
Chapter 6. Epidemiology of Infectious Disease

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CHAPTER PREVIEW

- Infection and Related-terminologies
- Epidemiological Patterns
- Eradication and Elimination
- Epidemiological Determinants of Disease Causation

The epidemiology branch of infectious disease deals with the distribution and determinants of infection-related health states in specified populations, and their application to the control of the disease.

INFECTION AND RELATED-TERMINOLOGIES

Following the entry of the microorganism into the body, it may lead to either infection or colonization; both the terms need to be distinguished.

- **Infection:** It is a process in which a pathogenic organism enters, establishes itself, multiplies, and invades the normal anatomical barrier of the host resulting in disease
- **Colonization:** Here, the pathogenic organism enters, multiplies but does not invade, and neither causes disease nor elicits a specific immune response
 - Colonizers are different from normal flora
 - They have pathogenic potential and may invade and cause disease in another host or the same host later.
- **Healthcare-associated infection (HAIs):** Defined as the new infections acquired in a healthcare facility (HCF) by a patient after 48 hours of admission, which was neither present nor incubating at the time of admission. (Chapter 36)
- **Community-associated infections:** Refers to the infections which developed in the community or within 48 hours of admission to a healthcare facility.

EPIDEMIOLOGICAL PATTERNS

Infectious diseases that are capable of directly transmitting to a man from another man, animal or environment are called communicable disease. The spread of communicable diseases in the community may occur in several epidemiological patterns—outbreak, epidemic, pandemic, hyperendemic and sporadic.

- **Outbreak** is a sudden rise in the number of cases in a limited geographic area
 - Cholera outbreak in Bengaluru in 2020, affecting 17 people
 - Nipah virus encephalitis outbreak in Kerala in 2018, resulting in 18 cases with 16 deaths.
- **Epidemic:** If the infection occurs at a much higher rate than usual in a particular geographical area, it is known as an epidemic. It usually affects a large number of people within a community, population, or region. The classical examples include:
 - SARS epidemic in China in 2003
 - Ebola epidemic in Africa in 2014.
- **Pandemic:** An infection that spreads rapidly to large areas of the world is known as a pandemic. Examples include:
 - COVID-19 pandemic in 2020 affecting >200 countries
 - Influenza pandemics: Several flu pandemics occurred so far including the H1N1 pandemic in 2009
 - Cholera: Seven pandemics of cholera have occurred so far in the past.
- **Endemic:** When a disease occurs at a persistent, usually low level in a certain geographical area, it is called an endemic. India is endemic to several diseases such as typhoid fever, cholera, filariasis, malaria, etc.
- **Sporadic:** Infections occur at irregular intervals or only in a few places; scattered or isolated. For example, several sporadic cases of cholera occur in India every year.

ERADICATION AND ELIMINATION

Eradication, elimination, and control of an infectious disease are related terminologies with distinct differences.

Eradication

It refers to the complete and permanent worldwide reduction to 'zero new cases' of the disease through deliberate efforts. If a disease has been eradicated, no further control measures are required.

- Smallpox was the only disease to be eradicated from the whole world (in 1980)
- Polio is on the verge of eradication. Most countries including India have already declared polio-free except Pakistan and Afghanistan.

Elimination

It refers to the 'reduction to zero' (or a very low defined target rate) of new cases in a defined geographical area. Elimination requires continued measures to prevent the re-establishment of disease transmission. The diseases which attained elimination in India include neonatal tetanus and leprosy.

Control

It refers to the reduction of disease incidence, prevalence, morbidity, or mortality to a locally acceptable level as a result of deliberate efforts. However, continued intervention measures are still required to maintain the reduction, e.g. diarrheal diseases.

EPIDEMIOLOGICAL DETERMINANTS OF DISEASE CAUSATION

The *Epidemiological Triad* depicts the causation of infectious disease. The triad consists of an external *agent*, a susceptible *host*, and an *environment* that brings the host and agent together.

