

# **Principles of Disease and Epidemiology (Chapter 14)**

Lecture Materials

for

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Primary Source for figures and content:

Tortora, G.J. Microbiology An Introduction 8th, 9th, 10th ed. San Francisco: Pearson Benjamin Cummings, 2004, 2007, 2010.

**Pathology** = study of disease:

cause, development, & effects on host

**Etiology** = study of the cause of a disease

**Pathogenesis** = manner in which a disease develops

**Epidemiology** = study of when and where diseases occur and how they are transmitted

**Infection** = invasion or colonization by pathogenic microbes

**Disease** = change from a state of health

### Normal Microbiota (Normal Flora)

-in utero: sterile

-once born microbes colonize

Human body =  $\sim 1 \times 10^{13}$  cells

has  $1 \times 10^{14}$  microbes in or on it

**Normal microbiota** = permanent residents that do not usually cause disease

e.g. *Staphylococcus* on epidermis and mucus membranes; *Escherichia* in colon

Type and location depends on:

- availability of nutrients
- physical & chemical factors
- defenses of host
- mechanical factors

Some carry out **microbial antagonism** = normal microbiota prevent over growth of harmful microorganisms (pathogens)

e.g. vaginal microbiota (*Lactobacillus*) create pH 4 which inhibits *C. albicans*: disruption of flora (e.g. antibiotics) or pH can lead to yeast infection

*E. coli* in intestines produce bacteriocins that inhibit other similar bacteria like *Salmonella* (typhoid) & *Shigella* (dysentery)

Normal microbiota may inhibit potential pathogens by:

1. Competing for nutrients
2. Producing toxins (bacteriocins)
3. Altering pH
4. Affecting O<sub>2</sub> availability
5. Occupying space

Relationship between host and normal microbiota is a symbiosis (“living together”):

-most microbiota are commensals

**(commensalism):** microbe benefits, human is unaffected

-some are mutualistic (**mutualism**): both human and microbe benefit

e.g. *E. coli* synthesize vitamin K

**Probiotics:** typically lactic acid producing bacteria ingested to aid digestion and protect intestine from pathogens

**Prebiotics:** chemicals that promote growth of beneficial bacteria

- most pathogens tend to be **parasites**:  
microbe benefits, human is injured

**Pathogen** = disease causing microbe, not typically part of normal microbiota

## **Opportunistic Pathogens:**

- ordinarily do not cause disease in their normal habitat (commensal or mutualist normal microbiota)
- in new habitat or immune compromised host, can cause disease

e.g. *Candida albicans*:

- 80% of population has it in the gut as commensal
- in vagina: can cause vaginitis (new habitat)
- can kill AIDS patients: systemic infection (immunocompromised host)

# Etiology of Infectious Disease

Koch 1877:

- first to link a particular microbe with a particular disease (etiology)
- studying Anthrax, proved *Bacillus anthracis* to be causative agent
- later showed tuberculosis to be due to *Mycobacterium tuberculosis*

## **Koch's Postulates** (used to study etiology)

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 same disease when it is inoculated into a new healthy animal host
4. The pathogen must be isolated from the inoculated sick animal and must be shown to be the same original pathogen

## Exceptions to Koch's Postulates:

1. Some microbes cannot be cultured on artificial media
  - e.g. *Mycobacterium leprae* – leprosy
  - Treponema pallidum* – syphilis
  - Intracellular parasites
  - must use other methods such as growth in animals or eggs or direct testing of patients to prove all have the same pathogen
2. One infectious disease can have multiple causes/pathogens
  - e.g. pneumonia, meningitis, nephritis
3. One pathogen can cause several disease conditions
  - e.g. *Streptococcus pyogenes* = sore throat, scarlet fever, skin infections, osteomyelitis
4. Ethical considerations
  - some human diseases have no animal host
  - can not infect humans on purpose to prove the agent causes disease
  - e.g. HIV (AIDS), Papillomavirus (cancer)

# Classifying Infectious Disease

## 1. Patient Appearance

- A. **Symptoms** = subjective changes in body function (e.g. pain)
- B. **Signs** = objective changes in body function that can be measured (e.g. fever)
- C. **Syndrome** = specific group of symptoms & signs that may accompany a particular disease

## 2. Spreadability

- A. **Communicable disease** = spreads from one host to another (e.g. herpes)
- B. **Contagious disease** = spreads easily from one person to another (e.g. chicken pox)
- C. **Non-communicable disease** = not spread from one host to another:
  - either resident flora that becomes an opportunistic pathogen (e.g. UTI)
  - or accidental inoculation from environment (e.g. tetanus)

- rate of spread of contagious/communicable disease is determined by susceptibility of population
- immunization/vaccination: attempt to prevent spread

