# Chapter 9 Disease and Epidemiology

## 9.1 The Language of Epidemiologists

The field of epidemiology concerns the geographical distribution and timing of infectious disease occurrences and how they are transmitted and maintained in nature, with the goal of recognizing and controlling outbreaks. The science of epidemiology includes etiology (the study of the causes of disease) and investigation of disease transmission (mechanisms by which a disease is spread).

Analyzing Disease in a Population

Epidemiological analyses are always carried out with reference to a population, which is the group of individuals that are at risk for the disease or condition. Susceptible individuals may be defined by particular behaviors, such as intravenous drug use, owning particular pets, or membership in an institution, such as a college.

The state of being diseased is called **morbidity**. The morbidity rate can be expressed as the number of diseased individuals out of a standard number of individuals in the population, such as 100,000, or as a percent of the population.

**Prevalence** is the number, or proportion, of individuals with a particular illness in a given population at a point in time.  **Incidence** is the number or proportion of new cases in a period of time.

A mortality rate can be expressed as the percentage of the population that has died from a disease or as the number of deaths per 100,000 persons (or other suitable standard number).

### Patterns of Incidence

Diseases that are seen only occasionally, and usually without geographic concentration, are called **sporadic diseases**. Examples of sporadic diseases include tetanus, rabies, and plague.

Diseases that are constantly present (often at a low level) in a population within a particular geographic region are called **endemic diseases**.

Diseases for which a larger than expected number of cases occurs in a short time within a geographic region are called **epidemic diseases**. Influenza is a good example of a commonly epidemic disease.

An epidemic disease signals the breakdown of an equilibrium in disease frequency, often resulting from some change in environmental conditions or in the population.

An epidemic that occurs on a worldwide scale is called a **pandemic disease.**

### Etiology

The cause of the disease, is called the **etiologic agent** or **causative agent**. Connecting a disease to a specific pathogen can be challenging because of the extra effort typically required to demonstrate direct causation as opposed to a simple association. Controlled experiments are needed to eliminate other possible causes.

Robert Koch was the first scientist to specifically demonstrate the causative agent of a disease (anthrax) in the late 1900s. Koch developed four criteria, now known as Koch’s postulates, which had to be met in order to positively link a disease with a pathogenic microbe.

### The Role of Public Health Organizations

The main national public health agency in the United States is the Centers for Disease Control and Prevention (CDC). The CDC is charged with protecting the public from disease and injury. One way that the CDC carries out this mission is by overseeing the National Notifiable Disease Surveillance System (NNDSS). **Notifiable diseases** or **reportable diseases** because all cases must be reported to the CDC.

The CDC publishes the Morbidity and Mortality Weekly Report (MMWR), which provides physicians and health-care workers with updates on public health issues and the latest data pertaining to notifiable diseases.

## 9.3 Modes of Disease Transmission

Understanding how infectious pathogens spread is critical to preventing infectious disease. All pathogens must also have a mechanism of transfer from one host to another or they will die when their host dies. Pathogens often have elaborate adaptations to exploit host biology, behavior, and ecology to live in and move between hosts. Hosts have evolved defenses against pathogens, but because their rates of evolution are typically slower than their pathogens (because their generation times are longer), hosts are usually at an evolutionary disadvantage.

### Reservoirs and Carriers

For pathogens to persist over long periods of time they require **reservoirs** where they normally reside. Reservoirs can be living organisms or nonliving sites.

Pathogens may have mechanisms of dormancy or resilience that allow them to survive (but typically not to reproduce) for varying periods of time in nonliving environments.

A human acting as a reservoir of a pathogen may or may not be capable of transmitting the pathogen, depending on the stage of infection and the pathogen.

An individual capable of transmitting a pathogen without displaying symptoms is referred to as a **carrier**. A **passive carrier** is contaminated with the pathogen and can mechanically transmit it to another host; however, a passive carrier is not infected.

An **active carrier** is an infected individual who can transmit the disease to others. An active carrier may or may not exhibit signs or symptoms of infection. For example, active carriers may transmit the disease during the incubation period (before they show signs and symptoms) or the period of convalescence (after symptoms have subsided).

A pathogen may have more than one living reservoir. In zoonotic diseases, animals act as reservoirs of human disease and transmit the infectious agent to humans through direct or indirect contact.

In parasitic infections, the parasite’s preferred host is called the definitive host. In parasites with complex life cycles, the definitive host is the host in which the parasite reaches sexual maturity. Some parasites may also infect one or more intermediate host**s** in which the parasite goes through several immature life cycle stages or reproduces asexually.

### Transmission

Regardless of the reservoir, transmission must occur for an infection to spread. First, transmission from the reservoir to the individual must occur. Then, the individual must transmit the infectious agent to other susceptible individuals, either directly or indirectly.

### Contact Transmission

**Contact transmission** includes direct contact or indirect contact. Person-to-person transmission is a form of **direct contact transmission**. Here the agent is transmitted by physical contact between two individuals (Figure 1) through actions such as touching, kissing, sexual intercourse, or droplet sprays. **Vertical direct contact transmission** occurs when pathogens are transmitted from mother to child during pregnancy, birth, or breastfeeding.  **Horizontal direct contact transmission** is often contact between mucous membranes is required for entry of the pathogen into the new host, although skin-to-skin contact can lead to mucous membrane contact if the new host subsequently touches a mucous membrane.

