INTRODUCTION TO

Public Health

Third Edition

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CHAPTER

9

The "Conquest" of Infectious Diseases

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Throughout history, until the beginning of the 20th century, infectious diseases were the major killers of humans. Bubonic plague, the "Black Death," is said to have wiped out as much as 75 percent of the population of Europe and Asia in the 14th century. Tuberculosis was the number one killer in England in the mid-19th century. An example of the toll of infectious diseases is demonstrated in **Figure 9-1**, which provides death rates of the population of New York City over the period 1804 to 2000. Epidemics of smallpox and cholera swept through the city every few years, killing many people in each wave. In the mid-19th century, background mortality rates—largely from tuberculosis, typhoid, and miscellaneous respiratory and gastrointestinal diseases—were double what they became by 1930.

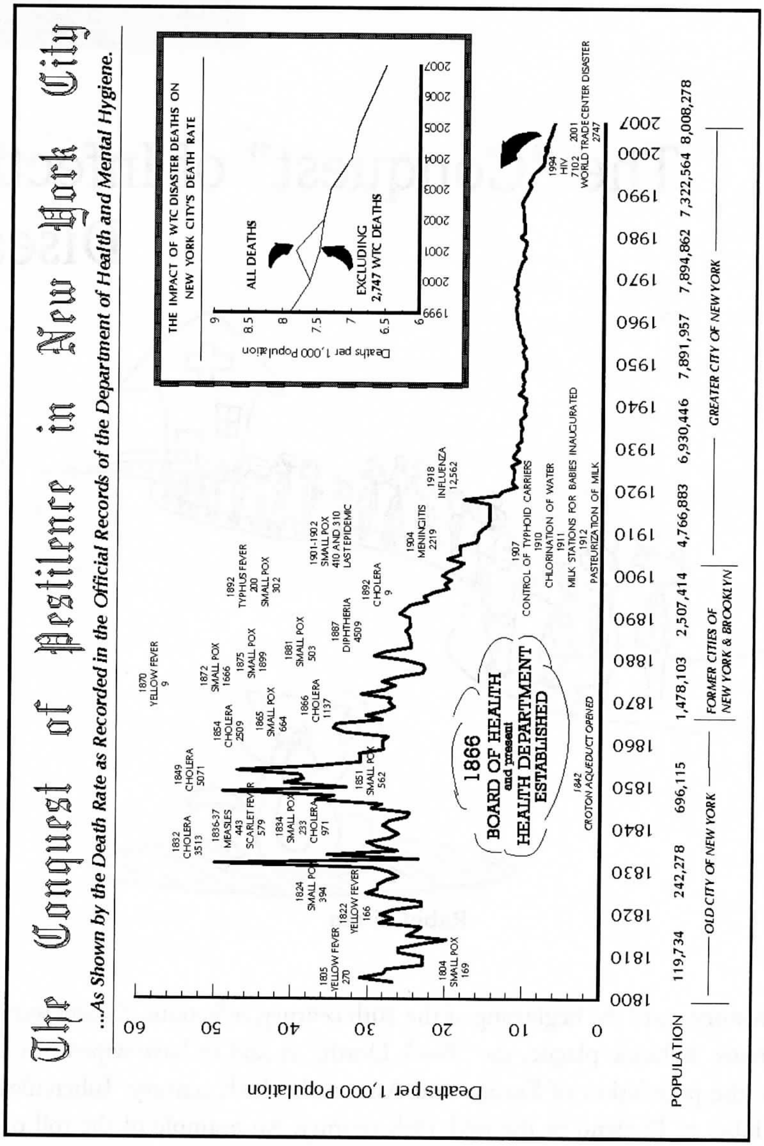
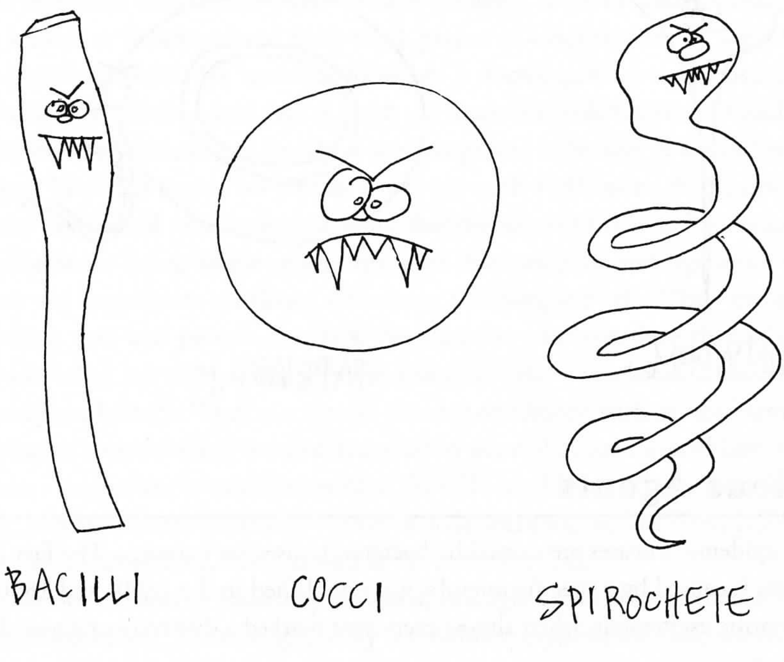
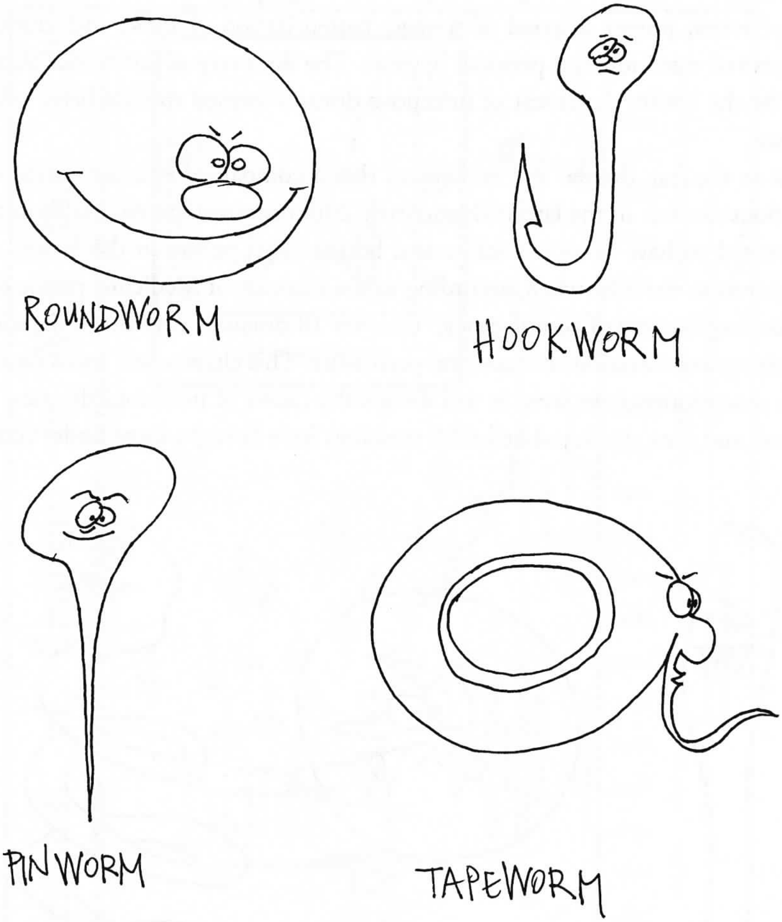


