INFECTION

ABSTRACT

Infections are caused by the invasion and multiplication of harmful microorganisms such as bacteria, viruses, fungi, and parasites within the body. It can range from mild conditions like the common cold to severe diseases such as tuberculosis, HIV/AIDS, and COVID-19. Infections can spread through direct contact, contaminated food or water, insect bites, or airborne droplets. This chapter explores the types, causes, transmission, prevention, and treatment of infections, highlighting their impact on individuals and public health. Understanding infections and effective control measures is essential for reducing disease burden and improving global health outcomes.

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I. INTRODUCTION

Infections have shaped the course of human history by affecting health, societies, and even the rise and fall of civilizations. Essentially, a definition of infection involves an invasion of the host body by microorganisms such as bacteria, viruses, fungi, or parasites that are capable of replication themselves and impairing normal functions of the host body.The interaction between host and pathogen forms a dynamic combat battle that very often scales up to disease in conditions where the immune system of the host is weak or the virulence on the part of the pathogen is very strong.From the common cold to pandemics such as COVID-19, infections have been one of the most ubiquitous aspects of the human experience, along with the cultures and borders that divide the human species. They put into relief how fragile this balance between humanity and the microbial world has been that continuously reconfigures itself in conjunction with changing environments and medicines, and against which new pathogens are arising. Understanding infection is not only fighting illness but, above all, it means understanding its deep biological, social, and environmental implications.[1]

Important Definitions

Pathogen: Disease-causing microbe is a pathogen.

Pathogenicity: The ability of pathogens to cause disease is called pathogenicity.

Parasites: Group of microbes that multiply in the host & cause harm to the host.

Commensal: Microbes reside within and surface of the host in complete harmony without causing any harm to the host.

Opportunistic Pathogen: A pathogen that is normally safe, but when a host is immunely compromised, it becomes infectious.

Attenuation: This is reduction of virulence achieved by repeated cultures of microbe in artificial media, growth in high temperature or in the presence of weak antiseptics, desiccation or prolonged or extended culture storage.

Infestation: It is different from infection in that it strictly refers to macroscopic parasites, like intestinal parasitic worms or surface arthropods.

II. CLASSIFICATION OF INFECTIONS

1. General Classification

Type of Infection	Definition
Primary infection	First exposure of pathogen in host
Reinfection	Subsequent infection by the same organism in host
Secondary infection	A new infection in an immunosuppressive host. Host resistivity is lowered due to pre-existing infection.
Focal infection	Localized infection caused by the dissemination of microbes
Cross infection	The existence of new infections in diseased patients
Nosocomial infection	This is a hospital-acquired infection.
Iatrogenic infection	Physician-induced infection during therapeutical procedure
Subclinical infection	Infection associated with no detectable symptoms
Pyogenic infection	Pus forming infection

2. Depending on the Origin of Infection

- **Exogenous Infection:** Exogenous sources of infection introduce organisms from anywhere outside to inside the body. The sources of infection can be human, beast or environmental origin.
- **Endogenous Infection:** When the infectious pathogen originates in the patient's body, typically from his natural vegetation.

3. Based on the Clinical Indication Produced

- **Asymptomatic (subclinical infection):** It is an infection with no detectable symptoms. E.g. Gonorrhoea
- **Symptomatic or Apparent Infection:** It further classified into acute and chronic infections.
  - Acute infection: Sudden or rapid onset of disease.
  - Chronic infection: The symptoms persist for a long period.
- **Latent Infection:** An infection in which pathogen remain dormant or hidden for prolong time; but capable of reactivating later. E.g. Syphilis, Tuberculosis etc

- **Atypical Infection:** The usual conventional symptoms of the disease are not present rather atypical symptoms may be present. [2]

