Chapter 15: Bacterial Pathogenesis & epidemiology

Phases of bacterial pathogenesis: we saw the bacteria’s perspective; now the host perspective

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Incubation period

- Microbes don’t instantly produce symptoms when they enter the body
- There is a lag between infection and symptoms
  - How long? Depends on the organism; the host’s response, how many microbes got in, by what route the microbes entered the body
- For the community, this can be a dangerous time: the infected person feels well but may be infectious (capable of spreading the infection to others)

Epidemiology: the study of disease in populations, not individuals

Is the end of infectious disease in sight?

- Deaths due to infectious diseases have declined rapidly:
  - Improved sanitation & nutrition
  - Universal vaccination programs
  - Antimicrobial drugs
- Smallpox has been eradicated (1977)
- Polio may be next
  - 1988: 300,000 cases worldwide; 2003: 700 cases; 2006: 1600 cases (1500 in 4 endemic countries: Nigeria, Pakistan, India, Afghanistan)
  - http://www.polioeradication.org/

U.S. Surgeon General William Stewart, in 1967:
“...The war against infectious diseases has been won...”
No way!

1. Proper sanitation & nutrition are unavailable for billions of people
2. Vaccines don’t exist for most infectious diseases; existing vaccines are not universally used
   1. In the rich world, parents refuse
   2. In poverty, vaccination programs inadequate
3. Antibiotic resistance is on the rise at a spectacular rate

Challenges in eradicating infectious disease:
Reservoirs

- Most microbial pathogens cannot survive for long outside of a host
- Reservoirs are sites in which microbes can persist and maintain their ability to infect.
- Reservoir types:
  - Human
  - Animal
  - Nonliving (soil & water; esp. for fungi, sporeforming bacteria)

Human Reservoirs of Infection

1. People with **active infections** can obviously spread disease
2. **Carriers**
   - Individuals with a subclinical or asymptomatic infection
   - Read incredible story of America’s most famous disease carrier, “Typhoid Mary” ch. 22 p. 654
   - Infectious organisms may be shed from mouth/nose, in urine or feces
   - Hepatitis, polio, pneumonia, TB

Animal Reservoirs of Infection

- Some pathogens can infect both humans & animals
  - Rabies, anthrax, plague, Lyme disease...
- **Zoonoses**: Diseases that can be transmitted under natural conditions to humans from other vertebrate animals
- Transmission (from animal to human) can be by:
  - Physical contact; respiratory droplets; bites; urine; ingestion of contaminated meats/eggs; insect intermediates (mosquitos, fleas, ticks)

Emerging Diseases

Infectious diseases come & go; microbial populations interact with human populations, and **both adapt**

Some infectious diseases seem to disappear:
  - e.g., 1918 influenza; **Syphilis**
    - Syphilis, a bacterial STD, first recognized in the 16th C.; then was often rapidly fatal.
    - Over next several hundred years, syphilis became more **chronic** (infected individuals suffer progressively worse symptoms over a long period of time)
    - Microbes become attenuated
    - Human populations become immune
    - Naturally resistant individuals survive; sensitive individuals die
Emerging Diseases

- Humans have always altered their environment
  - unintended consequences for infectious disease
- Migration into rainforests
  - Contact with animal viruses that “jump species”
    - HIV
- Animal & insect vectors (carriers) of infectious disease
  - Human activity changes their habitats & habits
  - New or increased contact with humans
    - Example: Bubonic plague carried by fleas on black rats

The most important emerging diseases are viruses

Re-emerging Diseases

Tuberculosis (TB), cholera, malaria:
Examples of old infectious diseases that are becoming a greater threat

- Antibiotic resistance
- Global migration & travel from endemic areas to areas that were previously disease-free
- Growth of high population density cities

Interests in emerging diseases & the inadequacy of public health systems to deal with them?
Read The Coming Plague by journalist Laurie Garrett