FIGURE 9-1 Death Rates in New York City, 1804–2007. *Source:* New York City Department of Health and Mental Hygiene, Bureau of Vital Statistics. www.nyc.gov/html/doh/downloads/pdf/vs/2007sum.pdf. 2007 (Accessed November 6, 2009).

These infectious diseases were largely conquered through public health measures, including purification of water, proper disposal of sewage, pasteurization of milk, and immunization, as well as improved nutrition and personal hygiene. The discovery of antibiotics also played a role. In fact, by the 1960s, the threat of infectious diseases seemed to have been reduced to a minor nuisance.

In contrast to the fear, drama, and excitement that accompanied efforts to understand and control infectious diseases in the late 19th and early 20th centuries, public health in the 1960s and 1970s seemed to have become routine and boring. This period in the history of public health corresponds to the time when, according to the Institute of Medicine, public health was falling into disarray because of complacency.[1] Chapter 10 discusses why the declaration of victory in the war against infectious diseases was premature. This chapter will focus on the battles public health practitioners have won. It will discuss the causes of infectious diseases, how they are transmitted, and how classic public health measures have brought them under control.





Infectious Agents

The major epidemic diseases are caused by bacteria, viruses, or parasites. The fact that each of these diseases is caused by a specific microbe was established in the 1880s and 1890s, at a time of great scientific excitement, when almost every year marked a discovery of a new disease-causing bacterium.

Robert Koch, a German physician, developed techniques to classify bacteria by their shape and their propensity to be stained by various dyes. Since billions of bacteria—most of them harmless to humans—inhabit the skin, throat, mouth, nose, large intestine, and vagina, it was necessary to develop a set of rules that could be used to prove that a specific organism caused a specific disease. These rules, called "Koch's postulates," are (1) the organism must be present in every case of the disease; (2) the organism must be isolated and grown in the laboratory; (3) when injected with the laboratory-grown culture, susceptible test animals must develop the disease; and (4) the organism must be isolated from the newly infected animals and the process repeated.[2]

Koch applied these rules in his proof that tubercle bacilli were the cause of tuberculosis, the leading cause of death in Europe at that time. Bacilli are bacteria that appear rod-shaped when observed under the microscope. Koch identified another bacillus, *Vibrio cholera*, as the cause of cholera. Other disease-causing bacilli identified during that period were those that cause plague, typhoid, tetanus, diphtheria, and dysentery.

Round-shaped bacteria, called *cocci*, include *streptococci*, which cause strep throat and scarlet fever; *staphylococci*, which cause wound infections; and *pneumococci*, which cause pneumonia. Syphilis is caused by a corkscrew-shaped bacterium called a spirochete. All these bacteria were identified by the beginning of the 20th century.

