Lesson 4. Epidemiology

Tools for Evaluating Environmental Health II:

Epidemiology, Statistics & GIS

January 13, 2005

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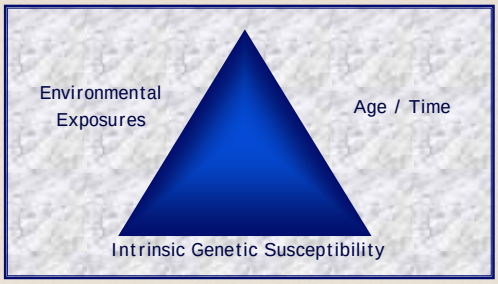
Determinants of Health



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"Genetics loads the gun . . . but the environment pulls the trigger."

Dr. Judith Senn
Professor of Nutrition & Internal Medicine
Univ. Of California, Davis

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EH Tools - Part II

- Statistics
- Epidemiology
- GIS

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Origins

John Snow
(1813-1858)

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

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Epidemiology

- Looks for patterns of disease occurrence
  - Geographically
  - Demographically

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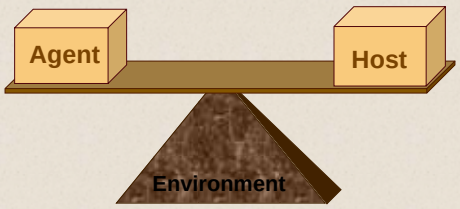
Epidemiological Model



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Definition

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

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Distribution Factors

- **Person**
- **Place**
- **Time**

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Distribution Factors

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

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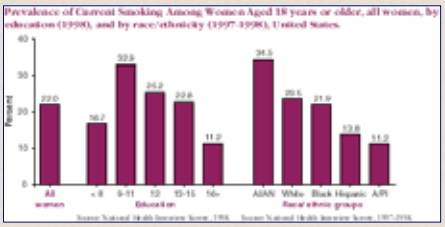
Population Differences



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Distribution Factors

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

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Temporal Distribution

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Distribution Factors

- Person
  - Age
  - Race
  - Sex
- Time
  - Episodic
  - Cyclical
  - Secular
- Place
  - Geographic
    - Longitude & Latitude
    - Geologic
    - Climatic
  - Geo-political
    - Urban / Rural
    - Industry
    - Pollution

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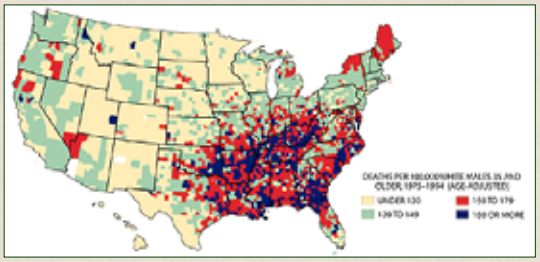
Spatial Distribution



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Determinants

- Determinants
  - Agent
  - Host
  - Environment

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Determinants

- Agent Factors
  - Biological
  - Chemical
  - Physical
- Host Factors
  - Genetic Predisposition
  - Exposure
- Environment Factors
  - Natural Environment
  - Built Environment
  - Socio-cultural Environment
  - Temporal Environment

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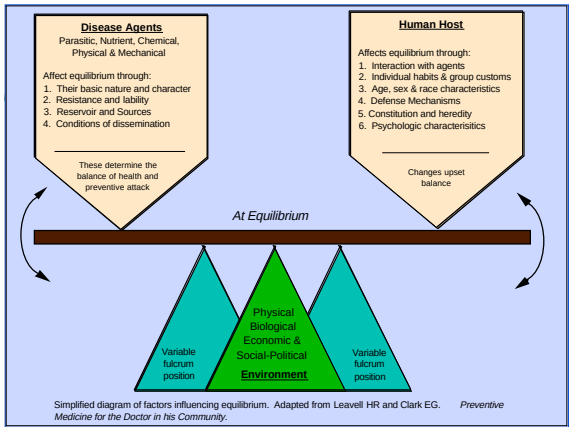