Epidemiological Pattern of Infection

- **Endemic:** Endemic refers to an outbreak of disease that is consistently present in a specific geographic area or population.
- **Epidemic:** An epidemic is disease outbreak that occurs suddenly and spreads rapidly among lots of people in a specific area or population, significantly exceeding the expected number of cases.
- **Pandemic:** A pandemic is a disease outbreak that spreads widely and impacts a significant number of people on a global scale. A pandemic involves widespread geographic distribution and impacts a significant portion of the global population. Ex. Covid 19 pandemic

Sources and Reservoir of Infection

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

Source of Infection: The source of infection is defined as origin of infectious agent from where it disseminated to the host. It includes

- Human beings e.g. Hepatitis, AIDS during body fluid transfusion
- Animals e.g. Rabies, Monkey pox etc
- Insect vectors e.g. Malaria, Dengu etc
- Food e.g. Food poisoning, Typhoid etc
- Water, air and soil

Period of Infectivity: The duration during which the source is infectious or is spreading the pathogen. [2,3]

Reservoir: Reservoir means any living or non-living source (animal, arthropod, plant, soil etc) where a pathogen naturally resides, grow & multiplies, serving as a starting point for its spread to a susceptible host. Understanding reservoirs is critical for controlling and preventing infectious diseases, as they play a central role in the transmission cycle.

Types of Reservoirs

1. Human Reservoir
2. Animal Reservoir
3. Non living Reservoir

1. **Human Reservoir:** A human reservoir for disease is a person or population of humans that harbors a pathogen (bacterium, virus, or other microorganisms) and can potentially pass the agent to another susceptible individual, even if the host does not develop apparent symptoms of the disease. Thus, such individuals are carriers of the disease and can contribute to the spread of the disease even when asymptomatic or in an incubation period. Human sources may either be cases (patients) or carriers.

   - **Patients:** These are individuals affected by disease. Patients may be of various types depending on the manifestation of symptoms. For the convenience of diagnosis, these have been classified as subclinical, latent, and clinical.
   - **Carrier:** A carrier of disease is an individual—human or animal—who harbors a pathogenic organism without showing symptoms of the disease but can transmit it to others. Carriers play a significant role in the spread of infections, especially when their asymptomatic status makes detection and control challenging.

     The carrier is less infectious than the patient, but it may more dangerous because it continuously spread the infection over a considerably longer period.

     Types of Carriers

     - **Convalescent Carrier:** Individuals who have recovered from the symptoms of the disease but continue to shed the pathogen. Example: Patients recovering from *Hepatitis B* or *cholera*.
     - **Incubatory Carriers:** Individuals who are in the early stages of infection, before symptoms develop, and are capable of transmitting the pathogen. Example: People infected with influenza or COVID-19 often spread the virus during the incubation period.
     - **Healthy Carrier:** An individual who only harbours the pathogen but never become ill.
     - **Temporary Carrier:** The carriers who shed the infectious agent for short period of time.
     - **Chronic Carrier:** Individuals who harbor the pathogen for an extended period, sometimes for life, and may intermittently or continuously shed it.
       Example: Chronic carriers of *Hepatitis C* or *Salmonella typhi*.

- **Incubatory Carrier:** Incubatory carriers are those individuals who shed the organism during the incubation period of disease.
- **Contact Carrier:** It is a person who acquires the pathogen from the patient.
- **Carrier of Paradox:** Paradox carrier is that carrier who gets the pathogen from another carrier.

2. **Animal Reservoir:** Animals act as reservoirs for pathogens that can be transmitted to humans. Such diseases are called zoonoses. Some examples of zoonoses are-

   Bacterial: Plague from rats, Leptospirosis from dogs, Psittacosis from birds etc.

   Viral: Rabies from dogs, yellow fever, monkey pox etc.

   Protozoal: Toxoplasmosis from cats, Trypanosomiasis etc.

   Helminthic: Hydatid disease from dogs, Teniasis etc.

   Fungal: Zoophilic dermatophytes from cats and dogs

3. **Non Living Things as Reservoir:** Inanimate objects in soil can also serve as infection reservoirs. E.g. Tetanus, Anthrax, Mycetoma etc

III. MODE OF TRANSMISSION

Human acquire infection from various modes.

