CHAPTER 6
TRANSMISSION OF INFECTION, THE
COMPROMISED HOST, AND EPIDEMIOLOGY

WHY IS THIS IMPORTANT?

Understanding the ways in which infectious diseases are transmitted and the role of a compromised host in the process are vital for developing methods to prevent the spread of disease.

In order to understand the transmission of disease, it is important to look at:
- Where pathogens responsible for infection are found
- Mechanisms of transmission from the environment to a host
- Mechanisms of transmission from a host to the wider population.

WHY IS THIS IMPORTANT?

- The compromised host must be viewed as an integral part of the infection process.
- The more compromised the host, the greater is the risk of successful infection.
- An understanding of the basic principles of epidemiology is critical in preventing the spread of disease.
TRANSMISSION OF INFECTION

- The transmission (spread) of infection is the final requirement for a successful pathogen.
- Two factors affect the spread of infection:
  - Reservoirs of infectious organisms – places where pathogens can grow and accumulate
  - Mechanisms of transmission – the various ways in which pathogens move from place to place.

PATHOGEN RESERVOIRS

- There are three potential reservoirs of pathogens:
  - Humans
  - Other animals
  - Nonliving reservoirs
HUMAN RESERVOIRS

- There are two types of human reservoir:
  - Sick people – easy to identify when symptoms are visible, but difficult when symptoms have yet to develop or have ceased.
  - Carriers of infections – individuals who will never show symptoms but are still infectious.

ANIMAL RESERVOIRS

- Diseases transferred from animals to humans are called zoonotic diseases.
- Zoonotic diseases are usually transmitted through direct contact with humans.
  - They can also be transmitted through indirect contact such as the waste material of a litter box, fur, feathers, or infected meats.
  - Zoonotic diseases can also be indirectly transmitted by vectors.

ANIMAL RESERVOIRS

<table>
<thead>
<tr>
<th>Zoonotic Agent</th>
<th>Mode of Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bubonic plague</td>
<td>Direct contact with infected animal, inhalation</td>
</tr>
<tr>
<td>Lymphatic plague</td>
<td>Direct contact with infected animal, inhalation</td>
</tr>
<tr>
<td>Typhus</td>
<td>Direct contact with infected animal, inhalation</td>
</tr>
<tr>
<td>Rocky Mountain spotted fever</td>
<td>Direct contact with infected animal, tick bite</td>
</tr>
<tr>
<td>Relapsing fever</td>
<td>Direct contact with infected animal, tick bite</td>
</tr>
<tr>
<td>Malaria</td>
<td>Mosquito bites</td>
</tr>
<tr>
<td>Rabies</td>
<td>Direct contact with infected animal, bite</td>
</tr>
</tbody>
</table>

Note: This table is a simplified representation and does not include all zoonotic diseases.
NONLIVING RESERVOIRS

- Nonliving reservoirs of infection include water, food, and soil.
  - Water is the most dangerous.
  - Infections of this kind are often seen in countries with poor sanitation and low levels of personal hygiene.

NONLIVING RESERVOIRS

- We cannot live without water and as a result, regions with poor sanitation practices can have high levels of fecal contamination in the water.
  - This leads infection to spread via the fecal-oral route of infection.
- Food contamination is often a product of natural spoilage.
- For soil pathogens, the skin must be broken for entry into the body.

MECHANISMS OF TRANSMISSION

- There are three mechanisms of pathogen transmission:
  - Contact transmission
  - Vehicle transmission
  - Vector transmission
CONTACT TRANSMISSION

- A healthy person is exposed to pathogens by either touching or being in proximity to an infected person or object.
- There are three types of contact transmission:
  - Direct contact transmission
  - Indirect contact transmission
  - Droplet transmission

DIRECT CONTACT TRANSMISSION

- There is no intermediary between infected and uninfected individuals.
- It encompasses such things as touching, kissing, and sexual interactions.
- Diseases transmitted through direct contact include:
  - Hepatitis A
  - Smallpox
  - Staphylococcal infections
  - Mononucleosis
  - Sexually transmitted diseases.

INDIRECT CONTACT TRANSMISSION

- Takes place through intermediates that are usually nonliving articles:
  - Tissues
  - Handkerchiefs
  - Towels
  - Bedding
  - Contaminated needles (the latter easily transferring HIV and hepatitis B).
- Nonliving intermediates that act as the agents of transmission by indirect contact are referred to as fomites.
DROPLET TRANSMISSION

- Droplet transmission is seen in the transfer of respiratory diseases such as influenza and whooping cough.
- It can occur through sneezing, coughing, and even laughing.

