Understanding and Confronting Emerging Disease

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Dr. John Snow - British Physician & Pioneer of Epidemiology
**Epidemiology** - study of diseases
   Includes: occurrence, distribution, control

**Health:** Body functions normally

**Disease:** Impaired function due to genetic factors, environmental influences or infectious disease agents

Understanding the source & spread of infectious diseases is one of the most important applications of epidemiology.
History of Epidemiology

- Cholera – acute, diarrheal illness caused by intestinal infection with the bacteria *Vibrio cholerae*

- 1849 - 33,000 people died of cholera in Britain, 13,000 in London alone

- John Snow - British physician believed that cholera was caused by a toxin that was produced by sick people & released in their stool. This contradicted the prevailing idea that disease was caused by bad air.
John Snow’s Map of Cases in London Cholera Epidemic

By making a map of cholera cases during the 1849 epidemic, Snow could locate the infection source: a water pump on Broad Street.
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Robert Koch & Koch’s Postulates

Isolate infectious material from an animal with disease. This material should cause the disease if introduced into a new animal.

Use the isolated infectious material to **grow** the organism on synthetic medium away from the host animal.

**Innoculate** an uninfected animal with the organism from the plate culture & show that it causes the same disease.
Terminology for Disease Occurrences

**Sporadic disease** - occurs at irregular intervals
example: typhoid fever or cholera

**Endemic disease** - occurs at steady, low-level frequency
example: the common cold

**Epidemic** - sudden increase in disease occurrence
example: The flu in certain years

**Outbreak** - a local epidemic
example: salmonella food poisoning

**Pandemic** - a world-wide occurrence
example: HIV/AIDS
the common cold

(a) Endemic disease

(b) Epidemic disease

(c) Pandemic disease
(a) Endemic disease  (b) Epidemic disease  (c) Pandemic disease

the common cold  the flu  AIDS
Measurement of Disease Occurrence

**Morbidity rate**: (Incidence rate) Number of people who *contract* disease within a given time period

\[
\frac{\text{# new cases during a specific time}}{\text{# of individuals in population}}
\]

Usually calculated per 100,000 people

*Example*: 700 case / 100,000 (or 0.7%)

**Prevalence rate**: Total number of people who *have* a disease within a given time period. This may be a larger number than incidence rate (depending on duration of disease).

**Mortality rate**: Number of *deaths* / number of people with disease
Infectious Disease Epidemiology

Determine:
- causative agent
- source &/or reservoir of disease agent
- mechanism of transmission
- host & environmental factors that facilitate development of disease within a defined population
- best control measures
Recognition of an Infectious

• involves use of surveillance methods
  – review of death certificates
  – field investigation of epidemics
  – investigation of actual cases

• disease cases are recognized by their characteristic disease syndrome, a set of signs & symptoms
  – Signs - objective changes in body that can be directly observed
  – Symptoms - subjective changes experienced by patient
Course of infectious disease

- **incubation period**
  - time after pathogen entry but before signs & symptoms appear
- **prodromal stage**
  - onset of signs & symptoms
  - not clear enough for diagnosis
- **period of illness**
  - disease is most severe
  - signs & symptoms present
- **convalescence**
  - signs & symptoms begin to disappear
Types of Epidemics

Common-source epidemic
- Peaks in short time
- Due to a single source of contamination
  (i.e. food poisoning)

Propagated epidemic
- Slow increase & decrease
- Due to single infected case in susceptible population
  (i.e. chickenpox)
What limits epidemics?

Decreases in the number of susceptible hosts: As number of cases increases, number of susceptible hosts decreases due to acquired immunity.

“Herd immunity” - Resistance of population to a pathogen due to previous infection or immunization – your chances of being exposed to a pathogen decrease as the number of people you are in contact with who are immune increases.
SARS: Number of Current Probable Cases as of 3 June 2003, 14:00 GMT+2

Canada: 66
United States of America: 35
Russia Federation: 1
Germany: 1
France: 1
China: 1437
China, Taiwan: 462
China, Hong Kong SAR: 138
Singapore: 10

Number of current probable cases
- 1 - 60
- 61 - 200
- 201 - 500
- 501 - 1000
- More than 1000

Data Source: World Health Organization
Map Production: Public Health Mapping Team
Communicable Diseases (CDS)
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The Infectious Disease Cycle: Story of a Disease

*SARS: Severe Acute Respiratory Syndrome*
The Infectious Disease Cycle: Story of a Disease

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SARS: Severe Acute Respiratory Syndrome
What Pathogen Caused the Disease?

