Microorganisms

Chapter 9: MICRO-ORGANISMS AND HEALTH

Learning Objectives: Upon completion of this chapter, students should be able to:

- Discuss the concept of health and disease.
- Explain how microorganisms cause diseases (pathogenicity).
- Identify common microbial diseases and their causative agents.
- Describe modes of disease transmission.
- Outline methods of disease prevention and control at personal and public health levels.
- Discuss the importance of sanitation, waste disposal, and clean water supply.
- Explain the role of vectors in disease transmission and their control.
- Understand the concept of immunity and its types.
- Describe the body's defense mechanisms against disease.

9.1 Health and Disease

- **Health:** A state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity (WHO definition).
- **Disease:** Any condition that impairs the normal functioning of an organism. Diseases can be caused by various factors, including pathogens (microorganisms), genetic disorders, nutritional deficiencies, environmental factors, or lifestyle choices.
    - **Infectious Diseases:** Caused by pathogenic microorganisms (bacteria, viruses, fungi, protozoa). They can be transmitted from one person/organism to another.
    - **Non-Infectious Diseases:** Not caused by pathogens and generally not transmissible (e.g., diabetes, heart disease, some cancers, genetic disorders).
- **Pathogenicity:** The ability of a microorganism to cause disease.
- **Virulence:** The degree of pathogenicity; the severity of disease caused by a microorganism.

9.2 How Microorganisms Cause Diseases

Pathogenic microorganisms cause disease through various mechanisms:

1. **Direct Damage to Cells/Tissues:**
    - **Invasion and Replication:** Microbes invade host cells or tissues and multiply, directly destroying cells (e.g., viruses replicating within host cells, bacteria invading tissues).

    - **Mechanical Blockage:** Some pathogens can multiply to such an extent that they physically block ducts or vessels (e.g., bacteria blocking airways).
2. **Toxin Production:**
    - Many bacteria (and some fungi) produce toxins (poisonous substances) that can harm host cells or interfere with normal physiological processes.
    - *Exotoxins:* Released by living bacteria (e.g., tetanus, botulism toxins).
    - *Endotoxins:* Part of the bacterial cell wall, released when bacteria die and lyse (e.g., cause fever, shock).
3. **Host Immune Response:**
    - The host's immune system's attempt to fight the infection can sometimes cause damage (e.g., inflammation, autoimmune reactions).
    - Symptoms like fever, swelling, and pain are often part of the body's immune response.
4. **Resource Depletion:**
    - Pathogens can compete with host cells for essential nutrients, weakening the host.

9.3 Common Microbial Diseases and Causative Agents

- **Bacterial Diseases:**
    - **Cholera:** *Vibrio cholerae* (waterborne, severe diarrhea).
    - **Tuberculosis (TB):** *Mycobacterium tuberculosis* (airborne, affects lungs primarily).
    - **Typhoid Fever:** *Salmonella Typhi* (food/waterborne, high fever, abdominal pain).
    - **Tetanus:** *Clostridium tetani* (spores in soil, affects nervous system, muscle spasms).
    - **Pneumonia:** Various bacteria (e.g., *Streptococcus pneumoniae*) (respiratory, lung infection).
    - **Food Poisoning:** *Salmonella*, *E. coli*, *Staphylococcus aureus* (ingestion of contaminated food/toxins).
- **Viral Diseases:**
    - **Influenza (Flu):** Influenza virus (respiratory, fever, body aches).
    - **Measles:** Measles virus (airborne, rash, fever).
    - **Common Cold:** Rhinoviruses, coronaviruses (respiratory, mild symptoms).
    - **HIV/AIDS:** Human Immunodeficiency Virus (sexual contact, blood, affects immune system).
    - **COVID-19:** SARS-CoV-2 (respiratory, range of symptoms).
    - **Chickenpox:** Varicella-zoster virus (airborne, rash, itchy spots).
- **Fungal Diseases:**
    - **Ringworm:** Various fungi (*Tinea* species) (skin infection).
    - **Athlete's Foot:** Various fungi (*Tinea pedis*) (foot infection).
    - **Candidiasis (Thrush):** *Candida albicans* (yeast infection of mouth, vagina, skin).
- **Protozoan Diseases:**
    - **Malaria:** *Plasmodium* species (transmitted by Anopheles mosquitoes, fever, chills, affects red blood cells).
    - **Amoebic Dysentery:** *Entamoeba histolytica* (contaminated food/water, severe diarrhea).
    - **Sleeping Sickness:** *Trypanosoma brucei* (transmitted by tsetse fly, affects nervous system).

9.4 Modes of Disease Transmission

How infectious diseases spread from one host to another:

1. **Direct Contact:**
    - **Physical Contact:** Touching an infected person (e.g., skin infections, STIs).
    - **Droplet Spread:** Short-range transmission of respiratory droplets (e.g., common cold, flu, COVID-19 when close to an infected person).
2. **Indirect Contact:**
    - **Airborne Transmission:** Pathogens suspended in air over longer distances (e.g., tuberculosis, measles).
    - **Fomites:** Contaminated inanimate objects (e.g., doorknobs, toys, clothing) (e.g., common cold, flu).
    - **Food and Waterborne:** Ingestion of contaminated food or water (e.g., cholera, typhoid, food poisoning).
    - **Soilborne:** Contact with pathogens in soil (e.g., tetanus).
3. **Vector-borne Transmission:**
    - **Biological Vectors:** Living organisms (usually arthropods like mosquitoes, ticks, flies) that transmit pathogens from one host to another (e.g., malaria by mosquitoes, Lyme disease by ticks). The pathogen often multiplies within the vector.
    - **Mechanical Vectors:** Vectors that physically carry pathogens on their bodies from one place to another without being infected themselves (e.g., flies carrying bacteria from feces to food).
4. **Animal-to-Human (Zoonotic Transmission):**
    - Diseases transmitted from animals to humans (e.g., rabies, avian flu, Ebola, sometimes COVID-19 origins).

