Ch 14:
Principles of Disease and Epidemiology
Learning Objectives

Define pathology, etiology, infection, and disease
Explain the difference between normal, transient, and opportunistic microbes
Compare commensalism, mutualism, and parasitism, and give an example of each.
List and explain Koch’s postulates.
Differentiate a communicable from a noncommunicable disease.
Categorize diseases according to frequency of occurrence.
Define herd immunity.
Review the common disease pattern: incubation period, prodromal period, periods of illness, decline, and convalescence
Define reservoir of infection and distinguish between human, animal, and nonliving reservoirs. Give an example of each.
Explain three methods of disease transmission.
Define nosocomial infections and explain their importance and prevention.
List probable reasons for emerging infectious diseases and name an example for each.
Define epidemiology and describe three types of epidemiologic investigation.
Explain the function of the CDC.
Define the following terms: morbidity, mortality, and notifiable disease.
A patient entered the hospital to have torn cartilage removed from her right knee. The surgery was scheduled as a same-day procedure. Unfortunately, she subsequently developed pneumonia and wasn’t released until 10 days later. How would you account for these events?
Vocabulary

- **Pathology**: Study of disease
- **Pathogenesis**: Development of disease
- **Pathogen**: Pathogenic agents have special properties that allow them to invade the human body or produce toxins.
- **Etiology**: 
- **Infection**: invasion and growth of pathogens in the body
- **Disease**: Abnormal state in which the body is not functioning normally.
  - *i.e.*: infectious agent overcomes body’s defenses
The Normal Microbiota (Flora)

**Microbial antagonism** due to competition between microbes.

**Resident flora** = **Normal microbiota** (acquired at passage through birth canal)

Establish permanent colonies on/inside body without producing disease. Protect the host by

1. Occupying niches that pathogens might occupy (Competitive exclusion)
2. Producing acids
3. Producing bacteriocins
4. Stimulation of immune system
Compare to Table 14.1

**Nose**
- Staphylococcus aureus
- Staphylococcus epidermidis
- Corynebacterium species

**Throat**
- Streptococcus species
- Branhamella catarrhalis
- Corynebacterium species
- Haemophilus species
- Neisseria species
- Mycoplasma species

**Mouth**
- Streptococcus species
- Fusobacterium species
- Actinomyces species
- Leptotrichia species
- Veillonella species

**Skin**
- Staphylococcus epidermidis
- Propionibacterium acnes
- Pityrosporum ovale

**Large intestine**
- Bacteroides fragilis
- Escherichia coli
- Proteus mirabilis
- Klebsiella species
- Lactobacillus species
- Streptococcus species
- Candida albicans
- Clostridium species
- Pseudomonas species
- Enterococcus species

**Vagina**
- Lactobacillus species
- Streptococcus species
- Candida albicans
- Gardnerella vaginalis

**Urethra**
- Streptococcus species
- Mycobacterium species
- Escherichia coli
- Bacteroides species
Transient Microbiota (Flora)

Certain microbes are present for various periods (days, weeks, or months) – then disappears.

Probiotics: Live microbes applied to or ingested into the body, intended to exert a beneficial effect

Dynamic nature of resident flora: changes due to age, type of food consumed, Hormonal state, antibiotics
Various Co-existence Relationships Between Bacteria and Host

- **Symbiosis**
  - **Mutualism:** microbe and host benefit from co-existence, neither suffers
  - **Commensalism:** microbe benefits but host doesn’t (is unaffected)
  - **Parasitism:** microbe benefits, host suffers

- **Opportunistic pathogens** cause disease under special conditions (mutualistic relationship becomes parasitic)

- **Healthy carriers of pathogenic organisms**

- **Cooperation among microorganisms:** One microorganism may make it possible for another to cause disease or produce more severe symptoms
Koch’s Postulates: Proof of Etiology of Infectious Diseases

1. The same pathogen must be present in every case of the disease

2. The pathogen must be isolated from the diseased host and grown in pure culture

3. The pathogen from the pure culture must cause the disease when it is inoculated into a healthy, susceptible lab animal

4. The pathogen must be isolated from the inoculated animal and must be shown to be the original microbe
Anthrax & Koch’s Postulates:

Postulate 1
The same microorganisms are present in every case of the disease.

Postulate 2
The microorganisms are isolated from the tissues of a dead animal, and a pure culture is prepared.

Postulate 3
Microorganisms from the pure culture are inoculated into a healthy, susceptible animal. The disease is reproduced.

Postulate 4
The identical microorganisms are isolated and recultivated from the tissue specimens of the experimental animal.