Although it is confined to short distances, the size of the droplet is important.
- Large droplets will fall to the ground quickly, but smaller droplets can stay airborne for long periods.
- The smaller the droplet, the more dangerous it is as an agent of disease.
VEHICLE TRANSMISSION

- Vehicle transmission involves pathogens riding along on supposedly clean components.
- Examples of vehicles include:
  - Air
  - Food
  - Water
  - Blood
  - Bodily fluids
  - Drugs
  - Intravenous fluids

VECTOR TRANSMISSION

- Pathogens are transmitted by carriers, usually arthropods:
  - Fleas
  - Ticks
  - Flies
  - Lice
  - Mosquitoes
VECTOR TRANSMISSION

- There are two types of vector transmission:
  - Mechanical vector transmission – pathogens are on vector’s body parts and are passively brushed off and onto the host
  - Biological transmission – pathogens are within the vector and transmission to the host is through a bite.

FACTORS AFFECTING DISEASE TRANSMISSION

- Initially, the overall health of the host has a clear influence on the disease process.
- For all people, the disease process is affected by:
  - Age – disease levels tend to increase as we age
  - Gender – some diseases are more prevalent in one gender or another
    - Urinary tract infections (UTIs) are seen more in women
    - Pneumonia is seen more in men.
  - Lifestyle
- Occupation – more infections are seen in health care workers.
- Emotional state – a vulnerable emotional state can decrease immunocompetence in the host.
- Climate – it appears that there is a greater incidence of respiratory infections in colder climates.
PORTALS OF EXIT

- Many portals of exit are identical to the portals of entry.
- Pathogens use these to exit from a host.
- In exiting, this is usually achieved through bodily secretions such as saliva, sputum, and respiratory droplets.
- However, disease can also leave the body via blood, vaginal secretions, semen, urine, and feces.

THE COMPROMISED HOST

- The infected host is a very important part of the disease process.
- Spread of disease and pathogens can be dependent on the host.
- The host’s ability to mount a defense is referred to as its immunocompetence.
- If host defenses are in some way compromised the potential for damaging infectious disease increases.
  - This point is dramatically illustrated in acquired immunodeficiency syndrome (AIDS).
THE COMPROMISED HOST

- Other situations which can weaken the immune defenses of the host include:
  - Lifestyle
  - Occupation
  - Trauma
  - Travel
  - Aging

THE COMPROMISED HOST

- Several groups of people are considered to be vulnerable to infection and therefore immunocompromised to varying degree:
  - People with AIDS and people with genetic immunodeficiency diseases
  - People undergoing chemotherapy and patients taking broad-spectrum antibiotics
  - Surgical, transplant, and burn patients
  - Premature and newborn infants
  - Health care workers
  - The elderly
  - Patients on artificial ventilators

NEUTROPENIA

- Neutropenia is defined as lower-than-normal numbers of neutrophils in the blood:
  - Neutrophils are a form of primary phagocytic defense and an important component of a host’s innate immune response.
  - The most common cause of profound neutropenia is the administration of cytotoxic chemotherapy for the treatment of malignant tumors seen in cancer.
  - The types of infections seen with neutropenia are primarily bacterial and fungal.
NEUTROPENIA

- Bacterial infections can begin as soon as neutrophil levels drop.
- Fungal infections are usually only seen after neutrophil levels have been low for a prolonged period of time.
  - These infections are often associated with surgical procedures and catheterization.

ORGAN TRANSPLANTATION

- The immune system recognizes the differences between host organs and transplanted organs.
  - Rejection of transplanted organs is suppressed through the administration of drugs.
  - These drugs reduce rejection but cause increased susceptibility to infection.
- Infections in organ-transplant patients require treatment with broad spectrum antibiotics.
  - Unfortunately, these drugs can cause antibiotic resistance and super infections.

BURN PATIENTS

- Burn victims are at risk because of the loss of large areas of the primary physical barrier to infection – the skin.
- When skin is lost, there is a greater chance of infection and septicemia.
- *Pseudomonas* infections are a particular problem in burn victims because this organism is very resistant to methods used to control bacterial growth.
OPPORTUNISTIC INFECTIONS

- Many infections are caused by opportunistic pathogens.
- These pathogens can be part of the normal flora in our bodies.
  - Pathogens can be safe in the specific areas where they normally reside but can move to other parts of the body and cause infection.
  - The best example of this type of infection is urinary tract infections (UTIs).

- Some opportunistic infections can be due to the loss of normal flora in our bodies.
  - This type of infection can be due to overuse/improper use of antibiotics with other conditions.