For some infectious diseases, however, no bacterial agent could be found. Smallpox, for example, was known to be transmitted from a sick person to a healthy one by something in the pus of the patient's lesions. Yet attempts to isolate a microorganism were unsuccessful. The agent that caused the disease could pass through the finest available filters and could not be observed in any existing microscope. Smallpox was recognized to be one of a number of diseases caused by such "filterable agents" or viruses. It was not until 1935, when the American scientist W. M. Stanley crystallized tobacco mosaic virus, that the nature of viruses was demonstrated.

While bacteria are living, single-celled organisms that can grow and reproduce outside the body if given the appropriate nutrients, viruses are not complete cells. They are simply complexes of nucleic acid and protein that lack the machinery to reproduce themselves. Various kinds of viruses infect not only animal cells but also plant cells—as tobacco mosaic virus infects tobacco—and even bacteria. They can survive extreme conditions such as treatment with alcohol and drying in a vacuum and become active again when they are injected into a living cell. They reproduce themselves by taking control of the cell's machinery, often killing the cell in the process. The human diseases caused by viruses include smallpox, yellow fever, polio, hepatitis, influenza, measles, rabies, and AIDS, as well as the common cold.

Human diseases can also be caused by protozoa, or single-celled animals that can live as parasites in the human body. Malaria, spread by mosquitoes; cryptospiridiosis, which caused the Milwaukee diarrhea epidemic; and giardiasis, also known as "beaver fever" are examples of protozoal diseases. Other parasites, such as roundworms, tapeworms, hookworms, and pinworms, are the most common source of human infection in the world. Except for pinworms, they are not common in the United States today.

Means of Transmission

Infectious diseases are spread by a variety of routes, directly from one person to another or indirectly by way of water, food, or vectors such as insects and animals. Bacteria and viruses that cause respiratory infections, including colds, influenza, and tuberculosis, are transmitted through the air on aerosols, water droplets produced when an infected person coughs or sneezes. They can also be transmitted from an infected person to objects he or she touches, such as doorknobs, utensils, or towels, to be picked up by the next person to touch the contaminated object and transferred by hand to the nose. The early European settlers made use of this route of transmission to inflict a primitive form of germ warfare on the Native American people, giving them blankets that had been used by patients suffering from smallpox. The disease decimated Native American populations because they had no immunity to the virus.

Gastrointestinal infections such as cholera, cryptospiridiosis, and diphtheria, are generally spread by the fecal–oral route, by which fecal matter from an infected person reaches the mouth of an uninfected person. This may occur as a result of poor personal hygiene or by contamination of drinking water because of inadequate sanitary systems. Vector-born diseases, including malaria, yellow fever, and West Nile encephalitis, generally use a more complex route from one person to another, most often through an insect.

Each disease has its own pattern of development after a person is infected, and the time during which the patient is capable of transmitting the infection to others varies from one disease to another. Some diseases are most likely to be transmitted during the most symptomatic phase, for example, when a patient suffering from tuberculosis or the common cold is most actively coughing and sneezing. Others, such as measles and mumps, are most communicable during the day or two before noticeable symptoms develop. A few diseases can exist in a carrier state, in which the infected person can transmit the disease without having symptoms, as demonstrated by the infamous case of Typhoid Mary.[3]

Mary Mallon worked as a cook in a series of wealthy New York homes at the beginning of the 20th century. After an increasing number of family members in these homes became sick with typhoid fever, some of them fatally, suspicion fell on the cook. Because she was healthy, and because cooking was the only way she knew to support herself, Mary resisted medical tests and, when finally proven to be a carrier of the bacteria, refused to accept the results. Eventually she had to be incarcerated to prevent her from taking jobs where she spread the disease by the fecal-oral route. She remained in the custody of the New York City Health Department for the rest of her life. It was Mary's occupation, of course, that made her such a threat to the public health. The discovery of antibiotics, too late to help Mary, made it possible to eliminate the bacteria in typhoid carriers. However some viruses, such as herpes and hepatitis B, can persist in carrier states, and no treatment is known to eliminate them.

Chain of Infection

Control of infectious diseases is still an important component of public health. The public health approach to controlling infectious diseases is to interrupt the chain of infection. Many methods used to accomplish this interruption have now become routine, but vigilance is always required.

The chain of infection, a term used to describe the pattern by which an infectious disease is transmitted from person to person, is composed of several links, as illustrated in **Figure 9-2**. These are listed here:

1. Pathogen. The pathogen is a virus, bacterium, or parasite that causes the disease in humans.
2. Reservoir. The reservoir is a place where the pathogen lives and multiplies. Some pathogens spread directly from one human to another and have no other reservoir. Others, however, may infect nonhuman species, spreading from them to humans only