Simplified diagram of factors influencing equilibrium. Adapted from Leavell HR and Clark EG. *Preventive Medicine for the Doctor in his Community.*

The Disease Process

- Natural History of Disease
- Problems with Detection & Reporting

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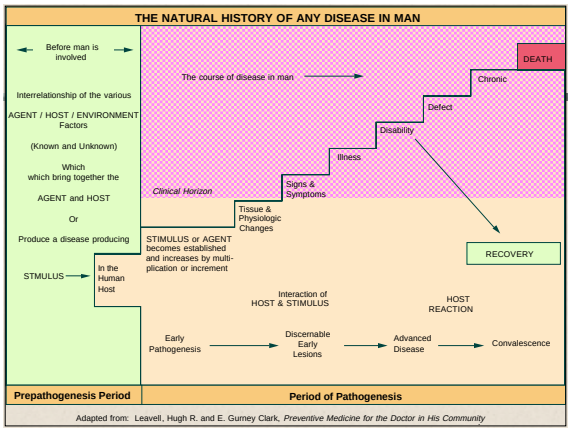

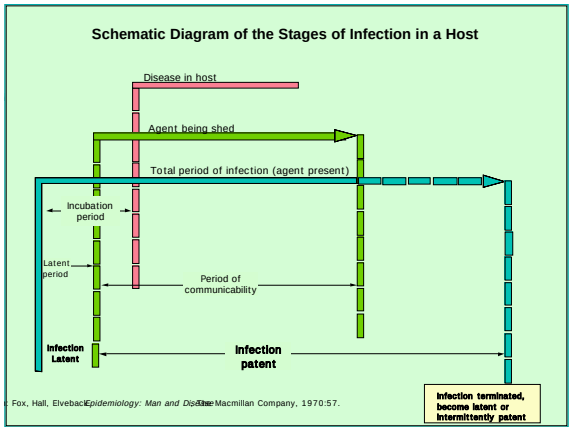

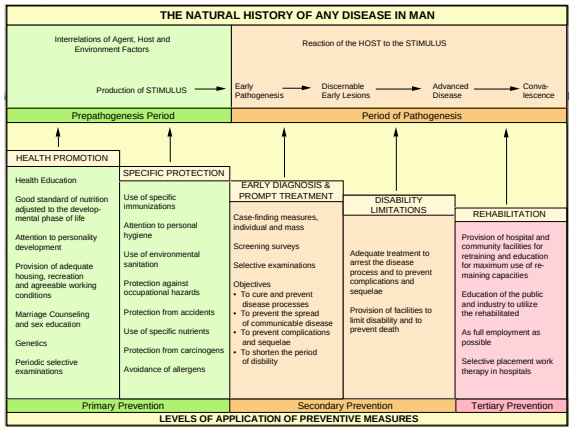

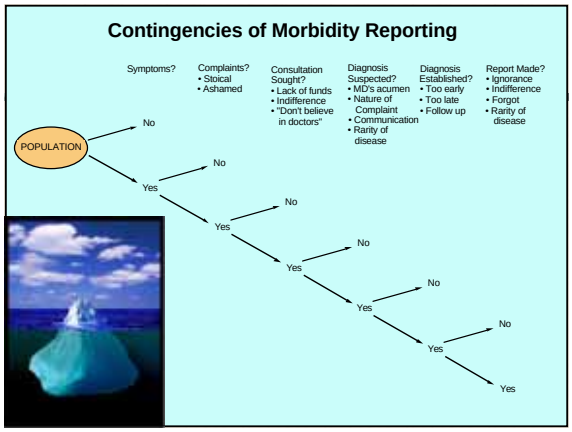

Concepts & Methods

- **Disease Prevalence – the proportion of a population with the disease, at a chosen point in time.**
  - $R_p = C_T / P$ (x 100,000)
    (at that time)
  - **E.g., 10% of the population of King County has respiratory asthma at present.**