February 2003: a viral respiratory illness is first reported in Asia.

- Koch’s postulates (or a modification of them) are used if possible
- Clinical microbiology labs isolate & identify the pathogen
- Means of transmission of the communicable disease is determined
- Isolation & culture of virus from patient throat swab samples
- DNA from patient samples is a new coronavirus
- Spread from civet cats to food workers, to health care workers & to the public through respiratory droplets
What was the Source & Reservoir of the Pathogen?

- **Source** - location from which pathogen is transmitted to host
- **Period of infectivity** - time when source is infectious or disseminating the organism
- **Reservoir** - natural location of pathogen (this sometimes functions as source of the pathogen)

- Masked palm civet & raccoon dog; human to human spread by respiratory droplets
- Patients are contagious while they have symptoms (fever & cough) for 7-10 days.
- Wild *bats*! (Spread to civet cats when both animals are captive & in close proximity.)
Civet cats are likely to be the source of the SARS virus in China, but *not the natural reservoir*. Scientists have not found infected civets in the wild.

Scientists have identified SARS antibodies in 80% of bats in the wild. **Hypothesis**: bats & civet cats were kept in close contact in live animal markets in Southern China where both are sold as food. The bats passed SARS to civet cats. Infected civet cats & bats passed the virus to humans.
Disease Sources

Human are the most common source of infectious disease!

1. **Active carrier** – has overt clinical signs

2. **Convalescent carrier** - has recovered from illness, but is still shedding organisms

3. **Healthy carrier** - harbors pathogen, but does not show disease signs

4. **Incubatory carrier** - is in early disease stages, but is not ill yet

*Note*: 2 or 3 may become *Chronic carriers*. 
Mary Mallon: 1896-1906, worked as a cook in 7 New York city homes. 28 cases of typhoid fever occurred in these homes while she worked there. She was arrested & admitted to an isolation hospital. She was found to shed high levels of typhoid bacteria but showed no evidence of having the disease. The hospital released her when she pledged not to cook for or serve food to others.

She changed name & became a cook again, avoiding re-capture for 5 years while spreading the disease. Eventually she was found & held in custody for 23 years until her death in 1938. She was responsible for 10 outbreaks, 53 cases & 3 deaths.

Mary was a Chronic carrier
Disease Sources

Animal sources

Zoonoses - animal diseases that occasionally occur in humans

Examples: Rabies via bite, trichnosis from undercooked pork, hantavirus via contaminated animal excretia, West Nile via infected Corvid birds-transmitted by mosquitos

Inanimate disease sources

Food, Water, Soil
How Was the Pathogen Transmitted?

four main routes

airborne  direct contact  vehicle contact  vector-borne
Airborne Disease Transmission

Pathogen suspended in air; travels >1m
Found in droplet nuclei (1 - 4 mm)
Source: Sneezing & coughing

Examples: anthrax, Hantavirus, mycobacterium (TB)
Influenza, SARS
Contact Disease Transmission

Direct Contact (person-to-person)
Requires direct touching
(Touching lesions, secretions, sexual contact, breastfeeding, etc.)

Indirect Contact (vehicle)
Inanimate objects (fomites)
(Drinking utensils, bedding, clothing, thermometers)
Vector-Borne Transmission

Mechanical vector (external transmission)
Microbe carried on surface of vector
Example: Fly lands on feces, then lands on your food!

Biological vector (internal transmission)
Microbe replicates & changes within vector
Example: Mosquito transmission of malaria
History's Most Deadly Events

- Influenza pandemic (1918-19) 20-40 million deaths
- Black Death/Plague (1348-50), 20-25 million deaths
- AIDS pandemic (through 2000) 21.8 million deaths
- World War II (1937-45), 15.9 million deaths
- World War I (1914-18) 9.2 million deaths.
Control of Epidemics

• Reduction or elimination of source
  – Treat infected individuals or quarantine
  – Control or remove animal reservoirs

• Sanitation methods
  – Food safety - pasteurization, food inspection
  – Control of insect vectors
  – Water chlorination

• Increasing the level of “herd immunity”
  – Vaccination programs
What causes new epidemics?