**Herd immunity** = enough immune people in the population to prevent the spread of disease

### 3. Occurrence

**Incidence** = number of people who develop the disease in a particular time frame (indicates rate of spread)

**Prevalence** = number of people who have the disease at one specified time (indicates how seriously and how long the disease affects the population)

A. **Sporadic disease** = occurs only occasionally in population (e.g. typhoid)

B. **Endemic disease** = constantly present in a population (e.g. hepatitis)

**C. Epidemic disease** = many people in a given area acquire the disease in a short amount of time (e.g. influenza)

**D. Pandemic disease** = worldwide epidemic (e.g. AIDS)

#### 4. Severity and Duration

**A. Acute disease** = develops rapidly, but lasts only a short time (e.g. common cold)

**B. Chronic disease** = develops slowly, may have mild symptoms or signs, but is continual or recurrent for a long time (e.g. tuberculosis)

**C. Subacute disease** = intermediate between acute and chronic (e.g. endocarditis)

**D. Latent disease** = agent remains inactive for a period of time, but then activates to cause disease (e.g. shingles)

## 5. Extent of Host Involvement

A. **Local infection** = microbe restricted to a particular location on the body

(e.g. abscesses)

B. **Focal infection** = local infection that moves via blood or lymph to set up a new infection at another site (e.g. tooth infection → rheumatoid arthritis)

C. **Systemic infection** = spread throughout the body by blood and/or lymph

(e.g. measles)

1. **Bacteremia** = bacteria in the blood

2. **Septicemia** = microbes multiplying in the blood

3. **Toxemia** = toxins in the blood

4. **Viremia** = virus in the blood

**Sepsis** = toxic inflammatory condition arising from spread of bacteria or their toxins from infection site

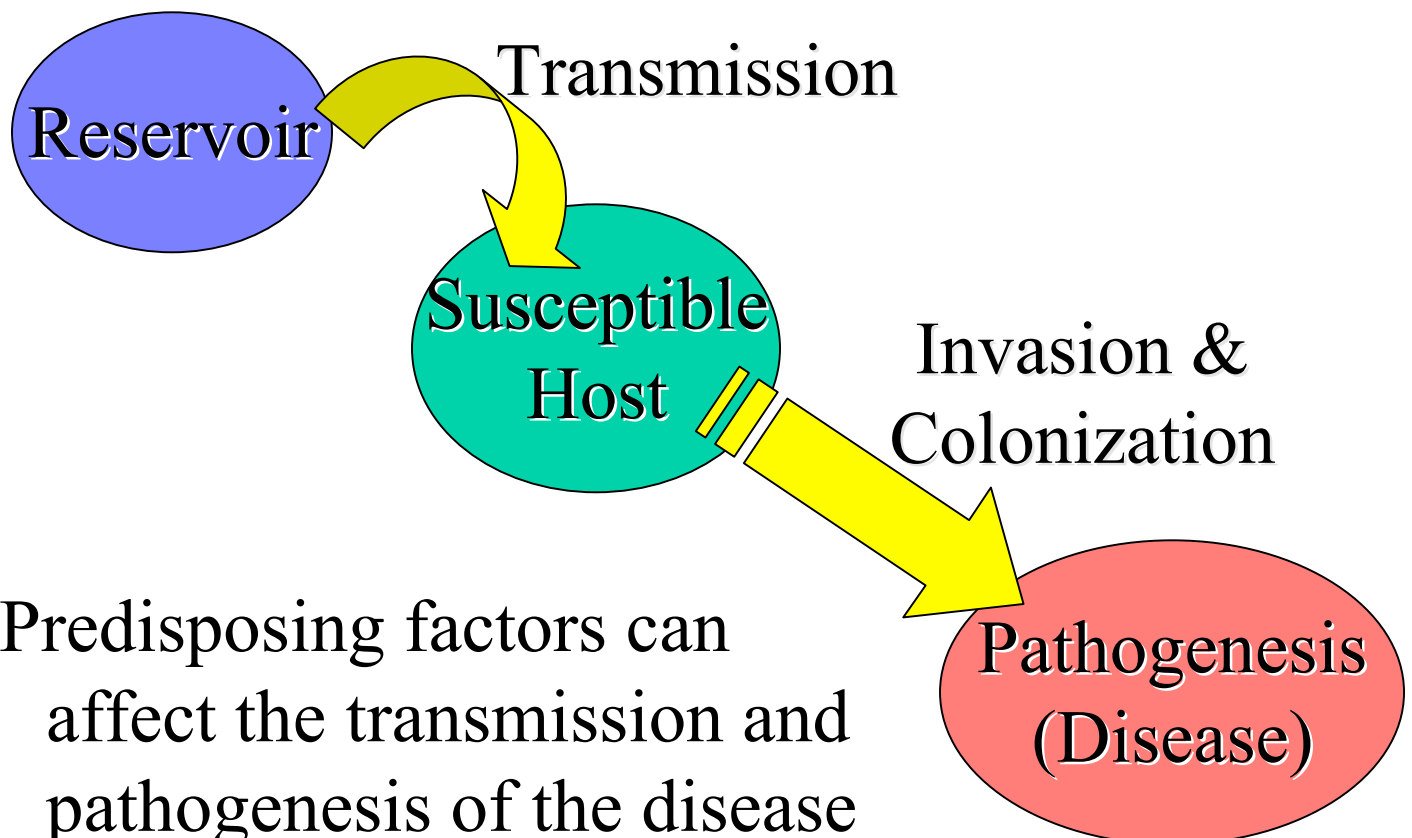
**Primary infection** = acute infection that causes initial illness

