CHAPTER 1

THE SCOPE OF PUBLIC HEALTH MICROBIOLOGY

LEARNING OBJECTIVES

- Describe how public health microbiology fits into the world of public health.
- Contrast medical microbiology with public health microbiology.
- Describe how the development of civilization has both helped and hindered the health of populations.

KEY TERMS

- Biostatistics
- Division of labor
- Environmental health
- Epidemiology
- Health services administration
- Social and behavioral sciences

INTRODUCTION TO THE TOPIC

Public health microbiology is a subdiscipline of environmental health, which itself is one of the five principal areas of public health (**Box 1-1**). Because public health is concerned with the causes of human morbidity and mortality, the scope of its practice is practically universal. It includes the environment in which people live, the attitudes and beliefs that people hold, and the methods that are used to deal with perceived problems. It can include subjects as diverse as infant mortality, folk medicine traditions, blood pressure screenings, irrational fears, lead paint removal, handling of health data, design of health laws and their implementation, and water purification.

The five areas of public health are interconnected and interdependent. **Biostatistics** and

BOX 1-1 The Areas of Knowledge Basic to Public Health

Biostatistics
Epidemiology
Environmental health sciences
Health services administration
Social and behavioral sciences

epidemiology are methods to understand the data that are collected by researchers in the other areas. Epidemiology is used to discern the trends in health and disease and the probable factors involved in these trends, and biostatistics are used to analyze whether those data pass the test of statistical significance. This information allows researchers to pursue cause-and-effect relationships that can then be used to change our environment for the better. **Social and behavioral sciences** concern the human element of public health: people form social organizations (e.g., families, neighborhoods, clubs, etc.) and practices (e.g., habits, addictions, preferences, customs, and traditions) that may affect health and well-being. These stand apart from the more obvious requirements of life—food, water, shelter, warmth—but are every bit as important. Humans are social animals and require personal interactions. It is essential to determine why people do what they do, whether what they do is helpful or deleterious, and how to effectively promote good social and behavioral practices. **Health services administration** concerns the public health policies of a group of people, as expressed through their government and the rules of society. A good example is the campaign against cigarette smoking. While smoking is a legal activity, it is also an unhealthy one. Legal requirements have been put into place to protect nonsmokers from other people's cigarette smoke, and high taxes on cigarettes have been levied to discourage the activity.

Because of its emphasis on the products that people use and the environment in which people live, **environmental health** is the area that is most closely associated with public health microbiology. In essence, environmental health is concerned with the dangers posed to humans from a variety of sources, such as acute chemical exposure, which may lead to acute poisoning, or chronic chemical exposure, which may lead to cancer. Other dangers include injuries from physical dangers, such as high energy sources (e.g., electricity, radiation) and accidents (e.g., falls, motor vehicle accidents, gunfire), and from biological agents (e.g., dog bites, falls from horses, and even bullfighting injuries). Environmental health concerns also include infectious disease and the means by which people encounter pathogens, the agents of infectious disease. Infectious disease comprises such a vast element of environmental health that the topic is most often treated separately.

Public health microbiology is dependent on an understanding of concepts from both environmental health and from microbiology, and it also requires an understanding of concepts from other disciplines such as hydrology, engineering, law, and food science. Throughout this study of public health microbiology, therefore, data from different disciplines will be woven into a core presentation of microbiology. This is the true value of this topic: it not only describes the pathogens and their means of infection but also how we avoid encountering them on individual and societal bases.

WHY STUDY PUBLIC HEALTH MICROBIOLOGY SEPARATELY?

Infectious disease is still a major health problem in the United States (**Table 1-1**) and worldwide (**Table 1-2**). In the United States, the biggest killers are, by far, cancer and heart disease. Both of these diseases can debilitate the patient and create opportunities for infectious disease to do further harm. For example, treatment for cancer involves radiation or chemotherapy, both of which severely weaken the immune system. Lengthy hospital stays, as often happen with cardiovascular disease, often involve invasive procedures and place the patient in proximity to antibiotic-resistant bacteria. Nosocomial (i.e., hospital-acquired) infections remain a huge problem in modern society.