1. Inhalation
2. Ingestion
3. Inoculation
4. Insect bite or vector borne
5. Direct contact
6. Congenital

Inhalation: Respiratory tract infections like whooping cough, influenza, TB, common cold etc are acquired through inhalation. Patients spread these microbes into the environment via nose and throat secretions when they sneeze, talk, cough, or perform similar forceful expiratory activities. From the nose & lips, large droplets larger than 0.1 mm in diameter shoot forward and downward a few feet before reaching the floor in a matter of seconds. Alternatively, they may land on the eyes, face, mouth, and clothing of the person standing in front of the spray producer. Small droplets with a diameter of less than 0.1 mm forth

with evaporate instantly to form tiny particles which are typically 1–10 μm in diameter and hang in the air for extended periods of time, serving as infection sources. Particles in the 1–5 μm range are likely to be readily absorbed into and possibly trapped in the lungs' alveoli.

Ingestion: Food borne infections like food poisoning, diarrhoea etc, water borne infections e.g. cholera, typhoid etc are transmitted through ingestion.

Inoculation: The microbial agent can be directly inculcated into the skin or mucous membranes by external cuts, animal bite, and accidental prick during medical procedure. For example, rabies virus deposited subcutaneously by the bite of an infected animal, tetanus spores implanted in deep wounds etc.

Insect Bite: Insects are mechanical as well as biological vector for infectious disease. Mosquitoes, ticks, mites, flies, fleas & lice are some blood sucking insects known to transfer disease causing agents from infected to healthy individuals.

- **Mechanical Vector:** These carry the microbes (which do not multiply) & transmit them to the eatables. e.g., Transmission of dysentery by flies
- **Biological Vector:** The pathogen multiplies in the body of the vector, often undergoing part of a development cycle in it. E.g-Female *Anopheles mosquito* in malaria, *culex mosquito* in filariasis. [2,4]

Direct Contact: The process in which pathogen is transfer from infected person to healthy individual through direct physical contact (kissing, sexual contact etc) or direct contact with body fluids (blood, urine etc). e.g. Conjunctivitis, Infectious mononucleosis etc.

Blood Borne Transmission: This involves the transmission of pathogens through blood and other body fluids. E.g. AIDS, Hepatitis etc.

Vertical Transmission: Vertical transmission includes the transfer of infection from mother to offspring during pregnancy, parturition & lactation. This may result in abortion, miscarriage, or stillbirth.

IV. MECHANISM OF MICROBIAL PATHOGENICITY

Microbial infectious mechanism differs among pathogens. In general, infectious mechanism has following stages –

1. Microbial entry in host

2. Microbial adhesion to host cells
3. Microbial propagation or invasion
4. Host damage
5. Evasion of host defence

Thus, microbial pathogenicity depends on these stages. Pathogenicity & virulence are two terms in which pathogenicity is the ability of an organism to cause disease while Virulence denotes the degree of pathogenicity. It gives evidence about how effectively a pathogen can yield a disease and serious the disease can be. The severity of virulence is often quantified by the potential of the pathogen to cause damage or harm to the host.

Bacterial Pathogenesis

1. **Entry into Host:** The first step of the infectious mechanism is the entry of the pathogen into the host via the respiratory, urogenital tract, gastrointestinal tract or through skin that has been injured. Once entry is achieved the pathogen overcomes diverse host defences before it can establish itself. These include phagocytosis, the acidic environments of the digestive & urogenital tract, and various hydrolytic enzymes found in the different routes of body.

2. **Adherence to Host Cells:** Bacterial surface possesses adhesions molecules and structure (pili, cell wall etc) on their surface. Adhesins are surface proteins on cell wall that enable the bacterium to colonize on host surface and resist physical removal.