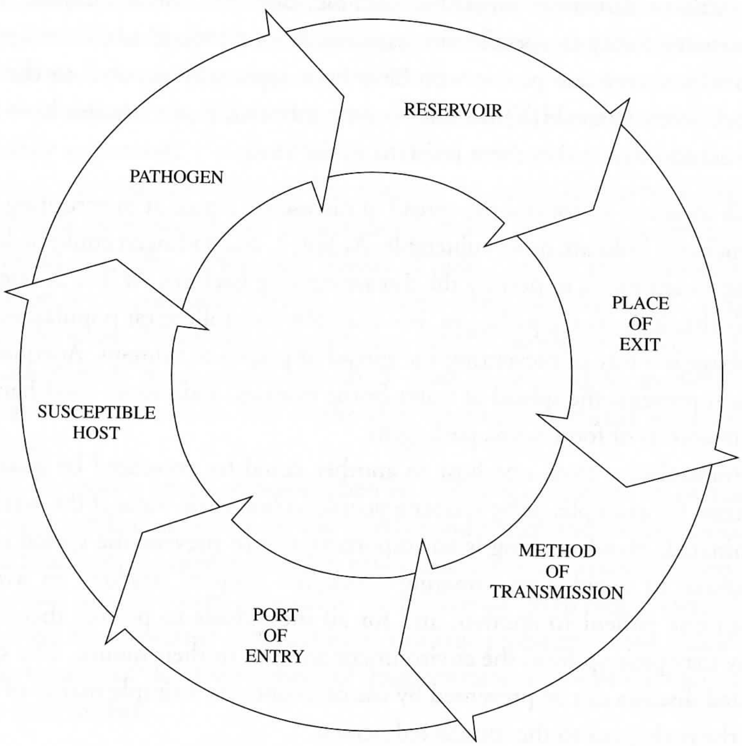


FIGURE 9-2 Chain of Infection. *Source:* Henry Schneider

occasionally. Plague, for example, is a disease of rodents that is transmitted to humans by the bite of a flea. Rats are the reservoir of plague. Raccoons and bats are reservoirs for rabies, which spreads to humans only through the bite of a rabid animal. Contaminated water or food may also serve as reservoirs for some human diseases.

3. Method of transmission. The pathogen must have a way to travel from one host to another, or from a reservoir to a new host. The flea is a vector for plague, transferring the plague bacillus from rat to human by sucking it up when it bites the rat and then injecting it into a human host with a second bite. Food-borne diseases are transmitted when a person eats contaminated food; water-borne diseases are transmitted when someone drinks contaminated water. Many respiratory diseases are transmitted by aerosol. AIDS, syphilis, gonorrhea, and a number of other diseases are transmitted by sexual contact.
4. Susceptible host. Even if the pathogen gains entry, a new potential host may not be susceptible because the host has immunity to the pathogen. Immunity may develop as a result of previous exposure to the pathogen, or the host may naturally lack susceptibility for a variety of reasons. Most microorganisms are specifically adapted to infect certain species. Canine distemper virus, for example, does not infect humans. Even within species, susceptibility to specific viruses varies among individuals. Scientists have been puzzled why a very few people who have been repeatedly exposed to the human immunodeficiency virus (HIV) do not become infected; recent studies have found a genetic mutation that makes them resistant to the virus.

Public health measures to control the spread of disease are aimed at interrupting the chain of infection at whichever links are most vulnerable. At link 1, the pathogen could be killed, for example, by using an antibiotic to destroy the disease-causing bacteria. At link 2, one could eliminate a reservoir that harbors the pathogen. For example, controlling rat populations in cities by picking up garbage is a way of preventing the spread of plague to humans. Adequate water and sewage treatment prevents the spread of water-borne diseases, and proper food-handling methods eliminate reservoirs of food-borne pathogens.

At link 3, transmission from one host to another could be prevented by quarantining infected individuals, for example, or by warning people to boil their water if the water supply becomes contaminated. Hand washing is an important way to prevent the spread of disease for restaurant workers to avoid contaminating food, for hospital workers to avoid carrying pathogens from one patient to another, and for all individuals to protect themselves against pathogens they may pick up from the environment and put in their mouth. The spread of sexually transmitted diseases can be prevented by use of a condom, a simple matter of blocking the movement of the pathogens to the uninfected person.

At link 4, the resistance of hosts can be increased by immunization, which stimulates the body's immune system to recognize the pathogen and to attack it during any future exposure. Vaccination not only keeps the individual from contracting a disease but also makes it harder for the pathogen to find susceptible hosts. In some cases, it may even be possible to completely eliminate a pathogen from the earth by eliminating the susceptibility of its potential hosts. This was accomplished in the case of smallpox, as discussed below.

Other links are often included separately as part of the chain of infection when it is useful to consider them as sites for public health intervention. For example, the port of entry into the host for a mosquito-borne disease would be the skin, a link that could be interrupted if the potential host wears long sleeves and gloves. Similarly, the place of exit is the route by which the pathogen leaves the host.

Public health measures to control the spread of infectious disease include both routine prevention measures and emergency measures to control an outbreak once it has begun. Many of the measures referred to above—especially those concerning links 2 and 3—come under the category of "environmental health" and will be discussed further in Part V. Immunization—link 4—is a major weapon that has had great success against the dread diseases that created the epidemics of the past. However, vaccines do not exist for all diseases—notably, a vaccine has not yet been developed against AIDS. Even when vaccines do exist, some diseases are too rare to justify the trouble and expense of vaccinating everyone. This is where surveillance is especially important.

Epidemiologic surveillance—discussed in Chapter 4—is the system by which public health practitioners watch for disease threats so that they may step in and break the chain of infection, halting the spread of disease. In the early history of public health, the solution was often quarantine—isolation of the patient to prevent him or her from infecting others. Quarantine is still used occasionally, when the disease is serious and there is no effective vaccine. For example, a patient diagnosed with tuberculosis—which is slow to respond to medication—might be ordered to stay home for two to four weeks after treatment is started until the disease is no longer infectious.