Agent Factors

It refers to the infectious microorganism such as a virus, bacterium, parasite, or fungus that is responsible for the causation of the disease.

- Generally, the agent must be present for the disease to occur; however, the presence of that agent alone is not always sufficient to cause the disease
- A variety of agent-related factors influence whether the exposure to an organism will result in disease (*Table 6.1*).

Table 6.1. Epidemiological determinants of disease causation.

Agent
<ul style="list-style-type: none"> • Organism's pathogenicity • Infective dose • Source and reservoir: Human or animal • Mode of transmission: Contact, inhalation, ingestion, vector-borne, vertical transmission • Infectivity or communicability
<i>Host</i>
<ul style="list-style-type: none"> • Age, gender, and race • Underlying disease, pregnancy, etc. • Underlying immune status and nutritional status • Occupational status • Personal practices: Hygiene and sexual practices • Genetic make-up
<i>Environment</i>
<ul style="list-style-type: none"> • Seasonality • Resistance to disinfectants • Soil, moisture, rainfall

Organism's Pathogenicity

Pathogenicity refers to the ability of the organism to cause disease. Pathogenic microbes express various virulence factors that allow the organism to become established in a host and maintain the disease state.

Infective Dose

The infective dose is the minimum inoculum size that is capable of initiating an infection.

- **Low infective dose:** For example, *Shigella*, *Cryptosporidium parvum*. They require small inoculum to initiate infection
- **Large infective dose:** For example, *Salmonella* and *Vibrio cholerae*. They require a large inoculum size to initiate infection.

Source and Reservoir

The starting point for the occurrence of an infectious disease is known as a source or/and reservoir of infection.

- **Source:** It refers to a person, animal, or object from which the microorganism is transmitted to the host
- **Reservoir:** It is the natural habitat in which the organism lives, and multiplies. It may be a person, animal, arthropod, plant, soil, or substance on which the organism is dependent for its survival
- In tetanus infection, the reservoir and source of the agent (*Clostridium tetani*) are the same, i.e. the soil
- In hookworm infection, the reservoir is man, but the source of infection is the soil contaminated with the larva of hookworm.

The reservoir (and/or source) may be of three types.

Human Reservoir

By far the most important reservoir and/or source of infection for humans is man himself. The diseases that can be spread from one person to another are called *communicable diseases*. Human sources may be either cases or carriers.

- **Cases or patients:** They are the persons in a given population identified as having a particular disease
- **Carrier:** It refers to the persons who harbor the infectious agent in the absence of any clinical symptoms and shed the organism from the body via contact, air, or secretions. It results due to inadequate treatment or immune response. Different types of carriers are as follows:
 - **Incubatory carriers** are those who shed the organism during the incubation period of the disease, e.g. measles, mumps, polio, diphtheria, pertussis, influenza, etc.
 - **Healthy carriers** refer to the subclinical cases who develop into carriers without suffering from overt disease, e.g. polio, cholera, salmonellosis, diphtheria, etc.
 - **Convalescent carrier** is the one who has recovered from the disease and continues to harbor and shed the pathogen from his body
 - Carriers can be *temporary* (shed the organism for less than six months) or *chronic carriers* (shed the organisms for an indefinite period).

Animal Reservoir

The source of infection may sometime be animals and birds. The disease and the infections which are transmitted to man from vertebrates are called zoonoses. Common examples include:

- **From animals:** Rabies (from a dog), leptospirosis (from rodents), influenza (from pigs), etc.
- **Birds** may be the source of infection for various diseases like influenza, *Chlamydia psittaci* infection (psittacosis), histoplasmosis, etc.

Mode of Transmission

Microorganisms may be transmitted from the reservoir or source to a susceptible host in different ways.

Contact

This is the most common mode of transmission. Infection may be transmitted by direct or indirect contact.

