Epidemiologic Investigation

Sukon Kanchanaraksa, PhD
Johns Hopkins University
Section A

Objectives of Epidemiology
I Keep six honest serving-men:
(They taught me all I knew)
Their names are What and Where and When
And How and Why and Who.

— Rudyard Kipling (1865–1936)
Epidemiology as a Science and a Method

- **Epi** = upon, among
- **Demos** = people
- **Ology** = science, study of
- **Epidemiology** = the science or the study of epidemic
  - It is the scientific method of disease investigation
  - Typically, it involves the disciplines of biostatistics and medicine
John Snow (1813–1858)

- An English physician and modern-day father of epidemiology
- He used scientific methods to identify the cause of the epidemic of cholera in London in 1854
- He believed that it was the water pump on Broad Street that was responsible for the disease
  - The removal of the pump handle ended the outbreak

Photo source of two color images: Sukon Kanchanaraksa
A Definition of Epidemiology

- The study of **distribution** and **determinants** of **health, disease, or injury** in human populations and the application of this study to the control of health problems.
Types of Epidemiology

- **Distribution**
  - Frequency of health events
  - By person, time and place

- **Determinants**
  - Search for causes or risk factors
  - Response to a study hypothesis
  - Use various epidemiologic methods
Types of Epidemiology

- **Distribution**
  - Frequency of health events
  - By person, time and place

- **Determinants**
  - Search for causes or risk factors
  - Response to a study hypothesis
  - Use various epidemiologic methods

- **Health, disease, or injury**
  - All health outcomes

- **Application**

---

Descriptive epidemiology

Analytic epidemiology

Disease-specific epidemiology

Applied epidemiology
Objectives of Epidemiology

- Investigate the etiology of disease and modes of transmission
- Determine the extent of disease problems in the community
- Study the natural history and prognosis of disease
- Evaluate both existing and new preventive and therapeutic measures and modes of health care delivery
- Provide a foundation for developing public policy and regulatory decisions

Source: Gordis, Epidemiology, 2004.
### U.S. Mortality, 2001

<table>
<thead>
<tr>
<th>Rank</th>
<th>Cause of Death</th>
<th>No. of Death</th>
<th>% of all Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Heart Diseases</td>
<td>700,142</td>
<td>29.0</td>
</tr>
<tr>
<td>2</td>
<td>Cancer</td>
<td>553,768</td>
<td>22.9</td>
</tr>
<tr>
<td>3</td>
<td>Cerebrovascular diseases</td>
<td>163,538</td>
<td>6.8</td>
</tr>
<tr>
<td>4</td>
<td>Chronic lower respiratory diseases</td>
<td>123,013</td>
<td>5.1</td>
</tr>
<tr>
<td>5</td>
<td>Accidents (Unintentional injuries)</td>
<td>101,537</td>
<td>4.2</td>
</tr>
<tr>
<td>6</td>
<td>Diabetes mellitus</td>
<td>71,372</td>
<td>3.0</td>
</tr>
<tr>
<td>7</td>
<td>Influenza and Pneumonia</td>
<td>62,034</td>
<td>2.6</td>
</tr>
<tr>
<td>8</td>
<td>Alzheimer’s disease</td>
<td>53,852</td>
<td>2.2</td>
</tr>
<tr>
<td>9</td>
<td>Nephritis</td>
<td>39,480</td>
<td>1.6</td>
</tr>
<tr>
<td>10</td>
<td>Septicemia</td>
<td>32,238</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Estimated U.S. Cancer Deaths, 2004

Lung and bronchus 32%  Men 290,890
Prostate 10%  Women 272,810
Colon and rectum 10%  25% Lung and bronchus
Pancreas 5%  15% Breast
Leukemia 5%  10% Colon and rectum
Non-Hodgkin lymphoma 4%  6% Ovary
Esophagus 4%  6% Pancreas
Liver and intrahepatic bile duct 3%  4% Leukemia
Urinary bladder 3%  3% Non-Hodgkin lymphoma
Kidney 3%  3% Uterine corpus
All other sites 21%  2% Multiple myeloma

ONS=Other nervous system

Source: American Cancer Society, 2004
Trends in Obesity

Prevalence (%) of Obesity in Adults Aged 20 to 74 by Gender, U.S. 1960–2000

*Obesity is defined as a body mass index of 30 kg/m² or greater.

What Is it? (Prion, Virus, Bacteria)

"Bacterial Cell Structure" from Epidemiology of Infectious Diseases. Available at: http://ocw.jhsph.edu. Copyright © Johns Hopkins Bloomberg School of Public Health. Creative Commons BY-NC-SA.
Mysterious Virus in the Four Corners Region of U.S.