More often, the public health response when an outbreak is detected by surveillance is to locate people who have had contact with the infected individual and to immunize them or give them medical treatment, as appropriate. For tuberculosis, contact tracing is used in addition to quarantine: people who have been exposed to the patient are given prophylactic doses of antibiotics. Tuberculosis has presented new and more difficult problems to the public health system in recent years because of the development of drug-resistant strains of the bacteria. Chapter 10 discusses this issue further.

Contact tracing is also routinely used for controlling sexually transmitted diseases, such as syphilis and gonorrhea. Syphilis, which tends to affect the poor, the homeless, drug users, and prostitutes, can be diagnosed by a blood test. Because it has few symptoms in the early stages, it may go untreated and is easily spread. The challenge for public health is to identify those with the disease through screening programs carried out, for example, in a city jail. Once a case is identified, public health workers try to discreetly alert those who have been exposed. The public health worker asks the person who has been diagnosed to identify sexual contacts; the worker then notifies the contacts that they have been exposed without identifying the source of the exposure. Syphilis is readily cured by penicillin. If untreated, it may cause long-term damage to the heart and brain; congenital syphilis in infants born to infected mothers can be lethal.

The classic public health measures of surveillance and quarantine were key components in combating severe acute respiratory syndrome (SARS), a highly infectious new disease that first broke out in southern China in November 2002. Because China did not at first report the disease, it was not recognized as a major threat until March 2003, when the World Health Organization (WHO) issued a global alert and a travel advisory. WHO had been alerted by Dr. Carlo Urbani, an infectious disease specialist working in Vietnam, who noticed that a patient who had recently arrived in Saigon from Hong Kong was suffering from an atypical form of pneumonia. Dr. Urbani himself soon contracted the disease and died. Epidemiologic detective work found that the patient in Saigon, as well as patients soon identified in Toronto and Singapore, had all stayed in the same hotel in Hong Kong where a traveler from southern China had spent one night before falling ill with the syndrome. More than a dozen guests at the hotel had been infected by that one traveler, and they carried the disease to several other countries.[4]

By July 5, 2003, when WHO declared that SARS had been contained, the disease had infected 8439 people in 30 countries and had killed 812 people.[5] Although a virus was identified, lab tests could not diagnose the disease until weeks after a patient had developed symptoms. No drug has been found effective against the virus, and treatment requires intensive respiratory therapy during extended hospital stays. SARS was contained by old-fashioned measures: quickly isolating patients who were suspected to have the disease—because of fever, cough, and previous contact with a known SARS patient—and quarantining anyone who had come in contact with them. The epidemic had severe economic impact wherever it broke out, keeping business and vacation travelers from affected areas and even scaring away visitors from Chinatowns in American cities.

There was concern that the disease would be seasonal and would break out again in 2004, but this did not occur. A few small outbreaks in 2004 stemmed from inadequate safety measures in research laboratories, but alert health workers kept the disease from spreading. Scientists are attempting to develop a vaccine against SARS, which could be used to break the chain of infection when and where the virus might appear again.

Rabies

Rabies, a fatal disease of the nervous system caused by a virus, kills an estimated 55,000 people around the world each year, usually contracted through a dog bite.[6] In the United States, transmission of the disease to humans is very effectively prevented by routine public health measures, including epidemiologic surveillance. Although there is an effective vaccine against rabies, routine immunization of everyone is not recommended. Human exposure to the rabies virus in this country is relatively rare, and the vaccine is expensive and inconvenient to deliver, requiring several injections over a period of approximately a month.

The rabies virus infects only mammals, and it is almost always transmitted when a rabid animal bites another animal or a human. Since the animal most likely to bite a human is the dog, mandatory immunization of dogs against rabies is the first line of defense in the protection of people. Wild animals serve as the reservoir of rabies, and dogs are most likely to be exposed by being bitten by a rabid wild animal. Domestic cats are also at risk for exposure to rabies from wildlife, and immunization is recommended for them as well.

The public health system has defined clear guidelines for responding to a report of a person's being bitten by a domestic or wild animal, depending on the likelihood that the animal is rabid. Because immunization of dogs is widespread in the United States, less than 100 cases of rabies occur annually in the 60 million dogs in this country, and a dog bite is considered unlikely to transmit the disease.[6] If the biting dog (or cat) appears to be healthy, it need only be observed for ten days to ensure that it remains healthy. Rabies virus affects the brain and from there travels to the salivary glands and is secreted in saliva. An animal capable of transmitting the virus in its saliva will already have brain involvement, exhibit symptoms, and be dead within a few days. That is sufficient time for the bitten person to be given the series of vaccinations that will protect him or her from the disease.

If the biting animal is wild, or if there is other reason to suspect that it is rabid, it must be killed and its brain tested for signs of rabies virus infection. There is no way to determine definitively whether a living animal has rabies. If the test shows the animal to be rabid, the bite victim receives the vaccinations. If no sign of rabies is found, no vaccinations are given. There is no room for error in these tests, because once symptoms of rabies appear, it is too late to save the victim. Public health laboratories take this responsibility very seriously. Generally, immunizations are given to anyone who is bitten by a wild animal that cannot be captured and tested.