Continual entry of pathogens from animal or environmental sources

Continual transmission between humans (for example, respiratory infections)

Changes in pathogen due to antigenic shift & drift
1960s-1970s: Belief that infectious diseases had been conquered via antibiotics, vaccines, & improved standards of living. Surgeon General William Stewart (1969) declared that it was “time to close the book on infectious diseases” & pay more attention to chronic ailments such as cancer & heart disease.

This has been challenged by new infectious diseases:

- AIDS (early 1980s)
- Increased antibiotic resistance in *Staphylococcus* & *Mycobacterium tuberculosis*
- Multi-state outbreaks of food-borne and respiratory illness due to various bacteria & viruses
In 1962, Nobel Laureate Sir Frank Macfarland Burnet wrote, "One can think of the 20th century as the end of one of the most important social revolutions in history--the virtual elimination of the infectious disease as a significant factor in social life."
Examples of Emerging and Re-Emerging Diseases

- Vancomycin-resistant Staphylococcus aureus
- Cryptosporidiosis
- Multidrug-resistant tuberculosis
- Drug-resistant malaria
- E. coli O157:H7
- Lyme disease
- West Nile virus
- v-CJD
- Typhoid fever
- Rift Valley fever
- HIV
- E. coli O157:H7
- H5N1 avian influenza
- Vancomycin-resistant Staphylococcus aureus
- Nipah virus
- Hendra virus
- Enterovirus 71
- Human monkeypox
- Plague
- Hepatitis C
- Whitewater Arroyo virus
- Hantavirus pulmonary syndrome
- Dengue
- Yellow fever
- Cholera
- Lassa fever
- Ebola hemorrhagic fever

Saturday, February 5, 2011
Factors Contributing to EIDs

- **Population Changes**
  - Population density & crowding
  - Land development
  - Community living arrangements (child day-care)

- **Food Practice Changes**
  - Globalization of food supply
  - Mass-processed foods

- **Excessive & inappropriate use of antibiotics**
  - Antibiotics prescribed for viral infections
  - Antibiotics added to animal feed
  - Availability of antibiotics without prescriptions

- **Increasing number of immunosuppressed patients**
  - Due to disease agents (HIV)
  - Immunosuppressive disease treatments
    *(chemotherapy & radiation, transplant anti-rejection drugs)*
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Avian influenza
Human influenza
New strain of influenza
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6. Farmers are infected by the recombinant virus & pass it on to the general population.

Avian influenza
Human influenza
New strain of influenza
Vibrio: From John Snow To Hurricane Katrina
The Public Health System

Local & State Level
- Public health laboratories
- Microbe culture & identification

National Level
- CDC - Centers for Disease Control & Prevention
  Headquarters - Atlanta, GA

CDC Publications (Web site: http://www.cdc.gov)
- Morbidity & Mortality Weekly Reports
- Emerging Infectious Diseases
- Health Facts
- Travelers’ Health Information
Epidemic Intelligence Service: A unique, 2-year postgraduate program of service & on-the-job training for health professionals interested in the practice of epidemiology.

Sites of Epidemic Intelligence Service EPI-AID Investigations During the 1950s

Sites of Epidemic Intelligence Service EPI-AID Investigations During the 1990s
Morbidity and mortality due to Diarrhea
Re-Emergence of Dengue virus in the Americas between 1970 and 1994 due to reduction in mosquito eradication programs.
Effect of Polio vaccine on disease incidence in the U.S. 1951-1994

![Graph showing the effect of Polio vaccine on disease incidence in the U.S. from 1951 to 1994. The graph indicates a significant decrease in polio cases after the introduction of the Salk and Sabin vaccines.](image)

**FIGURE 3.4** Total number of cases of poliomyelitis in the United States from 1951 to 1994 and the number of vaccine-related cases after the introduction of the live virus Sabin vaccine. [Data from Nathanson et al. (1996, p. 556) and from Morbidity and Mortality Weekly Report (MMWR), Vol. 46, p. 79 (1997).]
Currently under investigation in our Lab

Studies of the molecular Biology and Structure of Zoonotic Viruses of the Arenavirus and Coronavirus groups

Host-Virus Interactions resulting in Disease and Autoimmunity

Design of Antiviral Drugs and Vaccines for Emerging Viruses