Although industrialized countries have made major strides in preventing and treating infectious diseases, pathogens are still responsible for tens of thousands of deaths and millions of illnesses every year. Deaths attributable to influenza (often accompanied by a bacterial pneumonia), to antibiotic-resistant bacterial strains, and to both bacterial and viral meningitis are not uncommon. Illnesses caused by contaminated water and food number in the millions, and, although the vast majority are mild, a significant percentage require hospitalization. In tropical areas of the world a variety of other pathogens remain as dangerous as ever, including malaria and dengue fever, both of which are transmitted by mosquitoes. Malaria causes nearly a million deaths around the world annually, mostly in

TABLE 1-1 The Top Ten Causes of Death in the United States in 2006

Cause of Death	Number	Percentage
Heart disease	631,636	26.0
Cancer	559,888	23.1
Stroke (cerebrovascular diseases)	137,119	5.7
Chronic lower respiratory diseases	124,583	5.1
Accidents (unintentional injuries)	121,599	5.0
Diabetes	72,449	3.0
Alzheimer's disease	72,432	3.0
Influenza and Pneumonia	56,326	2.3
Nephritis, nephrotic syndrome, and nephrosis	45,344	1.9
Septicemia	34,234	1.4

NOTE: Percentage sums to 76.5% because all other causes of death equal the other 23.5%. No other cause of death exceeds 1.4% of total deaths.

SOURCE: http://www.cdc.gov/nchs/fastats/lcod.htm

TABLE 1-2 The Top Ten Causes of Death Worldwide in 2004

Cause of Death	Number (in millions)	Percentage
Coronary heart disease	7.20	12.2
Stroke and other cerebrovascular diseases	5.71	9.7
Lower respiratory infections	4.18	7.1
Chronic obstructive pulmonary disease	3.02	5.1
Diarrhoeal diseases	2.16	3.7
HIV/AIDS	2.04	3.5
Tuberculosis	1.46	2.5
Trachea, bronchus, lung cancers	1.32	2.3
Road traffic accidents	1.27	2.2
Prematurity and low birth weight	1.18	2.0

NOTE: Percentage adds to 50.3% because all other causes of death equal the other 49.7%. No other cause of death exceeds 2.0% of total deaths.

SOURCE: http://www.who.int/mediacentre/factsheets/fs310_2008.pdf countries where the income level is low. The prevalence of dual infection with the HIV virus and *Mycobacterium tuberculosis* is also a major cause of mortality in many countries (Table 1-2).

A course in microbiology is a prerequisite to a full understanding of this topic. Microorganisms constitute a diverse group of organisms, which are central to the functioning of our ecosystem. Therefore, the student must understand the various groups of microorganisms (**Box 1-2**), how they acquire carbon and energy, what their growth requirements generally are, and how they exist in the greater ecosystem. A vital component is knowing what autotrophs and anaerobes are. Some understanding of disease is also necessary because much of public health microbiology is concerned with avoiding or destroying pathogens. Other vital components include knowing which microbes are pathogenic, understanding the diseases they cause, communicating the importance of each disease to the medical community, and establishing access to the treatment of each disease. However, a course in medical microbiology (the study of pathogenic microorganisms) is not essential. Much of medical microbiology is devoted to the progression of disease after the host has encountered the pathogen and to the ability of the host to defeat the invaders using either the immune system or through medical intervention (e.g., antibiotics). Although these concepts are addressed, the emphasis here is on avoidance of pathogens and infection or on the destruction of pathogens before they can infect the population.

BOX 1-2 The Classes of Microorganisms

Bacteria
Protozoa
Viruses
Fungi (yeast, mold)
Algae

AN OVERVIEW OF THE DISEASE PROCESS

A person may encounter infectious disease in a number of ways. Contaminated drinking water is a major source of exposure, and great efforts are expended in society to reduce or eliminate this particular threat. The chapters on water treatment and waterborne diseases are extensive, reflecting the multiplicities of dangers and the monitoring and treatment methods that are used to counter them. Contaminated food is another obvious threat, especially considering the great variety of foods that people eat. Diseases that are spread through close contact include casual contact (e.g., being the recipient of airborne pathogens through a cough or sneeze), direct contact (e.g., through an insect bite or an inanimate object), and the much more intimate contact required to pass sexually transmitted diseases. Finally, deliberate exposure to pathogens is possible as a result of bioterrorism.

Because public health is concerned mainly with populations rather than individuals, issues of scale are relevant. While the practice of medicine for infectious disease is concerned with the individual patient and the specific disease involved, public health is more concerned with all pathogens, their prevalence, and the methods used to detect their presence and to limit their opportunities to infect people. While individual illness or a small outbreak of cases may be unfortunate, it does not pose a problem for society as a whole. For this reason, the examples shown in the text often describe large outbreaks or citywide problems. The potential for disaster is much greater when a large number of people are dependent on a common factor.

