Infectious Disease Epidemiology
BMTRY 713 (A. Selassie, DrPH)

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Lecture 6
Outbreak Epidemiology & Investigation

Learning Objectives
1. Define Outbreak, Epidemic, Endemic, & Pandemic
2. Describe the purpose of Outbreak investigation
3. List the main steps in outbreak investigation
4. Illustrate epidemic curves
5. Recognize main types of outbreaks

Outbreak Epidemiology

- Study of a disease cluster or epidemic in order to control or prevent further spread of disease in a population
- It is a specific form of descriptive epidemiology intended to identify immediate threat to public health
- Requires urgent action

Terminology

- Outbreak—a small localized cluster of cases, usually an infectious disease
- Epidemic—the occurrence of cases of a condition in a population in a number greater than expected for a given period of time
- Endemic—a constant presence of a communicable disease in a population
  - Holendemic: high proportion of children affected, conferring immunity in adults (e.g. malaria)
  - Hyperendemic: constant presence in all ages
- Pandemic—an epidemic that transcends national boundary extending to much of the world
Types of epidemics

- **Common source**
  - Single source of contamination
  - Single vehicle
    - Consider distribution patterns

- **Point epidemics**
  - Common source, everyone exposed at the same time

- **Propagated epidemics**
  - Transfer from one host to another
  - Bimodal with secondary cases
  - Overlapping secondary cases

- **Mixed**
  - Include both

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**Point source epidemics (short)**

![Figure 4-7: Salmonella point source airplane epidemic curve on a flight from London to the United States, by time of onset, March 11-16, 1994.](image)

**Point source epidemics (Long)**

![Figure 4-6: Point source epidemic curve.](image)
Propagated epidemics

Study design

- Case-control
  - Compares those ill with those not
  - Identify the underlying population
  - Useful when you do not know the cause
- Retrospective cohort
  - Suspected agent

Case-control study

- Large event
  - Cases and controls taken from attendees
- When the exposure is unknown
- Benefit
  - Rapid design
  - Less expensive
  - Efficient in collecting data
Cohort study

- Appropriate when it is possible to enumerate persons potentially exposed and contact them in a timely manner
- Suited to outbreaks at a specific event

Classification of infectious disease

- Clinicians -- use clinical manifestations or organ systems
- Microbiologist – by agent
- Epidemiologists – 2 common methods
  - Means of transmission
  - Reservoir of organism

Means of transmission

- Contact -- direct or indirect
- Food- or water-borne -- ingestion
- Airborne -- inhalation of contaminated air
- Vector-borne -- living organism
- Perinatal -- during pregnancy or at time of delivery
Biologic characteristics of the organism

- Infectivity
- Pathogenicity
- Virulence
- Immunogenicity
- Inapparent infections
- Carrier states

Immunogenicity

- Ability of an organism to produce an immune response after an infection that is capable of providing protection against reinfection with the same or a similar organism (antibodies)

Types of immunogenicity

- High, life-long immunity
  - Measles, polio
- Weak, reinfection is common
  - Neisseria gonorrhoeae (gonorrhea)
  - Plasmodium falciparum (malaria)
- Nonprotective, deleterious to the host
  - Streptococci infection resulting in glomerulonephritis or rheumatic fever
- Binding antibodies, markers of prior infection, non-immune
  - Hepatitis C, HIV
**Inapparent infections**
- Infection that can be documented by the isolation of the organism by culture, identification by PCR, or through a specific immune response but the person remains asymptomatic
- Measure of low pathogenicity, e.g. polio
- Rare in some diseases, e.g. measles, smallpox, hanta virus

**Carrier state**
- An individual who is asymptomatic but capable of transmitting disease to others
  - HBV infection is acquired perinatally
  - "typhoid Mary"
  - HIV has a long carrier state, average approximately 10 years

**Infectivity**
- Ability of the agent to cause infection in a susceptible host
- Two measures
  - Minimum number of infectious particles required to establish infection
  - Proportion of susceptible individual who develop infection after exposure, aka as ??
Pathogenicity

