Epidemiology of Disease

Epidemiology is the study of when and where diseases occur and how they are transmitted in populations. It includes relationships among the pathogens, their host, and the environment.

The prevalence rate is the percentage or fraction of a population of individuals infected at any given time in a population (new and old cases).

The incidence rate is the percentage or fraction of a population infected during a specific period of time (new cases).

Patterns of Infectious Diseases

There are four patterns which characterize infectious diseases:

1. **epidemic** - Many people in a given area acquire a certain disease in a relatively short period of time. Epidemic diseases include cholera, Ebola, diphtheria, and poliomyelitis.

2. **pandemic** - An epidemic that occurs worldwide. Periodically influenza may be a pandemic disease.

3. **endemic** - A disease constantly present at about the same level in a population. Endemic diseases include the common cold, chicken pox, and mumps.

4. **sporadic** - A particular disease occurs only occasionally in a population. Typhoid fever occurs sporadically in the U.S.

Sources of Infection

Although microorganisms are widespread, the incidence of infectious disease is low due to two factors:

1. The lack of pathogenicity of the microorganism

2. The host's resistance and immunity.

Any disease that spreads from one host to another, either directly or indirectly, is a **communicable disease**. A **contagious disease** is one that is easily spread.
Sources which supply a pathogen with adequate conditions for survival, reproductivity, and an opportunity for transmission are known as **reservoirs of infection**. They may be living organisms or inanimate (nonliving) objects and transmission may occur by direct contact or indirect contact.

**Living Reservoirs**

There are three types of living reservoirs:

1. **humans** - The principle living reservoir of human disease is the human body itself. Many people harbor pathogens and transmit them directly or indirectly to others. Humans with active infections may transmit the pathogens to other people during the incubation period and sometimes during the convalescent period. Carriers are individuals who harbor an infectious organism without having signs or symptoms, but can transmit them to others. Diphtheria, typhoid fever, amoebic dysentery, hepatitis, and streptococcal infections may be spread by carriers. Transmission may occur by hand-shaking, kissing, sexual intercourse, or contact with feces. Influenza, common cold, measles, and whooping cough (pertussis) may be spread when exposed to droplets consisting of mucus expelled from the respiratory tract during coughing or sneezing. Syphilis, gonorrhea, and AIDS may be sexually transmitted.

2. **animals** - Diseases that occur in animals and can be transmitted to humans are called **zoonoses**. The more physiologically similar an animal is to a human, the more likely they are to serve as reservoirs. Transmission may occur by direct contact with the infectious animal, pet wastes (litter boxes), or consumption of infected animal products, and indirectly by contaminated food and water, or by insect vectors. Monkeys may be reservoirs for malaria and yellow fever. Domestic and wild animals may be reservoirs for rabies (cats, dogs, bats, foxes, skunks) or toxoplasmosis (birds). Lyme disease may be transmitted indirectly from deer and mice reservoirs by ticks.

3. **insects** - Insects that transmit disease are known as **vectors**. Arthropods are the major vector and may transport microorganisms on their legs or other body parts or transmit them through bites. Flies land on decaying matter such as garbage or feces, pick up pathogens on their legs, and deposit them on people or their food. Mosquitoes may transmit encephalitis, malaria, and trypanosomiasis (African sleeping sickness). Ticks may transmit Lyme disease and Rocky Mountain spotted fever.
Inanimate Reservoirs

There are four types of inanimate reservoirs:

1. **soil** - Soil harbors pathogens such as bacteria and fungi. The bacteria *Clostridium botulinum* (botulism) and *Clostridium tetani* (tetanus) are found everywhere, but especially when animal fecal matter is used as fertilizer. They are normal intestinal flora of horses and cattle. Fungi which cause skin infections such as ringworm are found in soil.

2. **air** - Droplets expelled from infectious humans and dust may harbor pathogens.

3. **food** - Food may be contaminated by handling or diseased animals. Bacteria and helminths may contaminate meat (tapeworms, trichina worm, *E. coli*), fish (tapeworms), poultry (*Salmonella*), and milk (*Lactobacillus*, tuberculosis).

4. **water** - Water that has been contaminated by human or animal feces is a reservoir for bacteria that causes gastrointestinal diseases.

Endogenous Sources

Endogenous infections are caused by opportunists among a person's own normal flora, due to a lowered resistance or antibiotic elimination of the normal flora that competes with the pathogen. Intestinal bacteria may enter the bloodstream as a result of injury to the intestines. Blood clots form in response to the presence of the bacteria.

Transmission Routes From Living Reservoirs

The portals of exit are the same as the portals of entry for infectious agents. There are two transmission routes of infectious agents from living reservoirs:

1. **direct contact** - The direct transmission of pathogens to a susceptible host. Transmission may occur through kissing, sexual contact, handshaking, touching sores, droplet transmission, and insect vectors. The common cold, influenza, and hepatitis A may be transmitted by direct contact.

2. **indirect contact** - The pathogen is transmitted from its reservoir to a host by means of the hand-to-mouth transfer of infectious material from contaminated sputum, feces, seepage from wounds, and animal tissues.
Transmission Routes From Inanimate Reservoirs

1. **direct contact** - The pathogen is transmitted by ingestion of contaminated food and water, inhalation of dust, contact with soil, and injection of contaminated substances.

2. **indirect contact** - The pathogen is transmitted from its reservoir to a host by means of nonliving objects called *fomites*. Fomites include handkerchiefs, towels, bedding, diapers, drinking cups, telephones, toys, eating utensils, dishes, and syringes. Contaminated syringes spread AIDS and hepatitis B. Eggs of parasitic worms, such as pinworms, may be found in bedding or clothes of children. Hand-to-mouth transfer usually occurs from the contaminated objects.

Routes of Transfer of Animal Parasites

Parasitic protozoa and helminths may depend on one or more hosts to complete the stages of their life cycle.

There are six routes of transfer:

1. **human-to-human** - Cysts shed in human feces may be ingested in food or water. Eggs may be shed by one human and transferred by the inhalation of dust, or by the hand-to-mouth route. *Entamoeba* and *Giardia* are spread from human to human.

2. **human-to-soil-to-human** - Mature eggs shed in human feces are deposited in soil. The eggs are ingested in food or water. The eggs of some organisms hatch into larva in the soil and the larva penetrate the skin of another human. *Ascaris* (roundworm) eggs are ingested and *Necator* (hookworm) larva penetrate the skin.

3. **intermediate host-to-human** - The encysted larva form is ingested from undercooked meat. *Trichinella* is found encysted in the skeletal muscle of pigs (intermediate host) and ingested in undercooked pork. The larva hatch and migrate through the blood and become encysted in the skeletal muscle of the human.

4. **definitive host-to-human** - Dogs are definitive hosts for the tapeworm *Echinococcus*. The eggs are shed in the feces, ingested by humans and develop into larva in the intestines. They leave the intestines and encyst in the liver, lungs, and brain.

5. **human-to-intermediate host-to-human** - Humans infected with fish (Diphyllobothrium), beef, or pork tachyzoites of *Taenia* tapeworms shed the eggs in their feces. The eggs are ingested by the respective intermediate host where they hatch into larva and encyst. When undercooked fish, beef, or pork is ingested by humans, the larva migrate to the intestines where they develop into adults and produce eggs.
6. **insect-to-human-to-insect** - Insects, such as mosquitoes, feed on the blood of humans. If the human blood is infected with parasites, they are taken in by the mosquito and develop. When the infected mosquito bites another human, the parasite is transmitted into their blood and they become infected. *Plasmodium* (malaria) and *Trypanosoma* (African sleeping sickness) are transmitted by mosquitoes.