGURE 1.15 **(a)** An open wound on a hand. © Jonathan Noden-Wilkinson/ShutterStock, Inc. **(b)** A diagnostic culture of *Vibrio cholerae,* the cause of cholera. Courtesy of CDC.

fungal skin infection caused by *Apophysomyces trapeziformis* broke out. (Don't even try to pronounce the name. Also, be assured, the fungus is not related to trapeze artists!)

Life in less-developed countries is a struggle against poverty and disease. Approximately 1.5 billion people do not have access to safe drinking water. The lack of food and water takes its toll on the maintenance of a healthy immune system and leads to high child mortality rates. Natural catastrophic events exacerbate the potential for microbial-caused diseases.

Technological Advances

Human activities lead to technological advances that may pose public health risks; jet travel is an example. It has been well documented that air travel plays a significant role in the transmittance of infectious diseases from continent to continent. TABLE 1.7 lists approximate flying times from New York City to distant places. The farthest destination is Sydney, Australia, taking twenty-two hours, less than the incubation time for many microbial diseases. This means that an infectious traveler could board a jet and arrive at any world destination in less than the time it takes for that passenger to show symptoms (FIGURE 1.16). Such an incident occurred in the spring of 2000: A tourist left Tel Aviv bound for Newark International Airport, an approximately ten-hour nonstop flight, and died of bacterial meningitis approximately two hours after landing. Fortunately, there were no reports of other passengers acquiring the disease. Bacterial meningitis has an incubation period of only a few hours to about two days.

Not so lucky were thirteen travelers infected by a passenger with TB on a flight from Russia to New York. More recently, an international TB scare occurred in May 2007 when an Atlanta man previously diagnosed with an extremely drug-resistant strain of TB (XDRTB) traveled abroad. Although he did have TB, the diagnosis of XDRTB proved to be false. The good news is that none of his fellow passengers on the aircraft became infected. In these cases the best that can be done is to notify other passengers to seek medical advice.

TABLE 1.7 Jet Travel: Microbes Without Passports

Approximate Flying Time From New York City	Incubation Period for Selected Diseases
Sydney, Australia: 22 hours (1 stop)	Whooping cough: 7–10 days
Tokyo, Japan: 14 hours (nonstop)	Gonorrhea: 2–6 days
Tel Aviv, Israel: 10 hours (nonstop)	*Salmonella* food poisoning: 8–48 hours
Nairobi, Kenya: 16 hours (1 stop)	Ebola hemorrhagic fever: 4–16 days
Karachi, Pakistan: 23 hours (nonstop)	Measles: 12–32 days
Dehli, India: 22 hours (1 stop)	Chickenpox: 10–23 days
Moscow, Russia: 10 hours (nonstop)	Influenza: 24–48 hours
	Tuberculosis: weeks to years

Now consider the implications of the Airbus A380—a recently introduced and the world's largest commercial airliner—a super jumbo jet, double-decker, four engine craft with a wing span almost as big as a football field. In a three-class-seating configuration it can carry 555 passengers, but in a one-class-economy seating configuration approximately 850 can be accommodated. From an epidemiological point of view the aircraft is a nightmare—it serves as a huge potential mechanical vector capable of bringing infected people to any part of the world. Infected people can carry microbes to many different, final destinations, and in this way an epidemic can be triggered.

FIGURE 1.16 A flight departure board at an international airport. Jet aircraft, a major technological advance of the twentieth century, serve as vectors for microbes around the world. © Neale Cousland/ShutterStock, Inc.

Microbes can be harbored and transported across borders not only in their human hosts but also in their baggage and personal items. Further, vectors harboring infectious agents can also travel; fleas can be carried in rugs transported by jet cargo from the Middle East and Asia. Public health officials inspect many items being transported from country to country and are authorized to impose quarantine in an effort to minimize the risks.

The use of whole blood and blood products is a life-giving and lifesaving practice. Unfortunately, in some countries blood and blood products may be hazardous to your health. According to the WHO, most of the countries with an unsafe blood supply are developing nations, in which the chances of acquiring infectious diseases are highest. As population pressure increases, so does the demand for blood. In some countries blood is not screened and may harbor the causative agents of HIV infection, hepatitis, syphilis, malaria, and trypanosomiasis. Only recently has the blood supply in the United States been screened for the trypanosome protozoan parasite that causes Chagas disease. Although the disease is primarily spread by the bite of an infected beetle, also referred to as a "kissing bug," it can also be spread by blood transfusions and organ transplants.

