Pathogens and parasites

- Epidemiology
  - Definitions
    - epidemiology = study of spread of disease in populations
    - infectious disease = disease that are spread from one host to another
    - incidence = number of individuals with the disease in a population
    - prevalence = the proportion of a population with the disease at a given time
    - epidemic = disease outbreak with a high incidence
    - endemic = disease outbreak with a low incidence
    - pandemic = disease outbreak across continents
History of Epidemiology

- one of the early theories was that disease was caused by b________ a_________ (malaria actually means “bad air”)

- microorganisms weren’t s________ until Antonie van Leewenhoek - a 17th Century native of Holland devised the first m_________________ with sufficient magnification to see protozoa and bacteria

- wasn’t until the middle of the 19th Century that s_________________ and disease were linked - cities that cleaned up their filth and rubbish had lower i________________ of disease
History of Epidemiology

- J___________ S_____________ and the Broad Street pump in 1854
  - he was able to show that 59 of the 77 c_______________ victims used the pump on Broad Street
  - There was a w__________________ in the vicinity where cholera was endemic but nobody at this workhouse got cholera. This particular workhouse had its own w___________.
    The cause of contamination turned out to be the d___________ of an infected person that was within three feet of the well.
Background

- Many if not most pathogens are w_________ and are therefore a concern to environmental engineers.
- Need to be familiar with l______ c_________ of pathogens: some can stay infective for periods longer than one year, some less than one day, some have a l_________ period greater than one year.
- Almost all pathogens can be spread by a s___________ carrier - makes detection difficult.
- Usually the very young, very old, and those with w___________ i___________ systems are affected the most.
Chain of infection

- Infectious agent - m________ i __________
dose (MID) varies widely
  - b_________________
  - v_________________
  - p_________________
  - h_________________
- frank pathogen versus o_________________ pathogens
Reservoirs

- required for pathogen to s__________ and m__________
- Can be l____________: humans, animals, plants
- or non-living: s__________, w__________, w____________________
Mode of transmission

- Person to person - most common (STDs, hands, coughing, sneezing fall into this category)
- Water - intestinal illnesses (gastroenteritis), giadiasis, cryptosporidiosis (Milwaukee, Wisconsin, 1993: 400,000 affected, 47 deaths - animal runoff suspected)
- F - irrigation water, handling, preparation, shellfish
- A - legionnaires disease
- V - Malaria
- F - clothing, toys, etc.
Portal of Entry

- Gastrointestinal tract
- R________________ tract
- S________________

Host susceptibility

- A____________
- Natural or acquired i____________________
- H________________ (mental and physical)
Pathogens in Wastewater

- **Bacteria**
  - F________ material contains approximately 1012 bacteria per gram
  - B________________ content is approximately 9% of the weight (wet basis)
  - Most cause gastroenteritis (d________________ - inflammation of the intestines and loss of blood) or d________________ (typhoid fever is a notable exception)
  - Important groups:
    - *Salmonella* - most p________________ (over 2000 types)
      - primarily a f________ contaminant, but transmission by __________ water possible
      - causes gastroenteritis
Bacterial Pathogens

- *Salmonella typhi* produces t______ causing typhoid fever
- *Shigella*
  - causal agent of bacillary d________________________
  - small i_______________ dose (as low as 10 organisms)
  - mode of t________________________: primarily person to person, but f____________________ and waterborne possible (outbreak in Florida of 1200 people)
  - difficult to e____________________ in laboratory (viable but not culturable)
Bacterial Pathogens

- **Vibrio cholera** - causative agent of c___________________ - profuse diarrhea, r____________loss of fluid, causing death in short time period
  - e_______________ in various parts of Asia (Bengal state of India, Bangladesh)
  - documented outbreaks linked to s_______________ contaminated v___________________

- **Escherichia coli (E. Coli)**
  - found in gastrointestinal tract of humans and w_______________ blooded animals
  - many are harmless, some p____________________
  - 2-8% have been found to be enteropathogenic (EPEC) causing t_______________ diarrhea
  - infective d______ is relatively high - 106 to 109 organisms
  - several outbreaks have been associated with water d___________________ systems
    - Scotland (1990)
    - Cabool, Missouri (1990) 243 documented cases of diarrhea and four d__________
Bacterial Pathogens