A HISTORICAL PERSPECTIVE

Epidemic illness has been with us since the start of civilization. The Greek historian Thucydides wrote of a plague in Athens in the year 430 AD. By his account nearly a third of the city's population died from this plague, the source and identity of which remains unclear. However, it must have been terrifying, given his description of the symptoms:

> *. . . people in good health were suddenly attacked by violent heats of the head, redness*

> *and inflammation of the eyes, with the inward parts, such as the throat and tongue, becoming bloody and emitting an unnatural and fetid breath. These symptoms were followed by sneezing and hoarseness, after which the pain soon reached the chest, producing a hard cough. When it fixed in the stomach it upset it, causing discharges of bile of every kind named by physicians, and accompanied by very great distress. In most cases also an ineffectual retching followed, producing violent spasms, which in some cases ceased soon after, in others much later.*

We live in a modern, industrialized society, and it can be challenging to acquire a perspective on how our built environment is sometimes less than ideal in terms of health promotion. We have created structures and societies that serve certain purposes, and those purposes sometimes conflict with other purposes, such as avoiding disease. A good example of this concept comes from the time of the Roman Empire, when water pipes and goblets were constructed from lead. The pipes served a very useful purpose in delivering water to people who would otherwise have to carry it great distances, but lead is a toxic metal which, over time, accumulated in the bodies of the citizens. The Romans surely suffered from its effects. Nothing was known about the toxic effects of lead at that time, and some historians have speculated that it was a significant contributing factor in the decline of their empire. Their example makes us cautious today about effects that we may not fully appreciate.

Communities can create their own problems. To grasp the challenge of public health in the modern world, it is helpful to reflect on the beginnings of civilization, approximately 10,000 years ago. In small clans of hunter-gatherers, people searched for food and water and the other necessities of life. This is not a particularly bad way to survive because their diets were usually adequate and varied (and healthy), at least for small groups passing through a region. Such tribes have survived for thousands of years, and nomadic tribes still exist today. However, this lifestyle has distinct disadvantages: sometimes the game disappears and the local plants are not abundant, making starvation an occasional reality. Also, hunting can be a dangerous occupation, and hunters died from infected injuries that we would consider relatively minor.

Another often overlooked advantage of nomadic hunting–gathering was that food was under the direct observation and control of the consumers. If food appeared to be spoiled, they decided whether or not to eat it. If they made the wrong choice, they got sick and perhaps died. But the ultimate responsibility for food and water quality resided with the individual consuming them.

The adoption of agriculture somewhere between 8,000 and 10,000 years ago was a major advance in human development. People still hunted local game, and humans would eventually domesticate animals, but cultivation of food allowed a more stable food supply, while fiber crops (e.g., cotton and flax) became important for clothing. The foods that were selected could usually be stored for extended periods of time, making famine less likely. Occasionally, however, famine did occur due to climactic events such as a drought or a hailstorm or due to a swarm of locusts that destroyed the crops.

People settled in an area because it was amenable to cultivation and because it was near a reliable water supply, such as a river. The variety of foods in the diet declined because a farmer could not grow every plant that existed in the wild, and some crops were simply easier to cultivate than others. But the resulting food supply was usually greater. Early farming settlements were communities, and population density increased.

In these communities the person doing the planting and harvesting was responsible for the quality of the food consumed. But a greater advance in civilization accompanied the concept of **division of labor**. This was a very simple concept that had enormous benefits. For example, in a hunter–gatherer clan each member of the hunting party made his own weapons and used them to kill game. But not everyone excelled at hunting; some were exceptionally skilled at making flint arrowheads and spear points. At some point those making spear points decided to offer them to another hunter—perhaps someone lacking the patience to produce a good spear point—in exchange for part of the kill. This simple barter arrangement represents a division of labor because the two people involved each did something at which they excelled. This method allows each person to get the things he wants, which is another way of saying that it creates a more efficient economy. In fact, our spear-point maker may produce spear points so fast and so well that he created leisure time for himself. Alternatively, he might have started trading them to other clans for their specialty goods (e.g., clothing or jewelry). Hereby the creation of wealth emerged (at least by Neolithic standards). Although this arrangement has many benefits, it has a major drawback. The spear-point maker had given a large measure of responsibility for the quality of his food to the hunter. This simple arrangement should pose few problems; if the hunter traded a piece of spoiled meat the spear-point maker would know immediately and would complain loudly. A wise hunter would trade only good meat for spear points, or he might not get any in the future. Even after the advent of agriculture, this type of trade predominated. One farmer might have abundant wheat that he would trade for a butchered hog. Again, each party could easily determine whether the food was wholesome. Barter arrangements persist to the present day, and actually work quite well, even if they are ultimately limited in scope.