- **Direct contact** is via the skin and mucosa of an infected person, e.g. through an unclean hand, kissing, or sexual contact. Organisms transmitted by direct contact include agents of common cold, skin infections, and sexually transmitted infections (STIs)
- **Indirect contact** is through the agency of fomites, which are inanimate objects, such as clothing, toys, etc. These may be contaminated by a pathogen and act as a vehicle for its transmission, e.g. face towels shared by various persons may lead to the spread of trachoma.

Inhalation

The inhalational route is the second most common mode of transmission. Transmission through respiratory route occurs either through droplets or aerosols.

- **Droplet transmission:** Transmission via large droplets requires close contact (<3 feet). Droplets may fall on surfaces and fomites present within 1 meter. People can subsequently acquire the infection when they touch the infected surfaces or fomites and then touch their nose, eyes, or mouth. Agents transmitted through droplets include:
 - Bacterial agents/diseases: Diphtheria, *H. influenzae*, meningococcus, pertussis, streptococcal pharyngitis
 - Viral agents/diseases: COVID-19, influenza, viral hemorrhagic fever (e.g. Ebola), mumps, parvovirus B19, rhinovirus, rubella, adenovirus.
- **Aerosol transmission:** Aerosols are small particles (<5 μm) generated by an infectious person during coughing, sneezing, or while performing certain aerosol-generating procedures (e.g. intubation). Infectious agents that are transmitted through aerosols include:
 - *Mycobacterium tuberculosis*
 - Measles virus
 - Varicella (chickenpox and zoster)
 - Smallpox (variola) virus.

Ingestion

Infectious agents can be transmitted by ingestion mode, either through contaminated water or food. Examples include:

- Intestinal infections like cholera, dysentery, diarrheagenic *E. coli* and intestinal parasitic infections, and viral agents of gastroenteritis, such as rotavirus
- Extraintestinal infections: In this type of infection, pathogens are transmitted by enteric route but produce disease manifestations elsewhere—*Salmonella Typhi* (typhoid fever), hepatitis A and E viruses, poliovirus, etc.

Inoculation

Pathogens, in some instances, may be inoculated directly into the skin or tissues of the host:

- **Animal bite**—for example, rabies virus is inoculated directly by the bite of a rabid animal
- **Inoculated directly into tissue**—spores of *Clostridium tetani* present in the soil, get deposited directly into the host tissues following severe wounds leading to tetanus.

Transmission of Blood-borne Infections

Blood-borne infections, such as hepatitis B, hepatitis C, and HIV may be transmitted by:

- Needle prick and other sharp injuries
- Blood transfusion
- Intravenous drug abuse (contaminated needles).

Vector Borne

Arthropod vectors, such as mosquitoes, flies, fleas, ticks, mites and lice are the vectors that transmit many diseases. Examples for vector-borne diseases include— *Anopheles* mosquito in malaria; *Culex* mosquito in filariasis, and arboviral infections.

Vertical Transmission

It refers to the transmission of infection from the mother to the fetus. It may be categorized into:

- **Transplacental transmission:** Infection transmitted via the placental barrier can lead to abortion, miscarriage, or stillbirth. If babies are born, they suffer from congenital malformations. The pathogens causing congenital infections are abbreviated as 'TORCH':
 - *Toxoplasma gondii*
 - Others (*Treponema pallidum*, varicella-zoster virus, parvovirus, Zika virus)
 - Rubella virus
 - Cytomegalovirus
 - Herpes simplex virus.
- **Transmission via the birth canal** without causing congenital malformation in the baby, e.g. include Group B *Streptococcus*, *Neisseria gonorrhoeae* and *Chlamydia trachomatis*, *Listeria*, and viruses (e.g. Hepatitis B, C, and HIV).

Infectivity or Communicability

It refers to the ability of an infectious agent to transmit from one person to another. A *period of communicability* is the time during which an infectious agent may be transferred directly or indirectly from an infected person to another person.

- **Measles:** From -4 to +4 days of onset of rash
- **Rubella:** From -1 to +1 week of onset of rash
- **COVID-19:** From -2 to +10 days of onset of symptoms.

