Principles of disease and epidemiology

By
Dr. Carmen Rexach
Microbiology
Mt San Antonio College
Definitions

- **Disease**
  - Any change from state of health

- **Epidemiology**
  - Study of occurrences and transmission of disease in populations

- **Pathogens**
  - Disease causing organisms
Definitions

• Pathology
  - Study of disease

• Pathogenesis
  - How a disease develops

• Infection
  - Invasion or colonization of body with pathogenic microorganisms
Normal microbial flora

• Microbes normally present in the body, non-disease producing
  - Intestinal tract inhabitants
  - On surface of skin
  - In oral/urogenital cavities

• Symbiotic relationships
  - Commensalism
  - Mutualism
  - Parasitism
Normal gut flora

Monogenean parasite of fish
Microbial antagonism

- Control of growth of harmful bacteria by presence of normal flora
- Competitive inhibition
- Production of substances that inhibit growth of undesirable bacteria
  - *Streptococcus* in mouth inhibits growth of most gram-positive and gram-negative cocci
  - Bacteriocins produced by *E.coli* inhibit growth of pathogenic bacteria
Bacteriocins
Opportunistic organisms

- Organisms associated with disease but not in healthy individuals, under ordinary circumstances, in normal habitat

- Immunocompromised or suppressed
  - AIDS and *Pneumocystis carinii*
  - Fungal infections in feet of diabetics
  - Transplant recipients on immunosuppressive drugs
Cooperation among microorganisms

• Infection with one type of microbe makes it easier to contract particular disease

• Example
  - *Mycoplasma fermentans* infection and HIV
  - Synergistic relationship = effect of the two together greater than each as individual
Etiology of infectious disease

- Koch’s postulates
  - Same pathogen present in every case of disease
  - Pathogen isolated from disease host and grown in pure culture
  - Pathogen from pure culture must cause disease when introduced into healthy, susceptible lab animal
  - Must re-isolate organism and show it to be same as in the original case of disease
Exceptions

• Bacterial
  - *Treponema pallidum*
  - *Mycobacterium leprae*
  - Intracellular bacteria (rickettsias)
  - *Legionella spp.*

• Viral
  - Intracellular parasite of cells

• Signs/symptoms
  - Some very specific to etiologic agent, some general
  - Some organisms cause multiple symptoms or have variety of effects on body
Treponema pallidum
Mycobacterium leprae

Leprosy; ulcerated foot. L.K. Bhutani
Color Atlas of Dermatology. 1986
Staphylococcus aureus
Infectious disease

• **Symptoms**
  - Subjective changes in body function, (pain, nausea)

• **Signs**
  - Objective changes in body function, (fever or paralysis)

• **Syndromes**
  - Group of signs & symptoms associated with a particular disease

• **Communicable disease**
  - Disease which spreads from one host to another, directly or indirectly

• **Contagious disease**
  - Disease easily spread from one host to another, communicable

• **Non-communicable disease**
  - Not spread form one host to another, caused by normal flora or introduced microbes
Classification of infectious disease

- Occurrence of disease
- Severity or duration of disease
- Extent of host involvement
Occurrence of disease

• Incidence
  - Percent of new cases in population in given time period

• Prevalence
  - Percent of individuals having disease in population at specified point in time

• Frequency of occurrence
  - Sporadic
    • only on occasion
  - Endemic
    • constantly present in the population
  - Epidemic
    • infects many people in given area in short time period
  - Pandemic
    • epidemic disease with worldwide occurrence
Severity or duration of disease

- **Acute**
  - Develops rapidly, short duration

- **Chronic**
  - Slower development
  - Less severe reaction
  - Continual or recurrent in duration

- **Subacute**
  - Halfway between acute and chronic

- **Latent**
  - Causative agent is inactive for some time, can become active producing disease symptoms
Extent of host involvement

- **Local infection**
  - Infection localized to small area of body
- **Systemic**
  - Generalized, spread throughout body
- **Focal infections**
  - Spread via circulatory system to other locations
- **Conditions involving blood**
  - Bacteremia
  - Septicemia
  - Toxemia
  - Viremia
Extent of host involvement

• Primary infections
  - Acute infection resulting in initial illness

• Secondary infections
  - Caused by opportunist after primary infection

• Subclinical infections
  - No noticeable disease
Reservoirs

• Source of disease organisms
  - Human
  - Animal
  - Non-living
    • Water, soil
Human reservoirs

- Some symptomatic
- Carriers
  - Typhoid Mary
- Diseases in which humans are reservoir
  - AIDS
  - Diphtheria
  - Typhoid
  - Hepatitis
  - Gonorrhea
  - Dysentery
  - Streptococcus
Animal reservoirs