- **Yersinia** - a_________________ gastroenteritis
  - s __________________are a major reservoir
  - waterborne incidence was suspected as cause of some o________________________
  - psychotrophic - t____________ at low temperatures (~ 4°C)
  - poorly c___________ with bacterial indicator organisms

- **Campylobacter**
  - a_________________ gastroenteritis
  - municipal water supplies and m______________ streams implicated for outbreaks:
    - V________________ (1978) 2,000 out of a population of 10,000 infected
    - high recovery of organisms in s__________ water in Fall (55% of samples positive) and Winter (39% of samples positive)
    - poorly correlated with bacterial i__________ organisms

- **Legionella pneumophilia** - causative bacteria in Legionaire’s disease
  - first encountered in P_________________ in 1976
  - found in natural habitats such as l________ and r________
  - acute pneumonia (respiratory distress) with high f___________ rat
  - organism is s___________ by aerosolization
  - microbial a_______________ from evaporative condensers, humidifiers and cooling towers
  - also affects gastrointestinal, u__________, and nervous system
  - can be persistent in local water distribution systems (e.g. h___________)

- Other opportunistic bacterial pathogens -
  - *Pseudomonas*
  - *Aeromonas*
  - *Klebsiella*
  - *Flavobacterium*
  - hospitals can harbor a_________________ resistant strains
Viral Pathogens

- 140 known viral pathogens
- Smallest “living” unit, but are they alive? Require a host cell to reproduce
- Invade cells and take over their metabolic functions
- Infect humans, animals, plants, bacteria, protozoa, etc.
- Weren’t identified until 1931 with advent of electron microscope
- Viruses are ingested, multiplied in intestines and are excreted in large numbers
- Usually present in small numbers overall therefore need to be detected in order to detect
  - Adsorption to molecular filters
  - Detection using animal tissue culture, immunological testing (ELISA) or gene probes
- Most probable transmission is person to person or foodborne, but waterborne transmission also possible
- Infection depends on MID and host susceptibility
- MID is smaller compared to bacterial pathogens (tens of plaque forming units, PFUs)
- Viruses can cause fever, diarrhea, respiratory infection, meningitis, or paralysis
- Difficult because can’t treat with antibiotics (can use antibiotics to prevent secondary infection)
- Some viral vaccines available
Major Viruses of Concern

- **Hepatitis A** (i____________ Hepatitis - HAV) oral/fecal route
  - short i____________ period (2-6 weeks)
  - oral/fecal route of transmission (water borne, foodborne, or person to person)
  - causes l____________ damage, nausea, fatigue, jaundice (yellowing of eyes), loss of appetite
  - p_____________ worldwide
  - s_____________ contamination of particular concern
  - c______________ shellfish in 1988 in Shanghai was responsible for 292,000 cases

- **Hepatitis B** (s____________ Hepatitis - HBV)
  - transmitted by infected b__________ or sexual contact
  - higher m______________ than HAV (1-4%)
Major Viruses of Concern

- V_______ gastroenteritis
  - rotavirus -
    - 70-nm particles, d_____________ stranded RNA
    - acute i______________ gastroenteritis
    - responsible for significant proportion of childhood mortality in
d______________ countries (millions of deaths per year)
    - major c_______ of traveler’s diarrhea
    - w______________ pathogen
    - fecal/oral route most l__________, but respiratory route also
      suspected
    - ELISA kits are available for d________________
Major Viruses of Concern

- *Norwalk virus*
  - small 27 nm virus detected in Norwalk, Ohio
  - waterborne and difficult to detect in environmental samples
  - gastroenteritis and traveler’s diarrhea
  - 42% of nonbacterial gastroenteritis attributed to Norwalk virus in one study
Major Viruses of Concern