- In similar outbreaks in 1918 and 1936, there was an increase in the number of mice in the region due to the abundance of pi-on nuts (food for rodents) brought on by increased rainfall.
- Epidemiologic study confirmed the connection between rodents and households with sick occupants.

http://www.amnh.org/exhibitions/epidemic/section_02/sectwo_pg_02.html
http://www.cdc.gov/ncidod/diseases/hanta/hps/noframes/generalinfoindex.htm
Wood Mouse by Andy Field. Creative Commons BY-NC-SA.
Mysterious Virus in the Four Corners Region of U.S.

- Hanta virus was discovered in rodents that excreted the virus in their feces and urine.
- People inhaled the dust particles that contained the virus and became ill (hantavirus pulmonary syndrome).
- To prevent the spread of the virus:
  - Mice-proof the home
  - Wear a mask while sweeping in the home
  - Wash the floor with an antiseptic solution

http://www.amnh.org/exhibitions/epidemic/section_02/sectwo_pg_02.html
http://www.cdc.gov/ncidod/diseases/hanta/hps/noframes/generalinfoindex.htm
Wood Mouse by Andy Field. Creative Commons BY-NC-SA.
Lung Cancer Mortality
Colorado Plateau Uranium Miners

<table>
<thead>
<tr>
<th>Follow-up Date</th>
<th>Mortality Relative Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1959</td>
<td>2.0</td>
</tr>
<tr>
<td>1962</td>
<td>3.6</td>
</tr>
<tr>
<td>1967</td>
<td>6.2</td>
</tr>
<tr>
<td>1974</td>
<td>4.8</td>
</tr>
<tr>
<td>1977</td>
<td>4.8</td>
</tr>
</tbody>
</table>
Epidemiology and Radon as Treatment

- “… patients seeking a natural arthritis cure visit modern radon therapy clinics and underground galleries for the sole purpose of radon inhalation or radon balneology”
- “Clinical, double-blind and randomized controlled studies in those countries report findings substantiating claims of pain and symptom relief, supporting the observations of benefit equal to that reported by visitors to the Free Enterprise Radon Health Mine located at Boulder, Montana”
The year 2005 commemorated the 50th anniversary of the announcement that the Salk polio vaccine was effective.

In April, 1955, Dr. Thomas Francis, director of Poliomyelitis Vaccine Evaluation Center at the University of Michigan, announced that the two-year field trial of the Salk vaccine against polio was up to 90% effective.

“The results announced by Francis effectively marked the beginning of the end of polio as the most life-threatening and debilitating public health threat to the children of the United States.”

http://www.umich.edu/%7Ebhl/bhl/digpubs/polio/guideintro.htm
http://www.med.umich.edu/medschool/chm/polioexhibit/salk_report.htm
http://www.med.umich.edu/medschool/chm/polioexhibit/press_release.htm
Uses of Epidemiology

- In historical study of health and diseases in the population and in projecting into the future
- For community diagnosis of the presence, nature and distribution of health and diseases among the population
- To study the working of health services
- To estimate the individual’s chances and risks of disease
- To help complete the clinical picture of diseases
- In identifying syndromes from the distribution of clinical phenomena among sections of the population
- In the search for causes of health and disease

Source: Morris, JN. Uses of Epidemiology. 1957.
Review Questions

- What is epidemiology?
- Choose a disease that is of interest to you
  - Describe the disease by time, place, and person
Section B

Dynamics of Disease Transmission
Describing a Disease: Epidemiologic Triad

Host

Vector

Agent

Environment
### Factors Associated with Increased Risk of Human Disease

<table>
<thead>
<tr>
<th><strong>HOST</strong> (Intrinsic)</th>
<th><strong>AGENTS</strong></th>
<th><strong>ENVIRONMENT</strong> (Extrinsic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Biological (bacteria, etc.)</td>
<td>Temperature</td>
</tr>
<tr>
<td>Gender</td>
<td>Chemical (poison, alcohol, smoke)</td>
<td>Humidity</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>Physical (auto, radiation, fire)</td>
<td>Altitude</td>
</tr>
<tr>
<td>Religion</td>
<td>Nutritional (lack, excess)</td>
<td>Crowding</td>
</tr>
<tr>
<td>Customs</td>
<td></td>
<td>Housing</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td>Neighborhood</td>
</tr>
<tr>
<td>Heredity</td>
<td></td>
<td>Water</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td>Milk</td>
</tr>
<tr>
<td>Family background</td>
<td></td>
<td>Food</td>
</tr>
<tr>
<td>Previous diseases</td>
<td></td>
<td>Radiation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Air pollution</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Noise</td>
</tr>
</tbody>
</table>
Dynamics of Disease Transmission

