Lesson 3. Epidemiology

Human Disease: Identification & Control Strategies

April 11, 2006
Chuck Treser
University of Washington
Dept. of Environmental and Occupational Health Sciences

Definition of Health

“Health is the state of complete physical, mental and social well being and not merely the absence of disease or infirmity.”
World Health Organization 1970

Determinants of Health

Environmental Exposures
Intrinsic Genetic Susceptibility
Age / Time
“Genetics loads the gun... but the environment pulls the trigger.”

Dr. Judith Senn
Professor of Nutrition & Internal Medicine
Univ. Of California, Davis
Lesson 3: Epidemiology

Disease & Injury

- Acute Effects
  - Infectious Diseases
  - Injuries
- Chronic Effects
  - Chronic Disease
  - Disability

Epidemiological Model

Environment

Agent

Host

Origins

John Snow
(1813-1858)

John Snow's original 1854 map on the spread of 578 deaths from Cholera, from An Introduction to Visualisation Software for Astronomy, Starli ng Guide 8.1, A C Davenhall, 9th February 1996 CCLRC / Rutherford Appleton Laboratory Particle Physics & Astronomy Research Council
Epidemiology

- Looks for patterns of disease occurrence
  - Geographically
  - Demographically

Definition

- Epidemiology is the study of
  - the distribution and
  - determinants of
  - health effects (disease & injuries)
  - in human populations

Distribution Factors

- Person
- Place
- Time
**Distribution Factors**

- Person
  - Age
  - Race
  - Sex
  - Occupation
  - Education
  - Hobbies

**Population Differences**

**Distribution Factors**

- Person
  - Age
  - Race
  - Sex

- Time
  - Episodic
  - Cyclical
  - Secular
Temporal Distribution

![Graph showing temporal distribution of a health indicator over time.](image)

Distribution Factors

- **Person**
  - Age
  - Race
  - Sex
- **Time**
  - Episodic
  - Cyclic
  - Secular

- **Place**
  - Geographic
    - Longitude & Latitude
    - Geologic
    - Climatic
  - Geo-political
    - Urban / Rural
    - Industry
    - Pollution

Spatial Distribution

![Spatial distribution map of health outcomes across the United States.](image)
Determinants

Agent Factors
- Biological
- Chemical
- Physical

Host Factors
- Genetic Predisposition
- Exposure

Environment Factors
- Natural Environment
- Built Environment
- Socio-cultural Environment
- Temporal Environment

Balance Beam
Affects equilibrium through:
1. Interaction with agents
2. Individual habits & group customs
3. Age, sex, & race characteristics
4. Defense mechanisms
5. Constitution and heredity
6. Psychologic characteristics

Human Host
Affects equilibrium through:
1. Their basic nature and character
2. Resistance and lability
3. Reservoir and sources
4. Conditions of dissemination

These determine the balance of health and preventive attack.
The Disease Process

- Natural History of Disease
- Problems with Detection & Reporting

THE NATURAL HISTORY OF ANY DISEASE IN MAN

THE NATURAL HISTORY OF ANY DISEASE IN MAN

THE NATURAL HISTORY OF ANY DISEASE IN MAN

Schematic Diagram of the Stages of Infection in a Host

ENV H 311: Intro. to Environmental Health

Lesson 3: Epidemiology

April 11, 2006
THE NATURAL HISTORY OF ANY DISEASE IN MAN

**Levels of Application of Preventive Measures**

<table>
<thead>
<tr>
<th>Period of Pathogenesis</th>
<th>Levels of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-pathogenesis period</td>
<td>Primary prevention</td>
</tr>
<tr>
<td>Period of Pathogenesis</td>
<td>Secondary prevention</td>
</tr>
<tr>
<td>Convalescence</td>
<td>Tertiary prevention</td>
</tr>
</tbody>
</table>

**Health Promotion**
- Use of specific immunizations
- Attention to personal hygiene
- Use of environmental sanitation
- Protection against occupational hazards
- Protection from accidents
- Use of specific nutrients
- Protection from carcinogens
- Avoidance of allergens

**Health Education**
- Good standard of nutrition, adjusted to the developmental phase of life
- Attention to personality development
- Provision of adequate housing, recreation, and agreeable working conditions
- Marriage Counseling and sex education
- Genetics

**Case-Finding Measures, Individual and Mass Screening Surveys**
- Periodic selective examinations

**Objectives**
- To cure and prevent disease processes
- To prevent the spread of communicable disease
- To prevent complications and sequelae
- To shorten the period of disability
- To provide facilities to limit disability and prevent death
- To provide hospital and community facilities for retraining and education for maximum use of remaining capacities
- To education of the public and industry to utilize the rehabilitated

**Interrelations of Agent, Host and Environment Factors**
- Production of stimulus
- Reaction of the host to the stimulus

**Specific Protection**
- Early diagnosis & prompt treatment
- Disability
- Limitations
- Rehabilitation

**Contingencies of Morbidity Reporting**

1. **Symptoms? Complaints?**
   - Stoical
   - Ashamed
   - Consultation sought?
   - Lack of funds
   - Indifference
   - “Don’t believe in doctors”

2. **Diagnosis suspected?**
   - MD’s acumen
   - Nature of complaint
   - Communication
   - Rarity of disease

