Principles of Disease and Epidemiology (Chapter 14)
Lecture Materials for
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Primary Source for figures and content:

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 = ~1 x 10^{13} cells
  has 1 x 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_2 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

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<tr>
<th>Opportunistic Pathogens:</th>
<th><strong>Etiology of Infectious Disease</strong></th>
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<tr>
<td>-ordinarily do not cause disease in their normal habitat (commensal or mutualist normal microbiota)</td>
<td><strong>Koch 1877:</strong></td>
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<td>-in new habitat or immune compromised host, can cause disease</td>
<td>-first to link a particular microbe with a particular disease (etiology)</td>
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<td>e.g. <em>Candida albicans</em>:</td>
<td>-studying Anthrax, proved <em>Bacillus anthracis</em> to be causative agent</td>
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<td>-80% of population has it in the gut as commensal</td>
<td>-later showed tuberculosis to be due to <em>Mycobacterium tuberculosis</em></td>
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<td>-in vagina: can cause vaginitis (new habitat)</td>
<td><strong>Koch’s Postulates</strong> (used to study etiology)</td>
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<td>-can kill AIDS patients: systemic infection (immunocompromised host)</td>
<td>1. The same pathogen must be present in every case of the disease</td>
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<td>2. The pathogen must be isolated from the diseased host and grown in pure culture</td>
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<td>3. The pathogen from the pure culture must cause the same disease when it is inoculated into a new healthy animal host</td>
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<td>4. The pathogen must be isolated from the inoculated sick animal and must be shown to be the same original pathogen</td>
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<th>Exceptions to Koch’s Postulates:</th>
<th><strong>Classifying Infectious Disease</strong></th>
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<tr>
<td>1. Some microbes cannot be cultured on artificial media</td>
<td><strong>1. Patient Appearance</strong></td>
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<td>e.g. <em>Mycobacterium leprae</em> – leprosy</td>
<td>A. <strong>Symptoms</strong> = subjective changes in body function (e.g. pain)</td>
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<td><em>Treponema pallidum</em> – syphilis</td>
<td>B. <strong>Signs</strong> = objective changes in body function that can be measured (e.g. fever)</td>
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<td>Intracellular parasites</td>
<td>C. <strong>Syndrome</strong> = specific group of symptoms &amp; signs that may accompany a particular disease</td>
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<td>-must use other methods such as growth in animals or eggs or direct testing of patients to prove all have the same pathogen</td>
<td><strong>2. Spreadability</strong></td>
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<td>2. One infectious disease can have multiple causes/pathogens</td>
<td>A. <strong>Communicable disease</strong> = spreads from one host to another (e.g. herpes)</td>
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<td>e.g. pneumonia, meningitis, nephritis</td>
<td>B. <strong>Contagious disease</strong> = spreads easily from one person to another (e.g. chicken pox)</td>
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<td>3. One pathogen can cause several disease conditions</td>
<td>C. <strong>Non-communicable disease</strong> = not spread from one host to another:</td>
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<td>e.g. <em>Streptococcus pyogenes</em> = sore throat, scarlet fever, skin infections, osteomyelitis</td>
<td>-either resident flora that becomes an opportunistic pathogen (e.g. UTI)</td>
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<td>4. Ethical considerations</td>
<td>-or accidental inoculation from environment (e.g. tetanus)</td>
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<td>-some human diseases have no animal host</td>
<td>-can not infect humans on purpose to prove the agent causes disease</td>
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<tr>
<td>-can not infect humans on purpose to prove the agent causes disease e.g. HIV (AIDS), Papillomavirus (cancer)</td>
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- 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)
   - **Sporadic disease** = occurs only occasionally in population (e.g. typhoid)
   - **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**

- Reservoir
- Transmission
- Susceptible Host
- Invasion & Colonization
- Pathogenesis (Disease)

Predisposing factors can affect the transmission and pathogenesis of the 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)

   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