To some extent advances in medical technology that make organ transplantation possible contribute to the burden of infectious diseases. Recipients are at increased risk for infection because they are on a regimen of immunosuppressive drugs to minimize organ rejection. It appears that face transplants (both partial and full) are on the map. The first face transplant was performed in France on a woman who was severely mauled by her Labrador dog. The first full facial transplant in the United States was at Brigham and Women's Hospital in March 2011. Other conditions leading to immunosuppression include AIDS, certain inherited diseases, and malnutrition. CT scans, MRI, nuclear medicine, along with other advanced technologies, although life saving in many cases contribute greatly to today's medical costs.

Prostate cancer is the second leading cause of cancer-related deaths in the United States. Transrectal ultrasound-guided biopsies of the prostate gland are common diagnostic procedures. According to the CDC, 624 thousand procedures are performed annually. On July 21, 2006, the CDC reported on four cases of infection caused by *Pseudomonas aeruginosa* after transrectal ultrasound procedures. The infections were caused by contamination of the biopsy equipment

that had not been properly sterilized. The bacterial strains recovered from patients matched the strains recovered from the lumen of the biopsy needle. This is an excellent example of a **nosocomial infection** (hospital-acquired infection); these infections are described in the texts on epidemiology and the cycle of microbial disease.

Advances in food technology make it much easier to eat "on the run" by buying prepared foods in markets and frequenting fast-food restaurants. Obesity is recognized as a major health problem in the United States and elsewhere around the globe. Obesity favors the development of numerous health problems, including susceptibility to microbial diseases.

Near the Fort Myers International Airport in Florida there are many medical specialties, including ones that advertise "eyelid surgery." Who knows, someday perhaps there will be a medical practice with a large billboard advertising "colonoscopies and rectal diseases—back in and open door."

Microbial Evolution and Adaptation

The 1940s ushered in the dawn of antibiotics—agents that were rightfully called "wonder drugs." Penicillin was the first, and numerous others quickly followed; some were tailored to be effective against a broad spectrum of bacteria, whereas others were more specific. It should be emphasized that antibiotics are not effective against viruses and hence should not be prescribed for viral infections. The number of lives saved worldwide over the past fifty-five years because of antibiotic therapy is beyond estimation. An individual today who is infected with a variety of life-threatening bacteria has a fighting chance, assuming antibiotics are administered promptly, whereas an individual infected 50 or 60 years ago had little chance of recovery. The development of antibiotics was a major factor leading to the optimism of the 1970s. Many dread diseases, so it seemed, were about to become vanquished. But it turns out that the tables are turning—antibiotics are losing their punch, and increasing numbers of microbes are resistant. The expression "I'm resistant to such and such an antibiotic" has no meaning; people do not become resistant to antibiotics—their microbes do.

Emblazoned on the cover of the September 12, 1994, issue of *Time* is the headline "Revenge of the Killer Microbes" and the question "Are we losing the war against infectious diseases?" The answer to this question might be an uncomfortable "Yes" (TABLE 1.8). Resistance to antimicrobial agents is at a crisis level worldwide (FIGURE 1.17). Vancomycin, an antibiotic considered by many to be the last stronghold in certain situations, is no longer effective against many bacterial strains that responded ten years ago. Some refer to antibiotic-resistant bacteria as "super bugs." What's happening? To put it in a nutshell, the forces of natural selection are in play. Antibiotics have been grossly misused and have promoted the emergence of antibiotic-resistant organisms in a Darwinian fashion. The antibiotic-resistant strains are the result of chance mutations, and their survival is favored by the presence of antibiotics. Antibiotics are the "selecting" and not the "causing" agent.