3. **Diagnosis established?**
   - Too early
   - Too late
   - Follow up

4. **Report made?**
   - Ignorance
   - Indifference
   - Forgot
   - Rarity of disease

**Concepts & Methods**

- **Disease Prevalence** - the proportion of a population with the disease, at a chosen point in time. (snap shot)
  \[ R_p = \frac{C_p}{P} \times 100,000 \]
  (at that time)
  - E.g., 10% of the population of King County has respiratory asthma at present.
Incidence Rate - the proportion of a population with newly-diagnosed disease per given unit of time. (New cases over time)

\[ R_i = \frac{C_n}{P} \times 100,000 \]

(at the midpoint of the unit of time)

E.g., the total mortality rate (all deaths) is 0.89% per year among the population of Seattle
Incidence Rates

- That is, in a given year there were 4450 deaths reported among residents of Seattle, a population of 500,000.
- Incidence rate = \( \frac{4450}{500,000 \times 1 \text{ year}} \) = 0.0089/year
  - 890 per 100,000 persons per year
  - 2.4 per 100,000 persons per day

Incidence Rate

Analytic Techniques

- Stratification - dividing the sample according to some characteristic, e.g. age:
  - Age-specific deaths from heart disease among non-smoking British male doctors

<table>
<thead>
<tr>
<th>Age</th>
<th>Deaths/100 persons per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>35-44</td>
<td>1.064</td>
</tr>
<tr>
<td>45-54</td>
<td>11.23</td>
</tr>
<tr>
<td>55-64</td>
<td>49.04</td>
</tr>
<tr>
<td>65-74</td>
<td>96.71</td>
</tr>
<tr>
<td>75-84</td>
<td>212.04</td>
</tr>
<tr>
<td>Total</td>
<td>237.75</td>
</tr>
</tbody>
</table>
Analytic Techniques Continued

Association of disease with an environmental factor - comparing disease prevalence or incident rates between groups with and without exposure to the environmental factor.

Analytic Techniques Continued

Age-specific deaths from heart disease among smoking British male doctors.

Relative Risk

<table>
<thead>
<tr>
<th>Age</th>
<th>Deaths/100 persons per year</th>
<th>RR</th>
</tr>
</thead>
<tbody>
<tr>
<td>35-44</td>
<td>6.106</td>
<td>5.74</td>
</tr>
<tr>
<td>45-54</td>
<td>24.05</td>
<td>2.54</td>
</tr>
<tr>
<td>55-64</td>
<td>72.00</td>
<td>1.47</td>
</tr>
<tr>
<td>65-74</td>
<td>146.88</td>
<td>1.52</td>
</tr>
<tr>
<td>75-84</td>
<td>191.84</td>
<td>0.91</td>
</tr>
<tr>
<td>Total</td>
<td>44.29</td>
<td>1.72</td>
</tr>
</tbody>
</table>

Analytic Techniques Continued

What if smoking British male doctors drink more ethanol, compared to non-smoking British male doctors? Since from other studies we know that ethanol is associated with heart disease, can we argue that smoking is the cause of heart disease mortality in this group?
Analytic Techniques Continued

- **Confounding factor:** a factor that is associated both with exposure and outcome, and thus interferes in determining the relationship between exposure and outcome. Ethanol in this case is a confounder.

Limitations

- Most environmental diseases have multiple contributing causes - e.g. lung cancer, heart disease - so multiple exposures must be measured.
- Smoking, age, diet, and genetic make-up are powerful interfering factors.

Limitations Continued

- Measurement of exposure can be highly inaccurate, especially when past exposures are needed. The usual result is called misclassification, and any underlying association between exposure and illness is likely to be missed or underestimated.
Limitations Continued

- Latency of many (most?) environmental diseases is years to decades.
  - Thus exposures from the distant past are most relevant, and least likely to be known quantitatively.
- Longitudinal epidemiology, in which exposed persons are followed over years, is most precise.

Limitations Continued

- Examples of longitudinal studies:
  - Framingham, Mass. heart disease;
  - Fluoridation of water and dental caries;
  - Salk vaccine and polio incidence;
  - Smoking and several diseases.

Limitations Continued

- An observed association between environmental agent and disease should not be termed a cause-effect relationship until a biological mechanism has also been demonstrated.
- Otherwise, the observed epidemiologic outcome could easily be a coincidence.
**Prevention & Control**

1. Modify the environment
   - Engineering Controls
2. Modify Behavior
   - Legal/Regulatory Controls
   - Administrative Controls
   - Education

**Engineering Controls Tactics**

1. Substitution
2. Treatment
3. Isolation
4. Shielding

**Control Tactics Continued**

- Substitution
  - New compound or process
- Host
- Agent
**Regulatory Controls**
- Statutes
- Rules and Regulations
- Enforcement Programs
- Private Sector Control

**Administrative Controls**
- Planning
- Supervision
- Biological Monitoring
- Work Scheduling

**Education**
- Education
- Training
- Safety campaigns
- Administrative priority
Control Strategies Continued

In order of effectiveness
- Engineering Control Tactics
- Legal / Regulatory Controls
- Administrative Controls
- Education

How do we operationalize these?

Summary

Epidemiology is the study of the distribution and determinants of health effects in human populations

- Distribution
  - Person
  - Place
  - Time

- Determinants
  - Agent
  - Host
  - Environment

Next Lesson

Ecology