To control rabies, public health practitioners conduct surveillance for rabies in wildlife. When raccoons, skunks, and foxes in a geographic area are infected with the virus, they are likely to be a threat to humans and domestic animals. In Europe and in some parts of the United States, public health officials are attempting to control rabies in wildlife by distributing bait containing an oral rabies vaccine.

Bats are the most dangerous rabies threat to humans. Even in parts of the country where the disease is not endemic among most wildlife, rabid bats are likely to be found. Because the animals are nocturnal and elusive, contact with bats may go unnoticed. During the period between 2000 and 2007, 18 of the 25 cases of human rabies in the United States were caused by a strain of the virus that is associated with bats. However, many of these victims were not aware of having been bitten by a bat and did not realize that any exposure to bats might constitute a rabies risk.[7]

The rabies surveillance system has been remarkably successful. The cost of rabies control is significant, however. Testing the brain of an animal for rabies costs about $100, and the price of a series of vaccinations for a person suspected of being exposed may amount to $1500. In 1994, after a kitten in a New Hampshire pet store tested positive for rabies, 665 people received post-exposure treatment at a cost of over $1 million for the vaccines alone.[8] In 2008, a rabid puppy was among a group of 24 dogs and 2 cats that were brought to the United States in a rescue mission aimed at reuniting American soldiers with pets they had adopted in Iraq. By the time the puppy was diagnosed, the animals had been dispersed to sixteen states around the country. Concerned that the puppy might have bitten other animals in the group, federal and state public health workers tracked them all down, vaccinated them and placed them in quarantine for six months.[6] This incident spotlights the risks in the importation of animals to the United States. According to its report on the incident, the Centers for Disease Control and Prevention (CDC) is working to update current regulations.

Smallpox, Measles, and Polio

While constant vigilance is required to protect people from rabies because wild animals serve as a reservoir of the disease, some pathogenic viruses, including measles and polio, have no non-human reservoir. It is a possibility, therefore, that universal immunization against these diseases could eliminate the measles and polio viruses from the earth. This has been achieved with smallpox, one of public health's greatest victories.

Smallpox was a particularly feared disease that is believed to have first emerged in Asia about the time of Christ and tended to spread in major epidemics that claimed millions of lives in China, Japan, the Roman Empire, Europe, and the Americas.[2] It was highly contagious, spread by aerosol or by touch. The concept of vaccination originated with smallpox: the observation that survivors of the disease were immune to future infection inspired the idea that people could be protected against serious illness by inoculating them with small amounts of infected matter from a person suffering a mild case. While the procedure was not entirely safe, the practice became widespread in the American colonies, and George Washington ordered his entire army to be inoculated. In 1796, the practice of immunization became less risky when the British physician Edward Jenner—inspired by the observation that milkmaids appeared to be immune to smallpox—proved that inoculation with cowpox matter, which was harmless to humans, provided immunity against smallpox.[9]

By 1958, routine immunization had eliminated smallpox in the United States and other industrialized countries. However, it was still widespread in 33 underdeveloped countries, killing two million people per year. With support from both the United States and the Soviet Union, WHO developed plans for a program to eliminate smallpox. Between 1967 and 1977, medical teams traveled all over the world in search of outbreaks of the disease. Local governments were mobilized to vaccinate residents of areas where an outbreak was occurring. Because the lesions of smallpox were so conspicuous, it was possible for the investigators to track outbreaks by showing pictures of victims and asking people if they knew of anyone with this disease. Once a patient was located, he or she could be quarantined and everyone in the vicinity vaccinated, sometimes by force. The last case was found in Somalia in October 1977.[2]

Now smallpox virus officially remains in only two places, stored in laboratories at the CDC and in a Russian laboratory in Siberia. By international agreement, genetic studies were being conducted, after which both stocks of the virus were scheduled to be destroyed in 1999.[10] The decision to destroy the virus was controversial, with some scientists believing that valuable information might be gained in future studies using techniques that are not yet known. In 1999, WHO decided to defer the destruction for a few more years.[11]

Meanwhile, word was leaking out of the former Soviet Union that the Soviets had been working on smallpox as a bioweapon. There were fears that they had shared their stocks of the virus with rogue states such as Iraq and North Korea. The anthrax attacks of 2001 further raised fears about bioterrorism. Plans for destruction of the smallpox virus have been put on hold, and research priorities have focused on developing an improved vaccine and finding drugs that would be effective against the virus. Chapters 10 and 29 discuss bioterrorism further.

Poliovirus, like smallpox virus, infects human beings only, and polio similarly has the potential to be eradicated. In 1988, at a time when 350,000 children were being paralyzed each year, WHO set a goal of eradicating polio by the year 2000.[12] This goal was not met, but substantial progress has been made against this crippling disease: polio has been essentially eliminated from the Western Hemisphere, Europe, and the Western Pacific, and by 1999, annual polio cases were reduced by 99 percent worldwide. Many countries hold National Immunization Days each year, distributing doses of oral polio vaccine to millions of children.