Infectious diseases:
Frequency in a population

- **Endemic**: infectious disease agent is continually present in the population of a particular place
- **Epidemic**: a disease suddenly has a higher-than-normal incidence in a population
  - West Nile Virus in California (esp. birds)
- **Pandemic**: a global epidemic
  - AIDS: influenza

Endemic diseases can suddenly erupt into epidemics, and in today’s airplane world, pandemics can quickly follow

Infectious disease spread within a population

A crucial determinant of how widely a disease will spread, and how easily it might be controlled:

**Common-source outbreak**
Epidemic that arises from contact with contaminated substances (e.g., cholera from a bad well)

VS

**Propagated epidemic**
Epidemic spreading by direct person-to-person (horizontal) transmission

Who notices these things?

- **Public health agencies** are supposed to
  - City & County health officials are involved with immunization programs, restaurant inspections, and sewer & water treatment
  - At the federal level, the Centers for Disease Control (CDC) in Atlanta, GA
  - Global level: World Health Organization (WHO)
  - Certain infectious diseases are "notifiable" or "reportable"
    - Physicians are legally required to report cases of these diseases to authorities
    - Data published in Morbidity & Mortality Weekly Report
    - www.cdc.gov

A notifiable bacterial disease: Tuberculosis (TB)

- “Consumption”; TB has been around for millennia
  - Epidemic proportions in 18th & 19th C. Europe
  - Chopin, Paganini, Thoreau, Keats, Bronte sisters: a very artsy way to die
  - Now, 3,000,000 deaths per year
- **Mycobacterium tuberculosis**
  - Very hard to culture: extremely slow growing
    - 12 to 18 hours generation time (E. coli: 20 minutes!)
  - “Acid fast” stain (lipid layer in cell wall)
**TB**

- **Respiratory spread**
  - In hospitals, patients with active TB are kept in special isolation rooms with negative air pressure
- **Primary disease is in the lungs:**
  - Bacteria actually *live & multiply inside* white blood cells which have phagocytosed them (*intracellular infection*)
- **TB exposure is tested for by tuberculin skin test** ("**PPD**" for "purified protein derivative")
  - A small amount of TB-derived protein is injected under the skin; if person has an immune response it indicates previous exposure

A TB vaccine is available (BCG) but it is not very effective; used only in endemic areas (not approved for use in U.S.)

**TB**

- **Slow, chronic disease in otherwise healthy people**
  - Treatment is also slow & difficult; multiple antibiotics taken for months or years
- **TB is back! # cases rising**
  - **Association with AIDS** (immunosuppression leads to reactivation of dormant cases)
  - Most cases in lower socioeconomic groups & immigrants
  - TB strains often **resistant to multiple antibiotics**

**Notifiable bacterial disease:**

*E. coli O157:H7*

- *Escherichia coli* is part of the normal flora of the gut
  - Gram negative rod; facultative anaerobe; ferments lactose
  - Indicator of fecal contamination of water
- **Some strains of E. coli are pathogenic**
  - Many cause diarrheal disease of varying severity
  - **Traveler’s diarrhea**: enterotoxigenic *E. coli*
  - Urinary tract infections (UTIs): frequently caused by *E. coli*

- 1982 McDonald’s hamburgers in 2 states:
  - Several kids died after eating *undercooked* ground beef
  - *E. coli O157:H7* strain responsible
  - Also caused the raw spinach outbreak fall ’06
  - strain is **enterohemorrhagic**
    - Produces **toxins** that cause bloody diarrhea
    - Toxins are actually derived from *Shigella* & are encoded on a plasmid
    - Lethal consequences include systemic problems & kidney failure; young kids are most susceptible
    - *E. coli* is killed by thorough cooking

- Ch. 15 p. 412-414; 417-418; 428-431
- P. 654 Typhoid Mary
  - Ch. 21 p. 623-626 TB
  - Ch. 22 657-658 E. coli