3. **Invasiveness:** Invasion properties are mediated by bacterial enzymes such as collagenase and hyaluronidase, which degrade extracellular matrix so that the bacteria easily access to host cell machinery. Bacterium pathogen express extracellular membrane proteins “invasins” that interact with host cell receptors, thereby eliciting signalling cascades resulting bacterial uptake by induced phagocytosis. Invasion is often characterised by inflammation, which may be pyogenic, granulomatous, or nodular inflammatory lesions, depending on the organism.

4. **Host Damage:** Bacteria causes disease by producing toxins (exotoxins & endotoxins). Toxins are poisonous substances chemically proteinaceous in nature. Toxins disrupt host machinery by blocking protein synthesis, signalling cascades, etc.

Difference between Bacterial Endotoxins and Exotoxins

Feature	Exotoxin	Endotoxin
Source	Produced by both Gram-positive and Gram-negative bacteria.	Exclusively produced by Gram-negative bacteria. [10] [12]
Chemical Nature	Protein	Lipopolysaccharide (LPS).[11][12]
Heat Stability	Heat-labile typically inactivated at temperatures above 60°C.	Heat-stable, resistant to high temperatures. [10] [11]
Toxicity	Highly toxic, even in minute amounts	Moderately toxic, requiring larger quantities to affect the host [12] [13]
Specificity	Specific to certain cell types or systems (e.g., neurotoxins, enterotoxins).	Non-specific; elicits general effects like fever and inflammation. [10] [13]
Mechanism of Action	Directly acts on target cells, often enzymatic (e.g., inhibiting protein synthesis).	Activates immune responses by stimulating cytokine release. [11] [13]
Production	Actively produced and secreted by live bacteria during growth.	Released passively when bacteria die or the cell membrane is disrupted. [10] [12]
Examples	Botulinum toxin (*Clostridium botulinum*), diphtheria toxin (*Corynebacterium diphtheriae*).	Lipid A component of *Escherichia coli* and *Salmonella*. [11] [13]
Antigenicity	Highly antigenic; stimulates strong antibody responses.	Weakly antigenic, does not elicit strong immune protection. [12] [13]
Use in Vaccines	Can be converted to toxoids (detoxified exotoxins) for vaccines.	Cannot be converted to toxoids; not used directly in vaccines. [11] [13]
Effect on Host	Causes disease-specific effects (e.g., neurotoxicity, tissue necrosis).	Causes systemic effects like fever, septic shock, and inflammation. [10] [13]

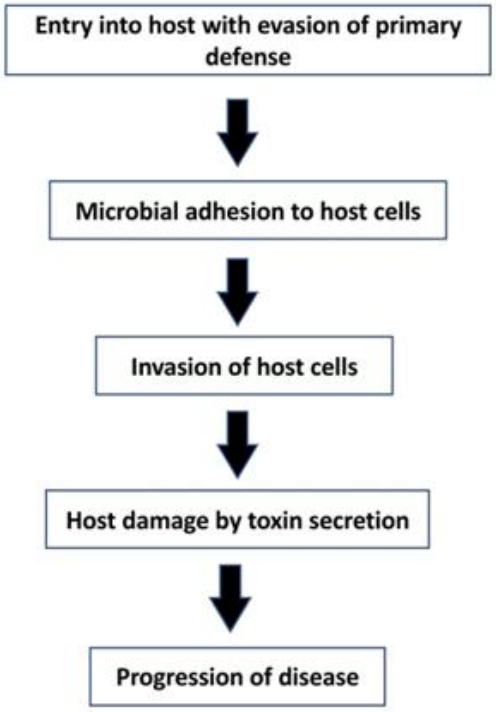

Figure 4: Bacterial Pathogenesis

Viral Pathogenesis

Viral pathogenesis differs from bacteria. Viruses are obligatory intracellular parasites that replicate only inside living cells. Consequently, pathogenic manifestations appear at the cellular level. The initial infection of viruses may be asymptomatic or mild because commonly they are cleared completely by the host's immune system. In the case of some viruses, the initial infection is followed by a latent infection. Entry routes are the same as bacterial infections. After entry, viruses remain localized & largely restricted to the primary site of infection. They multiply inside cells that may be accompanied by symptoms (cell death, transformation, etc). The presence of viral particles in blood circulation is called viraemia.[6]