Only Southern Asia and Sub-Saharan Africa still have a significant incidence of polio. An important reason that eradication did not succeed in these countries is that rumors spread in 2003 among Muslims, especially in Nigeria, that the polio vaccine had been deliberately contaminated to cause AIDS or infertility.[12] Several Nigerian states halted vaccinations, the number of cases in Nigeria jumped to 800 in 2004, and the virus spread to several other African countries that had previously been polio free. Under pressure from WHO, Nigeria resumed polio immunizations the following year. Now, only four countries continue to have endemic polio—Nigeria, India, Pakistan, and Afghanistan—but eradication from these countries has proven extremely difficult. As long as the disease exists in these countries, it tends to spread to neighboring countries.

There are several reasons why polio is proving more difficult to eradicate than smallpox.[13] Unlike smallpox, there are many "invisible" cases of polio, in which children may be infected, able to spread the virus by the fecal-oral route but not show symptoms. Thus it is not possible to focus on small outbreaks as was done with smallpox. The vaccine is imperfect and must be administered several times to become effective. India has made major effort to vaccinate children with repeated rounds of National Immunization Days each year, but in poverty-stricken areas of the country children suffering from other intestinal infections tend not to develop immunity even after multiple doses of the vaccine. Political upheaval in parts of Pakistan and Afghanistan has interfered with immunization campaigns in those countries. Some experts are now arguing that the goal of eradicating polio is unrealistic and that efforts should be focused on "control" rather than eradication.[13] They say that other vaccine-preventable diseases are being neglected because of the intensive effort on polio, that the campaign has been going on too long and has become too expensive. However, a WHO advisory committee in 2008 reaffirmed the eradication goal, stating that abandoning the effort would lead to many more cases in poor countries, and proposing several recommendations for improving the campaign.[14]

Measles, another viral disease that could in theory be eradicated, offers an example of what happens when public health relaxes its vigilance. Before a vaccine was available, almost all children contracted measles, causing 400 to 500 deaths a year in the United States and 1000 cases of chronic disability from measles encephalitis.[15] Worldwide, an estimated 750,000 children died of measles as recently as 2000.[16] A vaccine became available in 1963, and the number of cases in the United States dropped precipitously. In 1978, the U.S. Department of Health and Human Services set a goal to eradicate measles from this country by 1982. That ambition proved overly optimistic. Two problems interfered.[17]

First, outbreaks of measles began to occur among high school and college students who had been vaccinated as babies. It became clear that the immunity conferred by vaccination in infancy wears off and that a booster vaccination is necessary in older children, a practice that is now recommended at the age of four to six. The booster should be given to adolescents if they did not receive it earlier.

The greater problem was that too many children were not being immunized until it was required for entry into school. This was particularly true in large cities among poor African-American and Hispanic children. Immunization rates in the United States were worse than those of some third-world countries. More than 27,000 American children contracted measles in 1990, and 89 died.[18] Even the surveillance system was doing poorly: a study in New York City during 1991 found that up to 50 percent of cases were not reported.[19] The public health system was shaken by this evidence of failure, and a better job is now being done on measles immunization. In fact, measles was declared eliminated from the United States in 2000, meaning that all cases can be traced to individuals who contracted the disease outside the country and brought it here. However, during the first 6 months of 2008, 131 measles cases were reported to CDC, compared to an average of 63 cases per year during 2000 to 2007.[20] Of these, 123 were American residents, the majority of them children, and 91 percent of them were unvaccinated or had unknown vaccination status. Over half were unvaccinated because of philosophical or religious beliefs, discussed later in this chapter.

Public health leaders had hoped that when and if polio is eradicated, the organizational and medical resources that had been mobilized in that campaign could then be used in a vaccination campaign against measles. Given the uncertainties with polio eradication and the difficulties with achieving universal immunization in the United States, the prospect for measles eradication worldwide is doubtful. Measles is still endemic at low levels in some European countries as well as at higher levels in Africa and Southeast Asia.[20] However, some progress has been made. The number of estimated deaths from measles has been reduced from 750,000 in 2000 to 197,000 in 2007. The WHO has set a goal of 90 percent reduction in measles mortality by 2010.[16]

An attempt to eradicate an eradicable disease can backfire if it is not conducted with sufficient political will, knowledge, and resources. This was the case with malaria, which was the target of an international eradication campaign in the 1950s and 1960s. There is no nonhuman reservoir for the malaria-causing parasites, but the route of transmission is a vector, certain species of mosquito. The primary weapon in the eradication effort was the pesticide DDT. While the campaign produced dramatic results, funding ran out before the objective was achieved, and there was a resurgence of the disease with greater impact than ever. A combination of factors contributed to the calamity: DDT-resistant mosquitoes emerged; the pathogen developed resistance to the main antimalarial drug, chloroquine; and populations in former malarial areas lost their immunity to the disease because of lack of exposure.[21] Now, malaria is one of the most widespread potentially fatal infectious diseases in the world, killing an estimated one million people annually, mainly children.[22] The disease occurs mainly in tropical and subtropical areas and has been largely eliminated in the United States, but global climate change and international travel could contribute to the re-emergence of malaria as a public health problem in the South.