- Ability of a microbial agent to induce disease
  - *Helicobacter pylori* with vac A and cag A alleles are much more pathogenic than *Helicobacter pylori* infections without these characteristics
  - Proportion of cases who develop disease

Virulence

- Severity of the disease after infection
- Best measured by
  - Case-fatality rate
  - Proportion of clinical cases who develop severe disease

Identification of an epidemic

- Increase in cases of a disease currently reported to CDC
- Reports from doctor’s office, hospitals, nursing home, laboratory
- May be reported by an individual
**Temporal trends in infectious disease**

- Seasonal variation
  - Vector-transmitted diseases
- Annual variation
  - Dependent upon the number of susceptible individuals in the community
- Variation over decades
  - Decrease in incidence and mortality in some
  - Large number of new infections occurring

**Outbreak investigations**

- Usually conducted by facilities or at the local or state public health level
- CDC is consulted for multi-state outbreaks or those requiring special expertise

**Steps in conducting an outbreak investigation**

- Identify investigative team members and their roles
- Confirm the existence of an outbreak
  - Compare rates with background levels
  - Rule out "spurious" factors (improved surveillance)
  - Verify diagnoses
  - Some diseases are so serious that a single case is investigated
    - Anthrax, human rabies, botulism, polio, bubonic plague
Steps in conducting an outbreak investigation (2)

- Select a case definition
  - May include time and place of exposure, laboratory findings, and clinical symptoms.
  - Initial case definition has a greater emphasis on sensitivity than specificity
  - Subsequent case definitions may have greater specificity
  - Classify cases as confirmed and probable

Classification of Cases

A case definition for plague

PLAGUE (Filled B99)

Clinical presentation

- In humans, plague is transmitted by fleas or by direct exposure to infected tissue or respiratory secretions; the disease is characterized by fever, chills, headache, malaise, prostration, and leukocytosis that may evolve into one of the three forms of the disease (pneumonic, septicemic, or bubonic plague).

- Septicemic plague
  - Involves noninfectious dissemination and can manifest as a disseminated intravascular coagulation (DIC) syndrome
  - Manifestation: noninfectious and noninfectious

- Pneumonic plague
  - Involves spontaneous release from the bacillus (plague bacillus) and can manifest as a self-sustained or self-distributed
  - Manifestation: spontaneous or self-distributed

- Septicemic plague
  - Involves spontaneous release from the bacillus (plague bacillus) and can manifest as a self-sustained or self-distributed
  - Manifestation: spontaneous or self-distributed

Laboratory confirmation criteria

- Spontaneous or self-distributed: noninfectious
  - Manifestation: noninfectious

- Self-sustained or self-distributed: noninfectious
  - Manifestation: noninfectious

- Spontaneous or self-distributed: infectious
  - Manifestation: infectious

- Self-sustained or self-distributed: infectious
  - Manifestation: infectious
Steps in conducting an outbreak investigation (3)

- Identification of cases
  - Case finding techniques reviewing existing surveillance data, surveying hospitals, asking existing cases if they know others who may have been exposed
- Identification of population at risk
  - Range from very few to many
  - Those with a common exposure

Determine study design

- Based upon size and availability of the exposed population, the speed with which results are needed, and available resources.
  - Small enumerable exposed groups
  - Large enumerable exposed groups
  - Groups where exposure can be identified but groups cannot be enumerated
  - Exposed population is unknown

Data collection

- Determine person, place, and time
- Survey administration
  - Variables to define cases
  - As soon as possible
  - Look for similarities among respondents
Complementary analyses

- Laboratory studies
- Environmental assessment
- Implement control measures

Formulate and Test the Hypothesis

- Assess data formally using descriptive and analytic epidemiologic techniques
- Test the hypothesis to determine the source of transmission and the vehicle of the agent (Food, water, milk, etc.)
- Assess the hypothesis to determine risk factors.
  - (E.g., Are those who attended the wedding luncheon at higher risk than those who did not attend the luncheon?)

Summary

- Outbreak investigations are intended to gain information about disease, pathogens, and risk factors so that urgent preventive measures will be implemented
- Involve series of well-planned and executed steps and methods
- Cooperation and communication are key elements