- Interaction of agents and environmental factors with human hosts
- Distribution of severity of disease
- Modes of disease transmission
- Level of disease in a community when transmission stops
The “Iceberg” Concept of Infectious Diseases

(At the level of the cell and of the host)

**Cell response**
- Lysis of cell
- Inclusion body formation
- Cell transformation
- Cell dysfunction
- Viral multiplication
- Without visible change
- Viral maturation
- Exposure without attachment and/or cell entry

**Host response**
- Death of organism
- Classical and severe disease
- Moderate severity
- Mild illness
- Infection without Clinical illness
  - (asymptomatic infection)
- Exposure without infection

Source: Evans, 1991
Distribution of Clinical Severity for Three Infections

(Not drawn to scale)

Class A: unapparent infection frequent
Example: tubercle bacillus

Class B: clinical disease frequent; few deaths
Example: measles virus

Class C: infections usually fatal
Example: rabies virus

Source: Mausner and Kramer, 1985 p.265
Unapparent Infection

- **Preclinical disease:** in the early stage of disease progression, disease is not clinically detected but is destined to become clinical disease
- **Subclinical disease:** disease is not detected but the host carries the organism or has antibody response.

A well known example is the typhoid disease outbreaks in New York City in the early 1900s. Typhoid Mary (Mary Mallon) was a healthy carrier of *Salmonella typhi*; she continued to work as a cook and infected numerous people until she was quarantined for life against her will.

Source: http://www.pbs.org/wgbh/nova/typhoid/
Pathway of Disease Infection

- Infected host (or reservoir)
- Portal of exit
- Modes of transmission
- Portal of entry
- Susceptible host
Transmission of Agents

- **Direct contact (person-to-person)**
  - Skin, saliva via kissing, sexual contact, aerosol from sneezing or coughing
  - Polio, hepatitis, HIV, influenza

- **Indirect contact**
  - Via vector (an organism that carries disease-causing micro-organisms, such as mosquito), dust particles, air, food, water, blood, tissues, organs, fomites (inanimate objects that can carry disease-causing micro-organisms—e.g., toothbrush, cutting board, toys, etc.)
  - Diseases that are commonly spread by means of fomites include the common cold, cold sores, conjunctivitis, coxsackievirus (hand-foot-mouth disease), croup, *E. coli* infection, Giardia infection, influenza, lice, meningitis, rotavirus diarrhea, RSV, and strep

Source: http://tos.beastlet.com/gallerym3.html
Transmission of Agents from Mother to Child

- **Vertical transmission** (inter-generation) is the transmission of disease-causing agents from mother directly to baby
  - Just before or just after birth
  - Via placenta or breast milk
- **Horizontal transmission**: all other transmissions
- Diseases that can be transmitted from mother to baby include:
  - HIV
  - Hepatitis C
SARS (Severe Acute Respiratory Syndrome)

- Spreads by direct contact (person to person) from droplets from cough or sneeze (short distance)
- Droplets enter via the mucous membranes of the mouth, nose, or eyes
- Can also spread by indirect contact when the person touches contaminated objects and then touches his or her mouth, nose, or eyes

Frequency of Exposure in Indirect Contact

- Single Exposure
- Multiple Exposure
- Continuous Exposure

Common vehicle single exposure
Common Vehicle Single Exposure

- Group of individuals exposed to a **common vehicle** (food, water, air, etc.)
- The exposure was one time (for example, the food was served only once)
- Typical characteristic
  - Explosive (abrupt) increase in the number of diseased individuals and then the number declines gradually over time
- Examples: food-borne outbreak at school, church, or on a cruise ship
Quick Check: SARS Virus

SARS virus is known to be transmitted via aerosol spread from coughing. On March 15, 2003, a Boeing 737-300 carrying 120 persons flew for three hours from Hong Kong to Beijing. An individual with SARS was on board. Eighteen people were believed to contract the disease on the flight.