- Other viruses
  - AIDS/HIV - not considered a waterborne pathogen, but may s_______________ in water for a limited time
  - c___________ virus - not waterborne
  - adenovirus - can cause e_____________ infections (conjunctivitis) in swimming pools and respiratory disease
  - poliovirus - can cause p________________, aseptic meningitis
Protozoan Pathogens

- Most produce c___________ that are resistant to disinfection, can survive for long periods of time
- In 1991-1992 there were 34 disease o_________________ associated with waterborne pathogens affecting about 17,000 people
  - five of 34 were c________________ water systems
  - 29 were c__________________, resorts, recreation areas, restaurants, and private systems
  - in 11 of the outbreaks the cause was i___________________
  - 7 of the 11 were p________________ parasites Giardia or Cryptosporidium
  - 4 were h_______________ A, shigella, or specific chemicals
Protozoan Pathogens

- **Giardia lamblia**
  - A person can excrete $10^6$ cysts per gram of feces
  - Wild and domestic animals act as reservoirs in mountain areas (beavers, muskrats, dogs, cats)
  - Infection may last for months to years
  - MID is $< 10$ cysts
  - Causes diarrhea, abdominal pain, nausea, fatigue, and weight loss (rarely fatal)
  - Bloody diarrhea
  - Infection may last from months to years
  - First major outbreak occurred in Rome, NY in 1975 - 5,000 people (10% of the population) water had been contaminated but not filtered
  - Major factor in waterborne outbreaks (as high as 50%)
  - Individuals with these organisms don’t correlate well, cryptosporidium does
  - *Giardia* has been detected in 16% of public water supplies at an average concentration of 3 cysts per 100 mL
  - Prevalence may be as high as 80% of surface water supplies
Cryptosporidium

- prevalent in cattle and sheep (billions of oocysts shed in feces every day)
- infections in humans not detected until 1970's
- incidence in water supplies outbreaks not identified until late 1980's
- cyst releases sporozoite after ingestion
- 1-10 MID (possibly as low as 1-10)
- produces diarrhea, rapid water loss, weight loss, nausea, vomiting, fever
- diarrhea lasts from 1-10 days usually, longer for immunodeficient patients
- prevalence in population is approximately __________%
- person to person contamination most probable route, hygiene important - especially in daycare centers
- major waterborne outbreaks:
  - New Carrollton, Georgia
    - 1987 - 13,000 people infected
    - No indicator organisms identified
    - 39% of patients treated p________ for crypto
    - Improper s________ f________ operation implicated
  - Milwaukee, Wisconsin
    - 1993 - 403,000 people infected, several deaths (#?)
    - Improper c_________________ and sand filter operation implicated
- Cryptosporidium has been detected in ________% of potable water supplies at an average concentration of 43 cysts per 100 mL, prevalence may be higher in surface water supplies
Helminths

- Similar to protozoan organisms in survivability and resistance to disinfection
- Parasitic worms
- Most are transmitted in contaminated food
- Some are transmitted by other routes: *Schistosoma* in water
- *Dracunculiasis* (guinea worm) - skin

Guninea Worm
Schistosomiasis

- Affects nearly _____ million
- Africa, South A______________, parts of Asia
- 200,000 d________ per year
- Causes enlargement of l__________, diarrhea, anemia
- Free swimming l________ in water called cercaria are emitted from s__________ which serve as intermediate hosts
- Cercaria attach to human s_______ and penetrate to the blood stream
- They mature in the l________, eggs are passed in urine
- Eggs hatch in water into free swimming c______________ larvae and infect snails
- Milder form of schistosomiasis - s__________________ i________
- D_______ and irrigation projects in developing countries have created ideal conditions for the spread of the disease
Ascariasis (roundworms)

- MID is a few infective e_________
- Each female can produce _______________ eggs per day
- Resistant to disinfection, can survive 2-7 years in s__________
- High prevalence worldwide _______ million to __ billion (1983)
- 85% of infections are s____________________
- Symptoms include pneumonia, nausea, abdominal pain, m_____________________________
- A child that has ______ worms may lose 10% of his daily intake of p______________
- Vitamin ____ and ____ deficiencies possible
- part of life cycle spent in l_____________