Compare to Fig 14.3 (Foundation Figure)
Exceptions to Koch’s Postulates

Modification of Koch’s postulates were necessary

1. to establish disease etiology for viruses and bacteria, which cannot be grown on artificial media

2. Some diseases, e.g.: pneumonia and nephritis, may be caused by a variety of microbes.

3. Some pathogens, such as S. pyogenes, cause several different diseases.

4. Certain pathogens, such as HIV, cause disease in humans only.
Classifying Infectious Diseases

- **Symptom**: A change in body function that is felt by a patient as a result of disease

- **Sign**: A change in a body that can be measured or observed as a result of disease.

  
  **Signs** *(objective)* - **Symptoms** *(subjective)*

- **Syndrome**: A specific group of signs and symptoms that accompany a disease

- **Communicable vs. Non-communicable vs. Contagious**
Classifying Infectious Diseases cont.

- **Communicable disease**: A disease that is spread from one host to another.
- **Contagious disease**: A disease that is easily spread from one host to another.
- **Noncommunicable disease**: A disease that is not transmitted from one host to another.
Occurrence of a Disease

- **Incidence**: Fraction of a population that contracts a disease during a specific time
- **Prevalence**: Fraction of a population having a specific disease at a given time
- **Sporadic disease**: Disease that occurs occasionally in a population
- **Endemic disease**: Disease constantly present in a population
- **Epidemic disease**: Disease acquired by many hosts in a given area in a short time
- **Pandemic disease**: Worldwide epidemic
Severity or Duration of a Disease

Scope of disease can be defined as

- **Acute**: Disease develops rapidly
- **Chronic**: Disease develops slowly
- **Subacute**: Symptoms between acute and chronic
- **Latent**: Disease with a period of no symptoms when the causative agent is inactive
- **Herd immunity**: Presence of immunity to a disease in most of the population
Extent of Host Involvement

- **Toxemia**: Toxins in the blood
- **Viremia**: Viruses in the blood
- **Primary infection**: Acute infection that causes the initial illness
- **Secondary infection**: Opportunistic infection after a primary (predisposing) infection
- **Subclinical disease**: No noticeable signs or symptoms (inapparent infection)
Extent of Host Involvement: *An Infection can be*

- **Local**: limited to small area of body
- **Systemic**: spread throughout body via _______
- **Focal**: spread from local infection to specific areas of
- **Primary**: acute infection causing initial illness
- **Secondary**: occurs after host is weakened from primary infection
- **Subclinical** (inapparent): no noticeable signs and symptoms

*Sepsis*: Toxic inflammatory condition arising from spread of microbes or their toxins, from a focus

*Bacteremia*: Bacteria in the blood.

*Septicemia*: Growth of bacteria in the blood.
Secondary infection

Antibiotic treatment of bacterial infection also kills beneficial vaginal bacteria.

Without the bacteria, vaginal yeast grows unchecked.

Uterus

Vagina
Patterns of Disease: Predisposing Factors

Variable susceptibility due to

- Genetics
- Gender
- Climate and weather
- Age
- Stress and fatigue,
- Lifestyle
- Chemotherapy
Disease Development and Stages

**Incubation period:** Time interval between initial infection and first appearance of signs and symptoms.

**Prodromal period:** Characterized by appearance of first mild signs and symptoms.

**Period of illness:** Disease at its height: all disease signs and symptoms apparent.

**Period of decline:** Signs and symptoms subside.

**Period of convalescence:** Body returns to prediseased state, health is restored.
The Course of Disease, as Typified by Measles
The Spread of Infection: Reservoir

Continual source of infectious agents

- Nonliving: Soil, e.g.: ??

- Human: people with disease or asymptomatic carriers may have inapparent infections or latent diseases

- Animal: Pathogen for some other species lives and multiplies in reservoir. Zoonoses may be transmitted to humans.
Disease Transmissions

Contact Transmission:

- **Direct**: Close association between infected and susceptible host.
- **Indirect**: Spread by fomites.
- **Droplet**: Transmission via airborne droplets from saliva or mucus (coughing or sneezing)

Airborne Transmission: Pathogens carried on water droplets or dust for a distance greater than 1 meter

Vehicle Transmission: Water, food, air

Vector Transmission: **Arthropods** carry pathogens from one host to another (**mechanical vector** vs. **biological vector**)
- Acquired as a result of a hospital stay.
- 5-15% of hospital patients acquire nosocomial infections.
- Aseptic techniques can prevent nosocomial infections.
- Hospital infection control staff members are responsible for overseeing the proper cleaning, storage, and handling of equipment and supplies.
Relative Frequency of Nosocomial Infections

Source: Data from CDC, National Nosocomial Infection Surveillance.