**Secondary infection** = caused by opportunistic pathogen as a result of primary infection

e.g. (HIV) AIDS → *C. albicans* mycosis

**Subclinical infection** = does not cause noticeable illness, person is a carrier (e.g. Hepatitis A)

## Patterns of Disease



# I. Development of disease

1. **Incubation period** = time between initial infection and appearance of signs or symptoms

-Time depends on the type of microbe, virulence, inoculum amount, and host resistance

2. **Prodromal period** = short, mild symptoms following incubation period

3. **Period of illness** = acute phase: most severe signs and symptoms

-Immune system either overcomes pathogen or person dies

4. **Period of decline** = signs and symptoms begin to subside, but host vulnerable to secondary infections

5. **Period of convalescence** = host returns to pre-disease state

-for some diseases, person is contagious from incubation to convalescence, for others only during illness

## II. Spread of Infection

1. **Reservoir of infection** = source of disease agent (microbe):

### A. Humans

1. Sick people = actively ill
2. Carriers = never any symptoms/signs of disease
3. Latent infection carriers = contagious during incubation period or convalescent period

### B. Animals

**zoonoses** = diseases that can be transmitted from animals to humans (e.g. rabies)

### C. Nonliving

environmental: soil and water (e.g. tetanus)

## 2. Transmission

### A. **Contact transmission**

1. direct contact (person to person)  
(e.g. STDs)
2. indirect contact: reservoir to host via a **fomite** (a non-living object that transmits disease)  
(e.g. syringe, surfaces)
3. droplet transmission = mucus droplets from sneeze or cough  
(e.g. pertussis)

### B. **Vehicle transmission** = in a medium

1. water borne transmission (e.g. cholera)
2. food borne transmission  
(e.g. food poisoning)
3. airborne transmission  
(like droplet transmission but travels further than 1 meter, or on dust, or by spores) (e.g. histoplasmosis)
4. other media: body fluids, drugs  
(e.g. HIV)

C. **Vectors** = animals that carry pathogens from one host to another: mostly arthropods

1. **mechanical transmission**

passively carry pathogens on body parts e.g. houseflies

2. **biological transmission**

from bites: usually involves complex life cycle of pathogen cycling between vector and host (e.g. mosquito - malaria)

## Nosocomial Infections

- acquired as a result of hospital stay
- 8th leading cause of death in U.S.

Result from:

1. Microbes in hospital environment
  - reservoir of opportunistic pathogens & antibiotic resistant pathogens
2. Compromised status of host
  - patients have reduced ability to resist disease
  - susceptible to own microbiota becoming opportunistic pathogens
3. Chain of transmission
  - fomites covered in microbes
  - health care workers: fail to wash between patients

Prevention: aseptic technique with equipment and materials and constant hand washing most important to stop spread of nosocomial infections!

## Epidemiology

-study of where and when diseases occur and how they are transmitted

-important for disease control in populations

Epidemiologists identify:

1. when the disease occurs
2. to whom (age, race, class etc.)
3. mode of transmission
4. reservoirs
5. effective methods of control
6. plans to prevent future outbreaks

**Descriptive epidemiology:** collection of data describing the occurrence (info about affected people, place and period of disease)

**Analytical epidemiology:** analysis to determine cause (compare diseased groups to non to determine factors responsible)

**Experimental epidemiology:** test hypotheses (e.g. effectiveness of a drug)

# Centers for Disease Control and Prevention

-CDC monitors U.S. population for disease and publishes weekly reports (MMWR) on notifiable diseases:

1. Morbidity = number of people in population affected/infected

2. Mortality = number of deaths

-trends are monitored and quarantines issued to prevent epidemics

-recommendations for diagnosis, treatment and prevention developed based on case reporting from health care workers

Notifiable diseases = contagious and/or deadly diseases doctors must report

e.g. Hepatitis, HIV, Lyme disease

complete list at <http://www.cdc.gov>