The battle against the natural process of microbial adaptation and change, whether exhibited by resistance against antibiotics or by evasive strategies, is an

TABLE 1.8 Drug-Resistant Microbial Diseases

Bacterial Disease	Viral Disease	Protozoan Disease	Fungal Disease
Tuberculosis	HIV infection	Malaria	Aspergillosis
Gonorrhea	Hepatitis B	Visceral leishmaniasis	Candidiasis
Staphylococcal infection	Hepatitis C		Cryptococcosis
Shigellosis			
Typhoid fever			
Pneumococcal pneumonia			
Enterococcal infection			
Acinetobacter infection			

ever-present and ongoing struggle for survival. Failure to meet the challenge affords microbes the upper hand.

Insect vectors are also able to adapt to a changing environment bringing up the issue of climactic change as previously discussed. Malaria, a mosquito-borne protozoan disease, was thought to be a disease of the past, thanks to the application of the insecticide dichlorodiphenyltrichloroethane (DDT). Little did scientists realize that the forces of natural selection would again interfere as a result of the misuse of the insecticide. DDT-resistant mosquitoes emerged with a vengeance, and other vector-borne diseases shared their triumph over DDT. West Nile virus, a mosquito-borne agent, now threatens all of the contiguous United States, prompting ground and aerial spraying. Can insecticide-resistant mosquitoes carrying West Nile virus emerge?

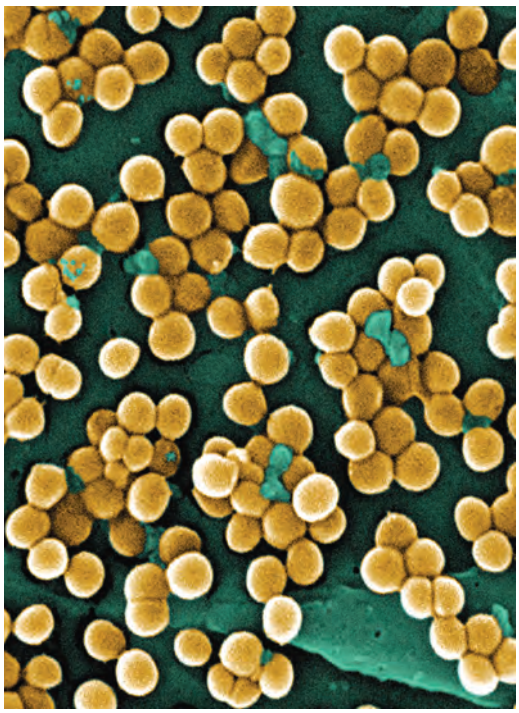


FIGURE 1.17 A scanning electron micrograph of methicillin-resistant *Staphylococcus aureus,* commonly referred to as MRSA. Courtesy of Janice Haney Carr/Jeff Hageman, M.H.S./CDC.

Human Behavior and Attitudes

Complacency

How easy it is to cut corners on health-related matters when it appears that progress and improvement have taken place, leading to the false assumption that prevention and control are no longer necessary. Complacency is the belief that "it can't happen to me." The failure of people to complete their full dose of antibiotics because they are feeling better is a prime example.

A dramatic example of complacency is evident in the threatened resurgence of AIDS, particularly among young gay men, because of a return to risky sexual behavior fueled by glowing reports of new drug therapies for the management of AIDS. At least five million Americans have sex and/or drug habits that put them at high risk for acquiring AIDS. The number of cases in the United States has fallen dramatically since the peak of the 1980s; the decrease is primarily attributed to safer sex habits and avoidance of dirty needles by drug abusers, but public health officials worry that the decrease in cases could cause complacency and result in an increase in the number of cases as people return to unsafe sex practices.

People have become complacent about receiving immunization shots or keeping their immunization boosters up to date. According to the CDC only 80% of two-year-olds in the United States have been given the full sequence of currently recommended immunizations, primarily because of parents' complacency and concern about safety. As an example, consider that in 2005 only about 81% of children between the ages of 19 to 35 months were fully immunized in the state of New York. This could mean trouble down the line. Past history reveals that a 10% decline in measles vaccination between 1989 and 1991 resulted in an outbreak of 55 thousand cases, several thousand hospitalizations, and 120 deaths, indicating the power of immunization. Fortunately, children entering school are required to have proof of being up to date on their immunizations; students entering college must also have proof of being fully immunized. Nevertheless, some slip through the cracks. Individuals traveling to foreign countries need to be aware that particular immunizations may be necessary against diseases prevalent in that area. For example, in 1996 tourists traveling to yellow fever areas neglected to be immunized against the disease and were responsible for infecting others with the disease upon their return to the United States and Switzerland.