Fear of Vaccines

The benefits of vaccination are obvious to public health and medical professionals. However, just as Muslim leaders in Nigeria resisted polio vaccination with the rumor of infertility, so suspicion has spread in the United States that measles immunization causes autism. Autism often becomes apparent at about the age when the vaccine is given. Consequently, some parents refused to allow their children to be vaccinated against measles. Similarly, unfounded stories about side effects of the pertussis (whooping cough) vaccine—that it might cause sudden infant death syndrome (SIDS)—led many parents to resist the vaccine.[23]

Because parental concerns became so widespread, the Institute of Medicine has conducted periodic reviews of the latest evidence on vaccine safety. In 2003 it published a review on SIDS and concluded that "the evidence favors rejection of a relationship between some vaccines and SIDS."[24] In 2004, the Institute of Medicine reviewed evidence on a possible link between the measles-mumps-rubella vaccine (MMR) and autism and again concluded that "the body of epidemiological evidence favors rejection of a causal relationship between the MMR vaccine and autism."[25] In both cases, the review committees acknowledged that the concern about the vaccines was understandable because the diseases are poorly understood, and they recommended more research on the causes of SIDS and autism.

The evidence cited in the autism report included a major study done in Denmark, in which records of a half million children were analyzed. About one in five children had not received the vaccine, and the researchers found that these children developed autism at the same rate as children who had received the vaccine.[26] Some vaccines do have real risks, including fever and seizures that occur in a small number of infants after they are vaccinated for pertussis and rare cases of polio caused by the oral polio vaccine, which contains live, weakened virus. These risks are much smaller than the risks of the diseases in an unvaccinated population. However, many American parents are too young to remember the fears aroused by polio in the past, and they may be unaware that formerly common childhood diseases such as measles and chicken pox sometimes have serious complications. Whooping cough can be fatal in infants exposed to unvaccinated older siblings who contract the disease. Because of the success of vaccinations, people have never seen these diseases and thus no longer fear them.

The measles outbreaks in 2008, discussed above, illustrate the dangers of leaving children unvaccinated. That year, 131 cases of measles were reported in the United States, more than double the average number reported in previous years. Most of the cases were linked to people who traveled abroad or visited from another country and spread the virus to unvaccinated children in this country. Some fifteen people were hospitalized, including four infants.[20]

It is often in wealthy communities that parents refuse to subject their children to the small risk of immunization. They count on the fact that most other children are vaccinated to protect their own children from being exposed. However, much of the protection afforded by a high rate of immunization in a population comes from "herd immunity," the phenomenon by which even infants too young to be vaccinated, old people with weakened immune systems, and those who refuse to be immunized are unlikely to be exposed to a disease because the majority of the population is immune. If the percentage of immunity in the population falls too low, however, outbreaks are likely. Then even vaccinated people are at risk, because no vaccine is perfect.

Another drawback of people's fear of vaccines is that pharmaceutical companies have become reluctant to invest in developing them. Parents' tendency to blame a recent immunization for any serious health problem suffered by their children leads them to sue the company that made the vaccine. This experience, together with the fact that prices that can be charged for vaccines tend to be low, has caused many companies to drop vaccine production altogether. While immunization is considered the most effective intervention for preventing disease and promoting health, it is not clear that even the current vaccines will continue to be available.[27] The example of the former Soviet Union, described in the Prologue, stands as a warning to us. Diphtheria is virtually unknown in the West now, but in the 1980s, when the public health system in Russia was in chaos and immunizations stopped, the disease surged, with 200,000 cases and 5000 deaths there.[28]

Public health in the United States can celebrate success in the fight against many common diseases. In 2007, the CDC reported that death rates for thirteen infectious diseases were at all-time lows; for nine of them, including whooping cough, polio, and diphtheria, deaths and hospitalizations declined by more than 90 percent since vaccines against them were approved.[28] However, it has become clear that infectious diseases are far from being conquered. The development of resistance to the chemical arsenal for combating disease will be discussed in Chapter 10, together with other new and emerging problems in infectious diseases.

Conclusion

Public health has had great success in controlling infectious diseases. Classic public health measures prevent transmission of disease-causing bacteria, viruses, and parasites by interrupting the chain of infection. Measures employed at various links in the chain include killing the pathogen, eliminating the reservoir that harbors the pathogen, preventing transmission from one host to another or from reservoir to host, and increasing the resistance of hosts by immunization.

Rabies is an example of a disease that has been successfully controlled in the United States by public health measures. Immunization of dogs is the primary barrier protecting humans from the reservoir of the virus, which is wild animals. By maintaining surveillance and intervening with vaccination when a person has been exposed to a possibly rabid animal, public health has kept the number of human deaths from rabies very low. SARS, a new, highly communicable disease first recognized in Asia in 2003, was successfully controlled by the classic public health measures of surveillance, isolation, and quarantine.

Smallpox, measles, and polio are viral diseases against which effective vaccines have been developed and which have no nonhuman reservoir. In theory, therefore, they could be eliminated from the earth. This has been accomplished with smallpox, with only two known stocks of the virus remaining. Polio has been eliminated from the United States and many other parts of the world, and a campaign is underway to eradicate it, although progress has been erratic and some experts doubt that the goal is realistic. The prospects for measles eradication are even less clear. The United States has had epidemics of measles as recently as the early 1990s, and cases of measles still occur when infected people enter this country from endemic areas. Reluctance by some parents to vaccinate their children weakens herd immunity and threatens to cause outbreaks of infectious diseases that could have been controlled.

Success in controlling infectious diseases requires adequate resources and political will to maintain effective immunization programs and ongoing epidemiologic surveillance.

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