 Direct droplet transmission, which refers to droplet transmission of a pathogen to a new host over distances of one meter or less. Transmission over distances greater than one meter is called airborne transmission.

**Indirect contact transmission** involves inanimate objects called fomites that become contaminated by pathogens from an infected individual or reservoir. Fomites can also include objects used in clinical settings that are not properly sterilized, such as syringes, needles, catheters, and surgical equipment.

### Vehicle Transmission

**Vehicle transmission** refers to the transmission of pathogens through vehicles such as water, food, and air. Water contamination through poor sanitation methods leads to waterborne transmission of disease.

Dust and fine particles known as aerosols, which can float in the air, can carry pathogens and facilitate the airborne transmission of disease.

### Vector Transmission

Diseases can also be transmitted by a mechanical or biological vector, an animal (typically an arthropod) that carries the disease from one host to another. **Mechanical transmission** is facilitated by a **mechanical vector**, an animal that carries a pathogen from one host to another without being infected itself.

**Biological transmission** occurs when the pathogen reproduces within a **biological vector** that transmits the pathogen from one host to another. Arthropods are the main vectors responsible for biological transmission (Figure 5). Most arthropod vectors transmit the pathogen by biting the host, creating a wound that serves as a portal of entry.

Biological insect vectors include mosquitoes, which transmit malaria and other diseases, and lice, which transmit typhus. Other arthropod vectors can include arachnids, primarily ticks, which transmit Lyme disease and other diseases, and mites, which transmit scrub typhus and rickettsial pox. There are also important non-arthropod vectors of disease, including mammals and birds.

### Quarantining

Individuals suspected or known to have been exposed to certain contagious pathogens may be quarantined, or isolated to prevent transmission of the disease to others. Hospitals and other health-care facilities generally set up special wards to isolate patients with particularly hazardous diseases such as tuberculosis or Ebola.

The duration of the quarantine depends on factors such as the incubation period of the disease and the evidence suggestive of an infection. The patient may be released if signs and symptoms fail to materialize when expected or if preventive treatment can be administered in order to limit the risk of transmission.

In the United States, public health authorities may only quarantine patients for certain diseases, such as cholera, diphtheria, infectious tuberculosis, and strains of influenza capable of causing a pandemic.

### Healthcare-Associated (Nosocomial) Infections

Higher rates of transmission may be caused by characteristics of the environment itself, characteristics of the population, or both.

Infections acquired in health-care facilities, including hospitals, are called **nosocomial infections** or **healthcare-associated infections (HAI).** HAIs are often connected with surgery or other invasive procedures that provide the pathogen with access to the portal of infection. In these settings, patients suffering from primary disease are often afflicted with compromised immunity and are more susceptible to secondary infection and opportunistic pathogens.

Such HAIs often occur when pathogens are introduced to patients’ bodies through contaminated surgical or medical equipment, such as catheters and respiratory ventilators.

## 9.4 Global Public Health

A large number of international programs and agencies are involved in efforts to promote global public health. Among their goals are developing infrastructure in health care, public sanitation, and public health capacity; monitoring infectious disease occurrences around the world; coordinating communications between national public health agencies in various countries; and coordinating international responses to major health crises.

### The World Health Organization (WHO)

International public health issues are coordinated by the World Health Organization (WHO), an agency of the United Nations. In addition to monitoring and reporting on infectious disease, WHO also develops and implements strategies for their control and prevention. WHO continues to be involved in infectious disease control, primarily in the developing world, with programs targeting malaria, HIV/AIDS, and tuberculosis.

WHO maintains a global alert and response system that coordinates information from member nations. In the event of a public health emergency or epidemic, it provides logistical support and coordinates international response to the emergency. The United States contributes to this effort through the CDC.

### Emerging and Reemerging Infectious Diseases

An **emerging infectious disease** is either new to the human population or has shown an increase in prevalence in the previous twenty years.

The importance of vigilance was made clear during the Ebola hemorrhagic fever epidemic in western Africa through 2014–2015. Although health experts had been aware of the Ebola virus since the 1970s, an outbreak on such a large scale had never happened before. Its high transmission rate, coupled with cultural practices for treatment of the dead and perhaps its emergence in an urban setting, caused the disease to spread rapidly, and thousands of people died.

Emerging diseases are found in all countries, both developed and developing. National and international public health agencies watch for epidemics like the Ebola outbreak in developing countries because those countries rarely have the health-care infrastructure and expertise to deal with large outbreaks effectively. The global nature of transportation means that an outbreak anywhere can spread quickly to every corner of the planet.

A **reemerging infectious disease** is a disease that is increasing in frequency after a previous period of decline. Its reemergence may be a result of changing conditions or old prevention regimes that are no longer working. Examples of such diseases are drug-resistant forms of tuberculosis, bacterial pneumonia, and malaria. Drug-resistant strains of the bacteria causing gonorrhea and syphilis are also becoming more widespread.