Human Migration

Human migration is a major factor in the emergence and reemergence of many communicable diseases. The Population Reference Bureau estimates that in the mid-2000s about 191 million people lived outside their native countries. Populations on the move contribute to the emergence of disease beyond that resulting from voluntary urbanization fueled by a search for a better life. Population movement is frequently not a matter of choice but rather a forced movement because of wars and conflicts resulting from political upheavals. The United Nations defines **internally displaced persons** (**IDPs**) as "Persons or groups of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights or natural or human-made disasters, and who have not crossed an internationally recognized State border." The term ***refugee*** is reserved for those who are forced under the same circumstances to cross an international border. The Office of the UN High Commissioner for Refugees estimates the number of forcibly displaced persons at nearly thirty-three million worldwide. These people carry with them their microbes and microbial vectors, resulting in an exchange with intermingling populations. Malaria is an excellent example; refugees migrating through regions where malaria is endemic can acquire the infection and disseminate the disease to other areas. Malaria is a common cause of death among refugees in numerous countries, including Thailand, Somalia, Rwanda, the Democratic Republic of the Congo, and Tanzania.

Masses of people are forced to settle in uninhabitable environments without adequate shelter, food, clean drinking water, and latrines. Personal hygiene and sanitation may be virtually nonexistent, and what few facilities are available become quickly overwhelmed. People live in filth and squalor. These camps are hotbeds for epidemics, and their potential spreads as refugees continue to flee from

one area to another (**FIGURE 1.18**). The Darfur conflict in western Sudan is a human catastrophe and a worst-case scenario. The United Nations has estimated 200 thousand to 400 thousand have died from violence and disease and another 2.5 million have been displaced to refugee camps. The 2011 drought in Somalia, the worst in 60 years, has forced more than 1,000 people per day to migrate to refugee camps in Kenya. The camps designed for 90 thousand house over 430 thousand refugees. Try to imagine the almost overwhelming public health problems created by the surge of people, many of whom suffer from cholera and other infectious diseases. Maintenance of sanitation and provision of clean water are of the first order.

FIGURE 1.18 A refugee camp. Refugee camps are hotbeds of infection. Crowding and lack of hygiene and sanitation favor the incidence and transmission of disease. © Northfoto/ShutterStock, Inc.

Wars and civil unrest, in addition to creating refugees and displaced persons, disrupt the public health infrastructure and favor the spread of disease. The destruction of housing leads to increased human-to-human and human-to-vector contact; decline in water management programs and a lack of treatment facilities are contributory factors.

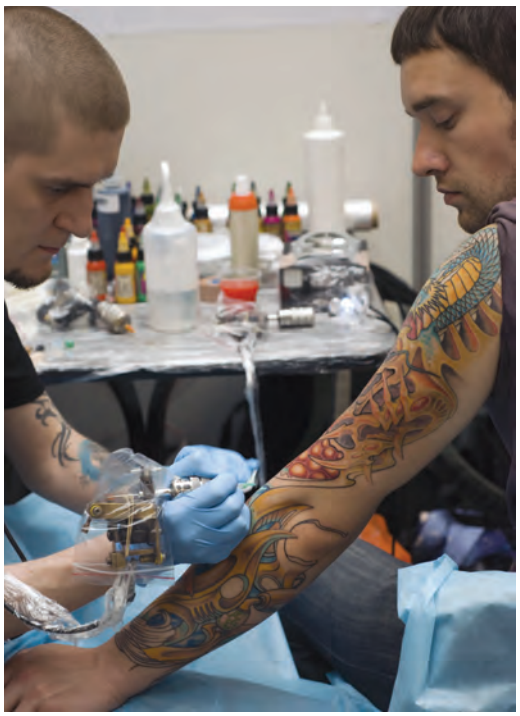
Societal Factors

In many societies, particularly in developed countries, family life and structure have changed as a result of economic growth and increased opportunities for women. In most American families both parents work, leading to an increase in child care centers. Millions of children attend day care centers, which put them at risk for a variety of intestinal parasites, diarrhea, middle ear infections, and meningitis. For example, outbreaks of shigellosis, a diarrheal disease, have caused problems in many day care centers around the country. (To a large extent, the simple act of hand washing by the staff after they change a diaper is an effective control measure.) Children convey the microbes to their family members, many of whom in turn bring their microbes to the workplace.