Was this a common vehicle single exposure outbreak?
Definition of Endemic, Epidemic, and Pandemic

- **Endemic**
  - The habitual presence of a disease within a given geographic area
  - May also refer to the usual prevalence of a given disease within such an area (APHA)

- **Epidemic**
  - The occurrence in a community or region of a group of illnesses of similar nature, clearly in excess of normal expectancy (APHA)
  - Outbreak

- **Pandemic**
  - A worldwide epidemic
London Smog Disaster, 1952

- Air pollution causes respiratory illnesses and death
- When fog and soot from coal burning created a dense smog in Winter, 1952, in London, the smog was around for five days from December 5–10, 1952
- There was a substantial increase in mortality
  - Estimated premature death of 12,000
- The death rate in London in the previous week was around 2,062
  - In the week of the smog, 4,703 died

"1952 London Fog. High levels of pollution correspond to a similar pattern in daily mortality." from Biostatistics Lecture Series. Available at: [http://ocw.jhsph.edu](http://ocw.jhsph.edu). Copyright © Johns Hopkins Bloomberg School of Public Health. Creative Commons BY-NC-SA.
Herd Immunity and Disease Transmission

- In a population, disease transmission may stop before all susceptible individuals are infected.
- **Herd immunity** is the resistance of a group to attack from a disease to which a large portion of members are immune, thus lessening the likelihood of a patient with a disease coming into contact with a susceptible individual.
Some Requirements of Herd Immunity

- The disease agent is restricted to a single-host species within which transmission occurs
  - For example, smallpox in human; no reservoir
- There is relatively direct transmission from one member of the host species to another (direct contact only)
- Infections must induce solid immunity (also from immunization)
The success of herd immunity in controlling the disease depends on the proportion of subjects with immunity in a population.

- Immunity can be from immunization or infection.

So, when the population is immunized (e.g., vaccinated) at or above the herd immunity level (critical immunization threshold), the infectious disease will not spread and will be eliminated.

Herd immunity level differs for various diseases.

- For example, it is estimated that 94% of the population must be immune before measles can be controlled.
- For mumps, it is around 90%.
- The more infectious the disease is, the higher the herd immunity level.
Review

- What is the epidemiologic triad of disease transmission?
- How is preclinical disease different from subclinical disease?
- Distinguish direct from indirect contact
- Distinguish horizontal from vertical disease transmission
- Explain the iceberg concept of disease transmission
- Distinguish endemic, epidemic, and pandemic diseases from each other
- What is the concept of herd immunity in disease transmission?
Section D

Investigation of an Outbreak
Importance of Outbreak Investigation

- Stop the current outbreak from spreading
- Prevent future similar outbreaks
- Provide scientific explanation of the event
- Provide knowledge for the understanding of the disease process
- React to and calm public and political concerns
- Train epidemiologists
I Keep six honest serving-men:
(They taught me all I knew)
Their names are What and Where and When
And How and Why and Who.

— Rudyard Kipling (1865–1936)

- Define **what** will be studied
- Find out **where** the problem is
  - **Who** gets it
  - **When** it is occurring
- Try to explain **why** the problem has such a distribution
- Do specific studies to find out **how** the problem is occurring

Source: “The Elephant’s Child” in *Just So Stories* by Rudyard Kipling
Photo source: [http://www.online-literature.com/kipling](http://www.online-literature.com/kipling), Public Domain
The steps in the epidemiologic approach to study a problem of disease etiology are:

- Perform an initial observation to confirm the outbreak
- Define the disease
- Describe the disease by time, place, and person
- Create a hypothesis as to the possible etiologic factors
- Conduct analytic studies
- Summarize the findings
- Recommend and communicate the interventions or preventative programs
Steps

- Conduct field work
  - Perform initial observation
  - Establish the existence of an outbreak
  - Verify diagnosis
  - Collect data
- Define disease
  - Establish case definition
  - Identify all cases
  - Identify the population at risk
- Describe disease by time, place, and person
  - Plot epidemic curve
  - Plot spot map
  - Tabulate data of exposure and other characteristics
Steps

- Develop hypothesis
  - Hypothesis: exposure to X is associated with disease Y
- Conduct analytic studies
  - Use appropriate analytic studies
  - Calculate measures of risk
  - Refine hypothesis
  - Conduct additional studies if needed
- Summarize findings
- Recommend and communicate interventions or preventative programs
Exercise

- “Foodborne Outbreak Following a Charity Luncheon”
  - (Initial observation has been conducted)
    - Line listing of data in Excel
    - Summary data from Stata
  - Define disease and population at risk
  - Describe disease (by time, place, and person), plot epidemic curves
  - Develop hypothesis
  - Analyze data (test hypothesis) by calculating attack rates and comparing attack rates in various subgroups
  - Summarize findings
  - Recommend interventions and preventative programs
Submit A Case Study

- The instructors of this course are using WikiEducator to collect case studies to illustrate different types of epidemiologic investigations.

- The instructors are particularly interested in studies conducted in Western Asia and the Arabian Peninsula, and they are looking to OCW users to help them find the best examples.

- Click here to visit WikiEducator and submit a case study by editing the wiki page.
  - Registration is required to submit a case study.