Host Factors

Host refers to the human who can get the disease. A variety of factors intrinsic to the host, sometimes called risk factors, can influence an individual's exposure, susceptibility, or response to a causative agent.

- **Age:** Most viral infections are common at extremes of age, i.e. childhood and old age
- **Gender:** Most infections are either equally distributed or common in males
 - Males have a greater exposure risk to infections transmitted in work environments than females
 - Women are at greater risk of acquiring HIV and gonorrhea from sexual intercourse with an infected partner, as compared to men.
- **Pregnancy:** Certain diseases are common in pregnancy such as transplacental infections (e.g. CMV, rubella)
- **Host immune status:** Low immunity predisposes to many infections, such as CMV
- **Prior immunity:** Prior immunity to the agent due to vaccination or past infection can protect the individual from further infection. Some viral infections such as smallpox, chickenpox, measles, mumps, and rubella provide lifelong immunity
- **Nutritional status:** Malnutrition lowers the host immunity and thus predisposes to many viral infections, e.g. measles
- **Underlying comorbid disease:** People with diabetes, immunodeficiency disorders, or receiving steroid therapy are more prone to acquire various infections
- **Occupational status:** Sometimes, infectious diseases are more common in certain occupations; for example, zoonotic diseases such as anthrax are common among butchers, abattoirs, and farmers
- **Sexual practices:** People with multiple sex partners, men who have sex with men are more prone to develop various sexually-transmitted infections such as HIV
- **Hygiene:** Poor hygiene, poor sanitation, over-crowding, etc. predispose to several diseases such as acute diarrheal illness and typhoid fever
- **Genetic makeup:** Certain individuals are more prone to develop some microbial infections. This depends on the genetic makeup of the individual.

Environmental Factors

Environmental factors play an important role in disease causation.

- **Seasonality:** Many diseases are common in winters such as influenza and meningococcal meningitis; whereas vector-borne diseases such as malaria, dengue are more common in the rainy season
- **Disinfectants:** The organisms which are more resistant to the action of disinfectant can survive in the environment for longer. This is particularly important in the hospital environment where the multidrug-resistant organisms such as *Pseudomonas*, *Acinetobacter* and *Klebsiella*, etc. are widely prevalent

- **Soil:** Damp, sandy, or friable soil with vegetation is suitable for certain soil-transmitted helminths such as hookworm, *Ascaris*, and *Trichuris* than clay soil
- **Moisture:** Moisture is necessary for the survival of most microbes as dryness is rapidly fatal.

EXPECTED QUESTIONS

1. I. Write short notes on:

1. Epidemiological patterns.
2. Droplet versus aerosol transmission.

2. II. Multiple Choice Questions (MCQs):

1. **If the infection occurs at a much higher rate than usual in a particular geographical area, it is known as:**
 - a. Epidemic
 - b. Pandemic
 - c. Outbreak
 - d. Sporadic
2. **Organisms with low infective dose include all, except:**
 - a. *Shigella*
 - b. *Cryptosporidium parvum*
 - c. *Giardia*
 - d. *Vibrio cholerae*
3. **Aerosol transmission occurs in all, except:**
 - a. *Mycobacterium tuberculosis*
 - b. *Corynebacterium diphtheriae*
 - c. Measles virus
 - d. Varicella
4. **Healthcare associated infection is defined as new infection acquired in a healthcare facility which was neither present nor incubating at the time of admission, within**
 - a. 24 hours
 - b. 48 hours
 - c. 36 hours
 - d. 72 hours
5. **The complete and permanent worldwide reduction to zero new cases of the disease through deliberate efforts is known as**

- a. Reduction
- b. Elimination
- c. Eradication
- d. Control

6. **The person who harbors the infectious agent in the absence of any clinical symptoms and shed the organism to others is called**

- a. Patient
- b. Carrier
- c. Reservoir
- d. Infectious

Answers

1. a	2. d	3. b	4. b	5. c	6. b
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