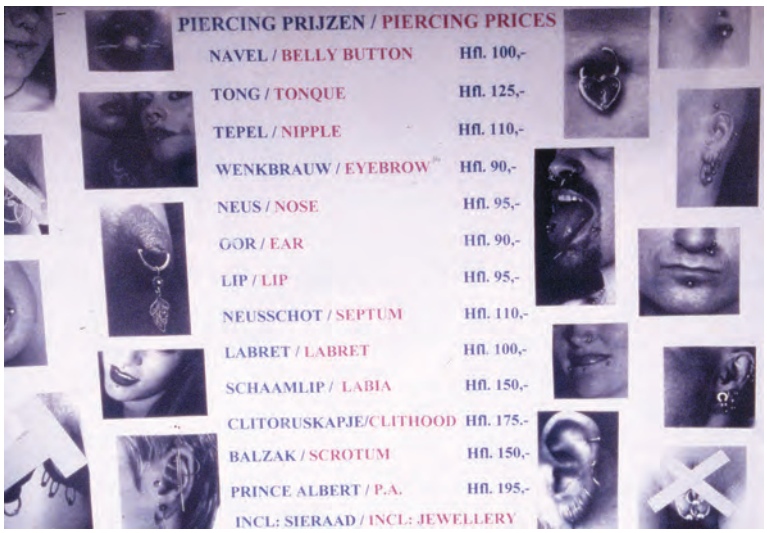
As longevity increases, so does the number of elderly citizens requiring nursing homes, day care centers, and assisted living environments. Like child day care centers, these facilities are potential hotbeds for the emergence and spread of communicable diseases within the resident population and the staff, visitors, and their contacts.

Food production and dietary habits also affect the spread of microbial diseases. Globalization of the food supply, centralized processing, fast-food restaurants, dining out, and take-out food are all significant. Foodborne diseases are a major public health problem in the United States. During the spring and continuing into the summer of 2008, over one thousand cases of salmonellosis occurred in the United States, presumably due to certain varieties of contaminated tomatoes. In 2011, turkey burgers, packaged bags of salad, strawberries, eggs contaminated with bacteria including *E. coli, Listeria* and *Salmonella* were the causes of foodborne illness. Other recent examples of foodborne outbreaks were described earlier in the chapter. In a better economy and a family structure in which both parents work, many people rely more on prepared foods to reduce household chores.

Fast-food restaurants and take-out restaurants are part of our social structure. Food has increasingly become a source of recreation. Consider, for example,



(a)



(b)

FIGURE 1.19 Tattooing and body piercing. Tattooing and body piercing are a risky part of popular culture. The skin is invaded, potentially resulting in serious infections because of the use of unclean instruments. **(a)** Tattoos. © PeterSVETphoto/ShutterStock, Inc. **(b)** Anything goes if the price is right (Amsterdam). Author's photo (RIK).

a typical conversation: "So, what'll we do tonight?" Answer: "Let's eat out!" This is all well and good, assuming that personal hygiene and sanitary control measures practiced by food handlers are not compromised. Television news shows have aired segments featuring high-end restaurants that are enough to make you sick!

Tattooing and body piercing are ancient art forms that have continued through the centuries. In developed countries these practices have long been popular with sailors and bikers. Young people in the 1990s and the new millennium have brought the trend into the mainstream. Tattoo and body piercing parlors are found in many countries, including the United States; for a price you can get just about any part of your body tattooed or pierced (**FIGURE 1.19**). The risk of infection with a variety of microbes, particularly staphylococci, is a real possibility, and patrons are often at risk because of nonsterile instruments and poorly trained personnel. The CDC reported forty-four cases of methicillin-resistant *Staphylococcus aureus* skin infections in Ohio, Kentucky, and Vermont in 2004–2005 as a result of thirteen unlicensed tattooists, presumably because of the use of nonsterile equipment in these three states. *Mycobacterium haemophilus* has also been identified as a cause of infection following tattooing. Even if the establishment is certified by a local health authority, let the buyer beware!