NOSOCOMIAL INFECTIONS

- Any infection acquired in the hospital or medical facility is called a nosocomial infection.
- Nosocomial infections can affect patients and health care workers.
- There are approximately two million nosocomial infections in the United States each year resulting in approximately 90,000 deaths and costs of over $5 billion.
NOSOCOMIAL INFECTIONS

- These types of infections are usually associated with intravenous applications such as the following:
  - Catheterization
  - Invasive tests and surgery

NOSOCOMIAL INFECTIONS

- The same factors used when considering any other type of infection apply to hospital-borne infections. Hospitals must consider:
  - The source of the infection
  - The mode of transmission of the pathogen
  - The susceptibility of the patient to infection
  - Prevention and control

NOSOCOMIAL INFECTIONS

- The most common sites of nosocomial infections are the following:
  - Urinary tract
  - Respiratory tract
  - Surgical wounds
NOSOCOMIAL INFECTIONS

- The most common sources of nosocomial infections within the hospital environs are:
  - Other patients
  - Hospital staff
  - Visitors
  - Unsanitary conditions
  - Water supplies
  - Respiratory equipment
  - Catheters

- The most common pathogens which cause nosocomial infections are:
  - *Escherichia coli*
  - *Enterococcus species*
  - *Staphylococcus aureus*
  - *Pseudomonas aeruginosa*

- These organisms are ubiquitous in hospitals all over the world.
  - They are so common because they are easily moved from place to place by staff, patients, or visitors.
  - Many of these organisms are resistant to antibiotics including methicillin-resistant *S. aureus* (MRSA) and vancomycin-resistant *S. aureus* (VRSA).
NOSOCOMIAL INFECTIONS

- Pathogens found on medical equipment can contribute to nosocomial infections when used in medical procedures. This can include:
  - Catheters
  - Respiratory equipment
  - Dialysis equipment

NOSOCOMIAL INFECTIONS: Universal Precautions

- All medical facilities in the US have to conform to specific guidelines for patient care.
- These procedures include protocols for handling the following:
  - Blood
  - Semen
  - Vaginal secretions
  - Tissue specimens
  - Bodily fluids
- These procedures do not include protocols for feces, nasal secretions, sputum, urine, or vomit.

NOSOCOMIAL INFECTIONS: Prevention and Control

- Every hospital in the US must have programs in place to address the following concerns:
  - Surveillance of nosocomial infections in patients and staff
  - On-site microbiology laboratory plus standardized isolation procedures
  - Standardized procedures for the use of catheters and hospital equipment
  - Proper decontamination and sanitary procedures
  - Mandatory nosocomial-disease education programs
  - In some cases, infection-control specialist on staff
EPIDEMIOLOGY

- Epidemiology is the study of the factors and mechanisms involved in the frequency and spread of disease and other health-related problems.
- Epidemiology can be used not only as a tool to study disease but also as a way to design methods for the control and prevention of diseases.

INCIDENCE AND PREVALENCE

- The incidence of a disease is the number of new cases in a set population over a specific period.
  - Knowing the incidence level gives information on the spread of a disease.

- The prevalence of a disease is the total number of people infected within a specific population at any given time:
  - Prevalence data measure how seriously and how long a population is affected by a disease.
MORBIDITY AND MORTALITY RATES

- Morbidity rate – the number of individuals affected during a set period divided by the total population number.
- Mortality rate – the number of deaths due to a specific disease divided by the total population number.

Epidemiological studies classify diseases as:
- Sporadic – occurring in random manner; no threat to public health
- Endemic – diseases that are constantly in the population
- Epidemic – incidence of a disease suddenly higher than expected
  - Morbidity and mortality rates may increase
  - This may become a more widespread public health problem.
- Pandemic – worldwide epidemic

TWO TYPES OF EPIDEMIC

- First type is a common source epidemic.
  - It arises from contact with contaminated substances, most commonly water contaminated with fecal material or improperly prepared food.
  - It affects a large numbers of people.
  - It subsides quickly when the contamination is dealt with.
TWO TYPES OF EPIDEMIC

- Second type is a propagated epidemic.
  - It is amplified by person to person contact
  - It remains in the population for a long time
  - It is more difficult to deal with than a common source outbreak.

TYPES OF EPIDEMIOLOGICAL STUDY

- There are two types of epidemiological study:
  - Descriptive
  - Analytical

A descriptive study is concerned with the physical aspects of patients and spread of disease.
- It allows for tracing the outbreak and identifying the first case.
- A descriptive study includes:
  - Data on a number of cases
  - Data on which segment of the population is affected
  - Data on the location of the infection
  - Data on the age, race, marital status, and occupation of the infected population.
TYPES OF EPIDEMIOLOGICAL STUDY

- An analytical study:
  - Focuses on establishing the cause-and-effect relationship
  - Always uses a control group
  - Can be retrospective or prospective
  - Considers factors that occur as the epidemic proceeds.

- Health departments of local and state governments require reports of certain diseases.
- This information has been able to show how the effects on infectious diseases have changed over the years.
- Some diseases are referred to as nationally notifiable meaning that in the United States, they must also be reported to the Centers for Disease Control, the clearing house for epidemiological studies.