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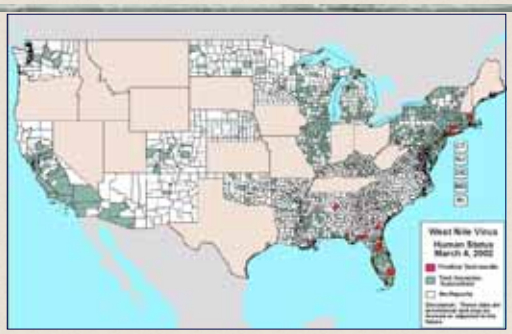
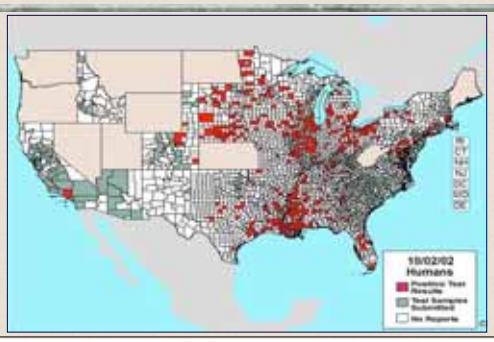
Prevalence Rate



Prevalence Rate



Concepts & Methods Continued

- **Disease Incidence Rate – the proportion of a population with newly-diagnosed disease (new cases) per given unit of time,**
  - **$R_i = C_n / P$ (x 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**

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Incidence Rates

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

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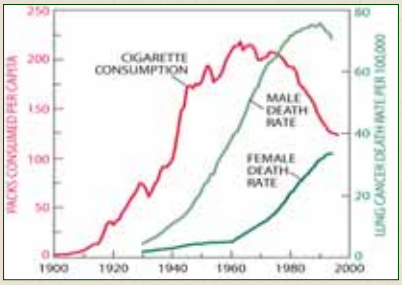
Incidence Rate



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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

Age	Deaths/10^4 persons per year
35-44	1.064
45-54	11.23
55-64	49.04
65-74	96.71
75-84	212.04
Total	25.75

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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**

Age	Deaths/10^4 persons per year	(RR)
35-44	6.106	5.74
45-54	24.05	2.14
55-64	72.00	1.47
65-74	146.88	1.52
75-84	191.84	0.91
Total	44.29	1.72

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**

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Analytic Techniques Continued

- **Comparison to "control" group: calculate expected prevalence from data on unexposed persons, convert to Standardized Mortality Rate (SMR)**
  - **Mortality due to lung cancer in male coke oven workers**

Work Area	Observed Deaths	Expected Deaths	SMR
Total sample	22	5.1	4.23
Side-oven	4	5.0	1.33*
Part-time topside	4	0.8	5.00
Full-time topside	14	1.3	10.77

* Broad generalization: when cases (deaths) in a group number less than 10, random variation due to factors not measured can produce SMR up to approx. 1.8.

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Analytic Techniques Continued

- **Expected deaths calculated from number of workers in the work area, and the rate of lung cancer mortality in non-exposed males with the same age distribution, socio-economic status, race, etc.**

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Limitations Continued

- 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

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Limitations

- 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

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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.

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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.

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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.

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Summary

- Epidemiology is the study of the distribution and determinants of health effects in human populations
  - Distribution
    - Person
    - Place
    - Time
  - Determinants
    - Agent
    - Host
    - Environment

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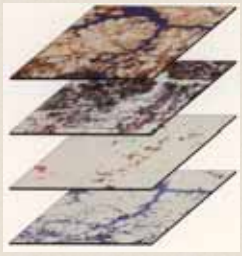
GIS



- GIS Permits:
  - Simultaneous examination of multiple data sets
  - Visual analysis
  - Effective risk communication
- Example

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Next Lesson

Environmental Health

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