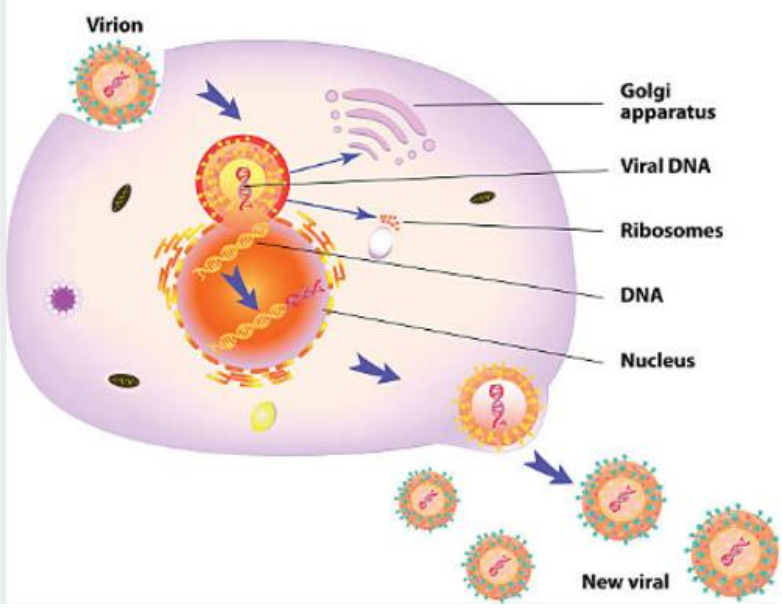

Figure 5: Viral Entry in Cells

Infective Dose of the Organism

The infective dose refers to the quantity of pathogens (bacteria, viruses, or other microorganisms) required to cause an infection in a host organism. It is typically measured in terms of the number of organisms needed to establish an infection in a person, animal, or other susceptible host.

Low Infective Dose

E. coli 0157:H7 (<10 bacilli)

Entamoeba coli and *Giardia*: Few cysts

C. jejuni (500 bacilli)

Large Infective Dose

E. coli –10^{6-} 10^{8} bacilli

Salmonella – 10^{2} -10^{5} bacilli

V. cholerae – 10^{6} – 10^{8} bacilli

Diagnosis and Treatment of Infection

Diagnosis

Diagnosis starts with a clinical assessment, followed by eliciting the history, symptoms, and physical examinations that are necessary. Blood cultures, PCR

test, and serological assays are use to identifying the etiological agent. Among all infections, some entities require the help of imaging (X- rays, ultrasound etc).

Treatment

Treatment depends on the pathogen involved and the severity of the infection. Key approaches include:

- **Antibiotics:** Used for bacterial infections (e.g., Penicillin for *Streptococcus pneumoniae*).
- **Antivirals:** Target viral infections (e.g., Oseltamivir for influenza).
- **Antifungals:** Treat fungal infections (e.g., Fluconazole for Candida).
- **Antiparasitics:** Used for parasitic infections (e.g., Chloroquine for malaria).

In addition to specific antimicrobial therapy, supportive care (e.g., fluids, pain management) is often necessary. In severe cases, surgical intervention may be required to drain abscesses or remove infected tissue.

Prevention of Infection

Preventive measures include:

- **Vaccination:** Vaccines helps to prevent infections caused by viruses and bacteria (e.g., MMR vaccine for measles, mumps, and rubella).
- **Hygiene:** Proper hand washing, sanitation, and food safety practices can prevent the spread of infections.
- **Antimicrobial Stewardship:** Limiting the unnecessary use of antibiotics can help reduce the emergence of resistant strains.
- **Vector Control:** Reducing exposure to vectors (e.g., mosquitoes) can help to prevent diseases like malaria and dengue fever. [7,8,9]

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