- Sylvatic/domestic
- Zoonoses
  - Transmission
    - Direct contact with infected animal (rabies)
    - Direct contact with waste of infected animal (HVPS)
    - Contaminated food/water (Giardiasis)
    - Contaminated furs/hides, feathers (Tularemia)
    - Consumption of infected animal parts (BSE)
    - Insect vectors (WEE, dengue, malaria, yellow fever)
3 routes of disease transmission

• Contact
• Transmission by vehicle
• vectors
Contact

• **Direct contact transmission**
  - Person to person, animal to person transmission
  - Physical contact between source and suspect host

• **Indirect contact transmission**
  - Agent of disease from reservoir to suspect host via fomite (non-living object involved with spread of disease)

• **Droplet transmission**
  - Microbes spread by droplet nuclei (mucus droplets), sneeze, cough, talk
Transmission by vehicle

• Transmission of disease agents by medium
  - Water, food, air, blood, body fluids, IV drugs, etc.

• Waterborne
  - Usually contaminated with untreated or poorly treated sewage

• Foodborne
  - Incompletely cooked, poor refrigeration, unsanitary conditions
Transmission by vehicle

• Airborne
  • Can travel in dust more than one meter from reservoir to host
  • Examples: fungal spores associated with coccidiodomycoses, blastomycosis, histoplasmosis
Distribution of *C. immitis* in US
Vectors

• Usually arthropods carry organisms from one host to another

• Mechanical transmission
  - Passive transport on insect body part

• Biological transmission
  - Pathogen acquired in blood meal
  - Multiplies in vector
  - Transmitted to host in bite, defecation, vomiting while biting

• Examples: *Yersinia pestis*, *Plasmodium spp.*, *Rickettsia prowazekii*
The life-cycle of *Plasmodium vivax* in man & the mosquito. (after Vickers and Cox, 1967)
Portals of exit

• Usually connected with infected part of body
• Most common
  – Respiratory
  – Gastrointestinal tracts
  – Urogenital tracts
• Skin or wound infections
Factors influencing emerging infectious diseases

- Movement of diseases from one species to another
  - Changes in susceptibility of new host
  - Changes in pathogen which change or increase host range
- Increase in human population
- Increase in travel
- Encroachment of humans into undeveloped areas
- Antibiotic resistance
Nosocomial infections

- Infections acquired in hospital
- CDC attributes 20,000 deaths annually
  - Microbes
  - Compromised host status
  - Chain of transmission
Microbes

- Primarily opportunists
- Antibiotic resistant strains
- Selection for more resistant strains by wide use of disinfectants
  - Ex) *Pseudomonas*
Compromised host

• Impaired resistance due to disease, therapy, burns

• Two main conditions
  - Broken skin
  - Suppressed immune system

• Invasive procedures
  - Catheterization
  - Tracheotomy
  - Corticosteroids for transplantation
  - Treatment of autoimmune disease
Chain of transmission

- Direct contact between patients and hospital personnel
- Indirect
  - Fomites
  - Hospital ventilation, etc
How to control infections?

• Hand washing
• Aseptic technique
• Education
• Isolation of contagious patients
• Careful administration of antibiotics
• Public health recommendations
Factors that predispose to disease

- Genetics
- Gender
- Occupation
- Climate
- Weather
- Host health status
- Age
- Nutritional status
- Life style
- Emotional condition
Disease Development

- Incubation
- Prodrome
- Illness
- Decline
- Death
- Convalescence
Development of disease

• Incubation
  - Time between initial infection and first appearance of signs/symptoms
  - Varies with virulence of organism, specific microbe involved, microbe titer, host resistance

• Prodromal period
  - Not in all diseases, early mild symptoms
Development of disease

• **Illness**
  - Most acute state of disease, signs and symptoms apparent
  - Two outcomes: immune system intervention = decline of disease; success of pathogen = death

• **Decline**
  - Signs and symptoms subside, susceptibility to secondary disease

• **Convalescence**
  - Return of body to pre-disease state
epidemiology

- Study occurrence of disease and disease transmission in populations
  - Etiology, disease patterns, contributing factors
- Results used in public health to develop methods of disease prevention
  - Also measure effectiveness of public health program
  - Assesses effectiveness of clinical procedures
History of epidemiology

- John Snow and Cholera epidemic in London 1854
Map showing Cases of cholera
Broadstreet pump
Types

• Descriptive
  - Retrospective analysis about occurrence of disease so that it can be described

• Analytical
  - Analysis to determine probable cause
    • Case-control studies
    • Cohort studies

• Experimental
  - Develop and conduct experiments to test hypotheses on groups of people
  - Ex) drug efficacy trials