- **40%** Urinary tract infections
- **20%** Surgical site infections
- **15%** Lower respiratory infections
- **8%** Bacteremia transmitted primarily by IV catheterizations
- **6%** Cutaneous infections
- **11%** Other

Table 14.5
### Common Causes of Nosocomial Infections

<table>
<thead>
<tr>
<th></th>
<th>Percentage of Total Infections</th>
<th>Percentage Resistant to Antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coagulase-negative staphylococci</td>
<td>25%</td>
<td>89%</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td>16%</td>
<td>80%</td>
</tr>
<tr>
<td><em>Enterococcus</em></td>
<td>10%</td>
<td>29%</td>
</tr>
<tr>
<td>Gram-negative rods</td>
<td>23%</td>
<td>5-32%</td>
</tr>
<tr>
<td><em>C. difficile</em></td>
<td>13%</td>
<td>None</td>
</tr>
</tbody>
</table>
MRSA

- **HA-MRSA**: USA100 and USA200
- **CA-MRSA**: USA300 and USA400. Affect young and healthy. Associated with contact sports, sharing towels or athletic equipment, illegal iv drugs, and living in crowded or unsanitary areas (e.g., prisons, hurricane evacuee centers)

<table>
<thead>
<tr>
<th>Procedure</th>
<th>MRSA-Infected Patients</th>
<th>Total Number of Patients Receiving Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemodialysis</td>
<td>813</td>
<td>1807</td>
</tr>
<tr>
<td>Intravenous (IV) catheter</td>
<td>1057</td>
<td>16,516</td>
</tr>
<tr>
<td>Surgery</td>
<td>945</td>
<td>5659</td>
</tr>
<tr>
<td>Urinary bladder catheter</td>
<td>1750</td>
<td>7919</td>
</tr>
<tr>
<td>Ventilator (invasive airway)</td>
<td>722</td>
<td>7367</td>
</tr>
</tbody>
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Emerging Infectious Diseases (EIDs)

- Diseases that are new, increasing in incidence, or showing a potential to increase in the near future

- CDC, NIH, and WHO are responsible for surveillance and responses to emerging diseases
Contributing factors for EIDs

- Genetic recombination (*E. coli* 0157; H5N1 avian flu)
- Evolution of new strains (*V. cholerae* 0139)
- Inappropriate use of antibiotics and pesticides (Antibiotic resistant strains)
- Changes in weather patterns (*Hantavirus*)
- Modern Transportation (West Nile virus)
- Ecological disaster, war, and expanding human settlement (*Coccidioidomycosis*)
- Animal control measures (Lyme disease)
- Public Health failure (Diphtheria)
- Improved case reporting
Crossing the Species Barrier

Bird

Wild bird infected with H7N7

Avian virus

H spike
N spike
Gene segments

Avian virus (H7N7) transmitted to pig

Pig

Pig infected with H1N1

Pig virus

Genetic exchange produces a new virus

New virus transmitted to human

Human infected with H3N2

Human virus

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Epidemiology

- The study of where and when diseases occur (disease transmission, incidence, and frequency)

- Centers for Disease Control and Prevention (CDC)
  - Collects and analyzes epidemiological information in the United States
  - Publishes *Morbidity and Mortality Weekly Report* (*MMWR*)
  - [www.cdc.gov](http://www.cdc.gov)
  - Worldwide disease surveillance: [WHO](http://www.who.int)
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<tr>
<td>John Snow</td>
<td>1848–1849</td>
<td>Mapped the occurrence of cholera in London</td>
</tr>
<tr>
<td>Ignaz Semmelweis</td>
<td>1846–1848</td>
<td>Showed that handwashing decreased the incidence of puerperal fever</td>
</tr>
<tr>
<td>Florence Nightingale</td>
<td>1858</td>
<td>Showed that improved sanitation decreased the incidence of epidemic typhus</td>
</tr>
</tbody>
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CDC

- **Case reporting**: Health care workers report specified disease to local, state, and national offices.

- **Nationally notifiable diseases**: Physicians are required to report occurrence.

- **Morbidity**: Incidence of a specific notifiable disease.

- **Mortality**: Deaths from notifiable diseases.

- **Morbidity rate**: Number of people affected in relation to total population in a given time period.

- **Mortality rate**: Number of deaths from a disease in relation to total population in a given time period.