9.5 Disease Prevention and Control

Strategies to minimize the spread and impact of infectious diseases:

- **A. Personal Health/Hygiene:**
    1. **Handwashing:** Frequent and thorough handwashing with soap and water, especially after coughing/sneezing, using the restroom, before eating.
    2. **Respiratory Etiquette:** Covering coughs and sneezes with a tissue or elbow.
    3. **Food Hygiene:** Washing fruits/vegetables, cooking food thoroughly, storing food safely, avoiding cross-contamination.
    4. **Personal Cleanliness:** Regular bathing, clean clothing.
    5. **Safe Sexual Practices:** Using condoms to prevent STIs.
    6. **Avoiding Contact:** Limiting contact with sick individuals.
    7. **Adequate Rest and Nutrition:** Boosting the immune system.
- **B. Public Health Measures:**
    1. **Sanitation and Waste Disposal:**
        - **Proper Sewage Disposal:** Treating and safely disposing of human waste to prevent water and soil contamination.
        - **Solid Waste Management:** Regular collection and safe disposal of refuse to prevent breeding grounds for vectors and reduce pathogen spread.

2. **Clean Water Supply:**
    - **Water Treatment:** Filtration, chlorination, and other processes to remove pathogens from drinking water.
    - **Protecting Water Sources:** Preventing pollution of rivers, lakes, and groundwater.
3. **Vector Control:**
    - **Mosquito Control:** Eliminating breeding sites (stagnant water), using insecticides, bed nets, biological control (e.g., fish eating larvae).
    - **Rodent Control:** Trapping, poisoning, improving sanitation to reduce rodent populations (which can carry diseases).
    - **Insecticides:** Targeted spraying to control insect vectors.
4. **Vaccination Programs/Immunization:**
    - Large-scale immunization campaigns to achieve "herd immunity," protecting vulnerable individuals who cannot be vaccinated.
5. **Disease Surveillance and Reporting:**
    - Monitoring disease patterns, identifying outbreaks, and implementing control measures quickly.
6. **Quarantine and Isolation:**
    - Separating infected individuals (isolation) or those exposed to disease (quarantine) to prevent further spread.
7. **Public Education:**
    - Raising awareness about disease prevention, hygiene, & healthy behaviors.
8. **Food Safety Regulations:**
    - Inspection of food processing plants, restaurants, and enforcement of hygiene standards.

9.6 Immunity and Body Defense Mechanisms

- **Immunity:** The ability of an organism to resist a particular infection or toxin by the action of specific antibodies or sensitized white blood cells.
- **Types of Immunity:**
    1. **Natural Immunity (Innate/Non-specific):**
        - Present from birth, provides immediate but general protection against a wide range of pathogens.
        - *Examples:* Skin, mucous membranes, stomach acid, phagocytic white blood cells (macrophages, neutrophils), natural killer cells, inflammation, fever.
    2. **Acquired Immunity (Adaptive/Specific):**
        - Develops during a person's lifetime in response to exposure to specific pathogens or vaccines. Highly specific and provides long-lasting protection (memory).
        - *Types of Acquired Immunity:*
            - **Active Immunity:**
                - **Natural Active Immunity:** Develops after natural exposure to an infection (e.g., getting measles once and becoming immune).
                - **Artificial Active Immunity:** Develops after vaccination (e.g., MMR vaccine for measles).
                - *Mechanism:* The body produces its own antibodies and memory cells. Long-lasting.

        - **Passive Immunity:**
            - **Natural Passive Immunity:** Antibodies transferred from mother to child (e.g., via placenta or breast milk).
            - **Artificial Passive Immunity:** Antibodies from another source are given to an individual (e.g., antitoxins for tetanus, antivenom).
            - *Mechanism:* Body receives pre-formed antibodies. Immediate but short-lived (no memory cells produced).
- **Body's Defense Mechanisms (Overview):**
    1. **First Line of Defense (Physical/Chemical Barriers):**
        - **Skin:** Intact skin acts as a physical barrier.
        - **Mucous Membranes:** Line respiratory, digestive, urinary, and reproductive tracts, trapping microbes.
        - **Cilia:** In the respiratory tract, sweep mucus and trapped microbes away.
        - **Body Secretions:** Tears, saliva (contain enzymes like lysozyme), stomach acid (low pH kills many microbes), urine (washes out urinary tract), sweat (antimicrobial properties).
    2. **Second Line of Defense (Non-specific Internal Defenses):**
        - **Phagocytes:** White blood cells (e.g., neutrophils, macrophages) that engulf and digest pathogens.
        - **Inflammation:** Localized response to injury or infection (redness, swelling, heat, pain) to contain and destroy pathogens, and initiate repair.
        - **Fever:** Elevated body temperature, which can inhibit microbial growth and enhance immune responses.
        - **Natural Killer (NK) Cells:** Lymphocytes that kill virus-infected cells and cancer cells.
    3. **Third Line of Defense (Specific Immune Response - Lymphocytes):**
        - **Lymphocytes (B cells and T cells):** Recognize and target specific pathogens.
        - **B cells:** Produce antibodies (proteins that bind to and neutralize specific pathogens or toxins).
        - **T cells:** Attack infected cells directly (cytotoxic T cells) or regulate immune responses (helper T cells).
        - **Memory Cells:** Produced after initial exposure, allowing for a faster and stronger immune response upon subsequent exposure to the same pathogen.