As societies became more complex, other means of supporting workers were needed. The Biblical book of Daniel describes how the young Daniel was educated as a servant of the royal court of King Nebuchadnezzar of Babylonia. The king ". . . appointed them a daily provision of the king's meat, and of the wine which he drank" (King James Version: Daniel chapter 1), indicating that room and board for the servants was provided directly by the king. Daniel and his friends refused the rich food as unhealthy, and they worked out an agreement to eat only vegetables and drink water. After a trial period they were found to be healthier than the other servants. This story suggests the risk of allowing others to prepare food: consumers are never completely certain of its quality.

CIVILIZATION HAS BECOME COMPLEX

A more robust economy required a common medium of exchange, i.e., money. Money promoted a further division of labor because it was storable, portable, and allowed the valuation of certain types of labor that were not easily traded. How could the work of judges, scribes, teachers, and other learned individuals be valued in an ancient society? The earliest recognizable money was probably in the form of precious metals such as gold and silver. While useful in themselves for creating jewelry and decorative objects, they could not be eaten or worn as clothing. Money became a means of exchange for such essential things. With money, a person could not only buy a measure of wheat but he could also let someone else do the milling of the wheat and just buy the flour. Or he could completely skip the steps in food production and buy a meal prepared by someone else. That is, he could have a restaurant meal. Then and now, this is very convenient, and a tremendous number of restaurant meals are consumed every day. However, the consumer of the meal has entirely surrendered control of the quality of the food to someone else, which can be a large disadvantage. In fact, the person responsible for his safety may be a complete stranger. The diner has no idea whether the food preparer uses proper hygiene, is passing off questionable food as fresh, or is even using the ingredients that are claimed. For example, it is not unusual today to find a cheaper grade of fish offered as a more expensive variety to unsuspecting shoppers.

As civilization progressed, specialization of labor increased. The gap between producer and consumer is now vast, and the variety of products offered has become immense. Potential health problems have been magnified by improvements in transportation that allow people and goods to travel thousands of miles in a matter of hours. Not only does modern transportation bring exotic products from all over the world, it also brings exotic diseases. With the advent of air freight, fresh produce can be delivered from South America to North America during the winter months, greatly improving the diets of American citizens and making their meals more varied and interesting.

In a modern, industrialized society, it is simply impractical for individuals to monitor the quality of their food. Complexity requires that an impartial authority—the government—must set appropriate rules for food handling and must monitor the process for safety. We give the government the authority to establish safe practices, to monitor production, and to punish those who put people at risk by breaking the rules. A major element of trust is involved with this authority; we expect them to be effective and impartial sentinels. The study of public health microbiology requires an understanding of the authorities (i.e., federal, state, and local) that affect processes and the most important rules and regulations at work in the food industry, i.e., effective regulation does not interrupt the supply of food and drink. In a complex, integrated world every nation is under threat from infectious disease, and our awareness of just how many pathogens exist and how they can become epidemic problems encourages us to adopt preventative measures (Fauci et al., 2005).

A simple analogy is helpful in thinking about public health microbiology: a community is much like the body of a single organism. The body needs to consume wholesome food and water and to remove waste products so that they no longer pose a health threat. The body also needs uncontaminated air to breathe, and it must take active measures to avoid other sources of infection, such as sexually transmitted diseases, exotic (unexpected) pathogens, and deliberate exposures. A healthy body—and a healthy community—is aware of the sources of pathogens and the risks of exposure. It takes active measures to avoid unnecessary exposure and to incorporate effective procedures to stay healthy. The active measures that we take to protect our citizens are both complex and effective; skilled workers are necessary to maintain that level of safety. Most people never think about the people who purify their water, treat their wastewater, and monitor their food supply, but without them we would all be at greater risk of disease.

QUESTIONS FOR DISCUSSION

1. Which innovations of the past century have contributed to public health? Which of them also have significant unintended deleterious outcomes?
2. How are the various fields of public health interdependent?
3. How do public health and medicine complement each other?
4. Can you foresee a public health problem arising in the future based on your experience today? How could it be avoided?

Reference

Fauci, A.S., N.A. Touchette, and G.K. Folkers. 2005. Emerging infectious diseases: a 10-year perspective from the National Institute of Allergy and Infectious Diseases. Emerg. Infect. Dis. 11:519–525.