Overview

This chapter makes the case that despite the optimism of forty or fifty years ago, microbial diseases have not been eliminated (with the single exception of smallpox) but continue to flourish as a major cause of mortality and morbidity around the world. The reasons for this are based on world population growth, urbanization, ecological disturbances, technological advances, microbial evolution and adaptation, and human behavior. A quotation from Donald A. Henderson during his tenure as associate director of the U.S. Office of Science and Technology Policy serves as an excellent way to close this chapter:

"The recent emergence of AIDS and dengue hemorrhagic infections, among others, [is] serving usefully to disturb our ill-founded complacency about infectious diseases. Such complacency has prevailed in this country [USA] throughout much of my career. . . . It is evident now, as it should have been then that mutation and change are facts of nature, that the world is increasingly interdependent, and that human health and survival will be challenged, ad infinitum, by new mutant microbes, with unpredictable pathophysiological manifestations."

Self-Evaluation

PART I: Choose the single best answer.

1. In 2011, world population was approaching
   a. 8 billion **b.** 7 billion **c.** 10 billion **d.** more than 12 billion
2. Which one of the following people warned of unchecked population growth?
   a. Satcher **b.** Stewart **c.** Malthus **d.** Darwin
3. In the United States, by 2050 estimates are that people over the age of sixty-five will constitute about what percentage of the population?
   a. 20% **b.** 28% **c.** 39% **d.** not predictable
4. The construction of the Central Railroad in Brazil led to an increase in
   a. leishmaniasis **b.** malaria **c.** tuberculosis **d.** Chagas disease
5. Which of the following is not an emerging or reemerging disease?
   a. common cold **b.** cholera **c.** bird influenza **d.** toxic *E. coli*
6. Which disease has been shown most conclusively to be linked to climate change?
   a. leishmaniasis **b.** *E. coli* infection **c.** leptospirosis **d.** malaria
7. Which of the following is a foodborne illness caused by a microbe?
   a. Dengue fever **b.** coccidioidomycosis **c.** salmonellosis **d.** tuberculosis
8. Tattooing carries a risk of infection. Which organism (or disease) is most likely to be involved?
   a. staphylococci **b.** *E. coli* **c.** meningitis **d.** cryptosporidiosis
9. Which of the following practices is used to prevent malaria?
   a. use of bed nets **b.** antibiotics **c.** vaccination **d.** blood transfusion
10. What is the biological vector that carries the pathogen that causes West Nile encephalitis?
    a. ticks **b.** mosquitoes **c.** fleas **d.** sandflies

PART II: Fill in the blank.

1. Most microbes are beneficial and many are essential to the cycles of nature without which higher forms of life could not exist. True or false? _____
2. In the United States infectious diseases are the leading cause of death. True or false? _____.

3. Name an infectious disease in the "top ten" worldwide. _____
4. Numerous studies have concluded that city dwellers get sick more often than their rural counterparts and that people living in poverty get sick less. True or false? _____
5. According to the U.S. Census Bureau, the world's largest urban area is _____.
6. Give an example of a drag-resistant bacterial disease. _____
7. What does the acronym IDP stand for? _____
8. Deforestation is a major factor in the eruption of emerging and reemerging diseases. True or false? _____
9. Diseases transmitted from animals to humans are called _____ diseases.
10. Infections are a part of civilization and some actually predate civilization. True or false? _____

PART III: Answer the following.

1. List five reasons why infections are emerging and increasing.
2. Choose two of the reasons you gave in question no. 1 and discuss them.
3. Why was the Aswan Dam a "disaster"?
4. Cairns described cities as "graveyards of mankind." Explain.
5. A number of quotations are cited in this chapter. Develop your own quotation that targets the problem of new, emerging, and reemerging infections.
6. Do you believe that a grade of C– should be given to the world for its efforts in coping with microbial diseases. What grade would you award, and why?
7. In 1967 the surgeon general of the United States declared it was "time to close the book on infectious diseases," but events proved otherwise. What was the basis of the surgeon general's remark?
8. Complacency is listed as a major factor responsible for the continued threat of microbial diseases. Describe some specific examples, including examples for which you and family members may be "guilty."
9. Create a list containing at least five drug-resistant diseases and discuss reasons for their development.
10. Explain how technological advances may pose public health risks.