Epidemiology, by Example

Joshua Naranjo

Department of Statistics,
Western Michigan University

Outline

Epidemiology

Etymology of "Epidemiology"

epi	*demos*	logos
$\Downarrow$	$\Downarrow$	$\Downarrow$
Upon	People	Study

literally meaning "the study of what is upon the people"

Epidemiology

Definition by the Centers for Disease Control (CDC):

Epidemiology

Definition by the Centers for Disease Control (CDC):

- "the basic science of public health"

Epidemiology

Definition by the Centers for Disease Control (CDC):

- "the basic science of public health"
- "the study of the distribution and determinants of health-related states in specified populations, and the application of this study to control health problems."

Epidemiological studies may be

- Observational

- Randomized controlled

Epidemiological studies may be

- Observational
  - descriptive
  - inferential
- Randomized controlled

Epidemiological studies may be

- Observational
  - descriptive
  - inferential
    - cross-sectional
    - cohort
    - case control
- Randomized controlled

Descriptive Studies

- Collect information to characterize and summarize the health event or problem

  Who? What? Where? When?

- Example: 1854 London cholera outbreak
- Example: Tractor related deaths in Georgia

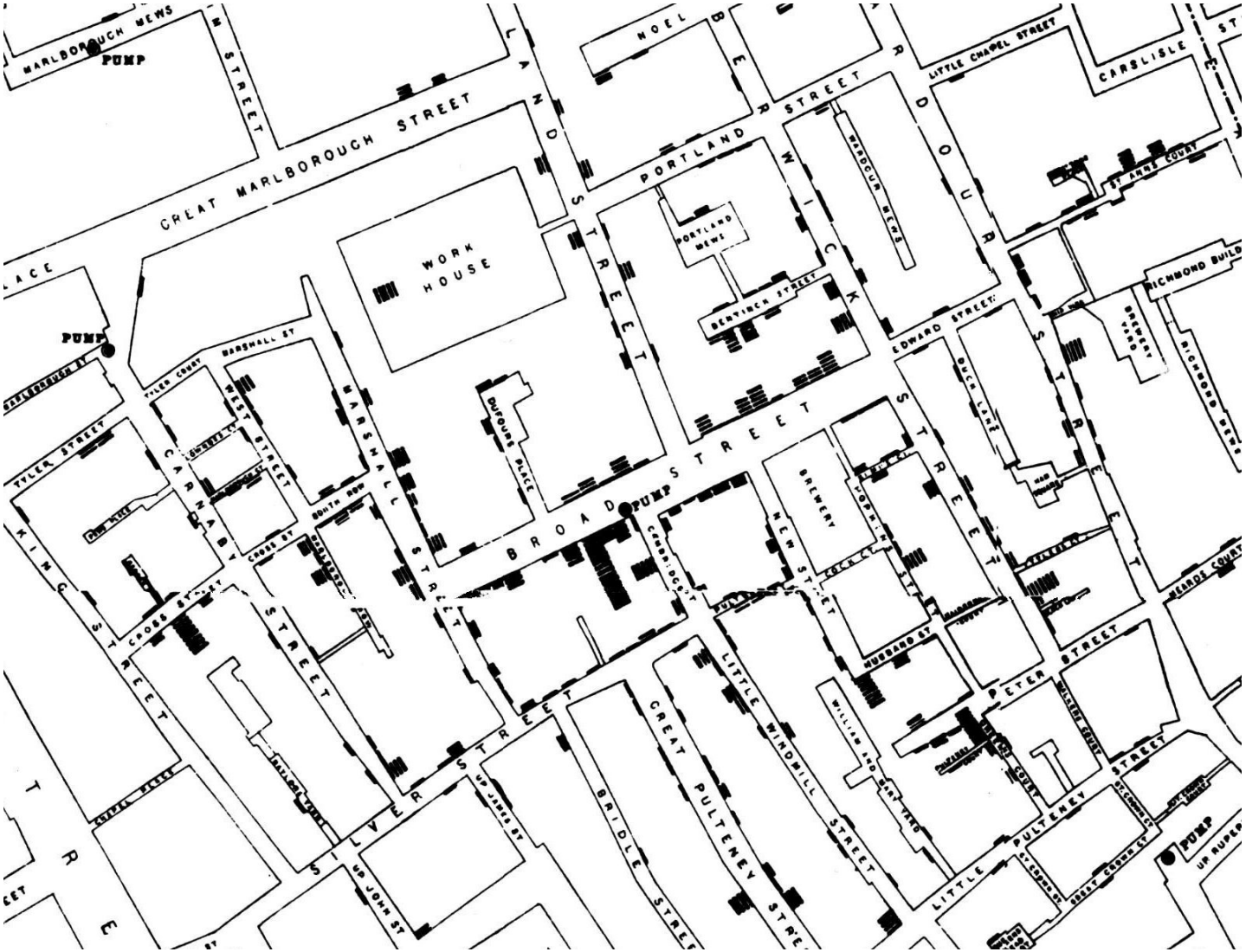
Example: 1854 London cholera outbreak

On 31 August 1854, an outbreak of cholera struck Soho, London. Over the next ten days, 500 people on or near Broad Street died.

John Snow studied the pattern of the disease and made a map showing the clusters of cholera cases.

In Snow's own words:

> *Nearly all the deaths had taken place within a short distance of the [Broad Street] pump. There were only ten deaths in houses situated decidedly nearer to another street-pump.*


GREAT MARLBOROUGH STREET
MARLBOROUGH MEWS
PUMP
WORK HOUSE
PORTLAND STREET
PORTLAND MEWS
BERWICK STREET
EDWARD STREET
LITTLE CHAPEL STREET
CARSLISLE
RICHMOND BUILD
BREWERY
BROAD STREET
PUMP
DUFOUR PLACE
MARSHALL STREET
WEST STREET
CARNABY STREET
TYLER STREET
KING STREET
NEW STREET
LITTLE WINDMILL STREET
GREAT PULTENEY STREET
BRIDLE STREET
PETER STREET
LITTLE PULTENEY STREET
PUMP

Example: 1854 London cholera outbreak

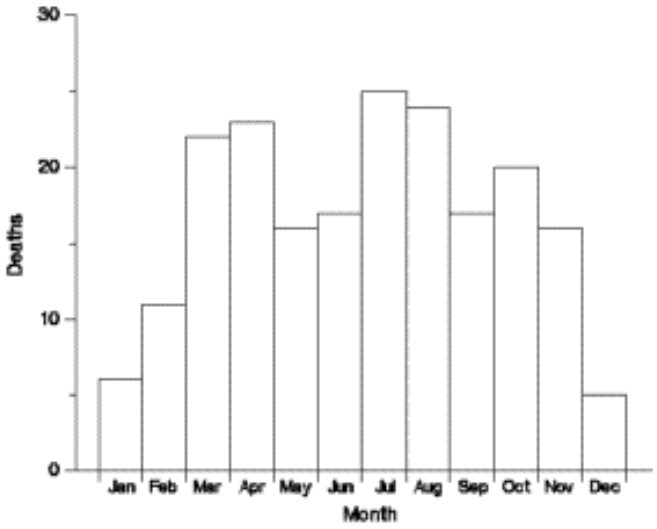
Snow and his map

-persuaded the local council to disable the well pump by removing its handle, effectively ending the outbreak.

-convinced the scientific community that cholera was a waterborne illness, and not transmitted by air.

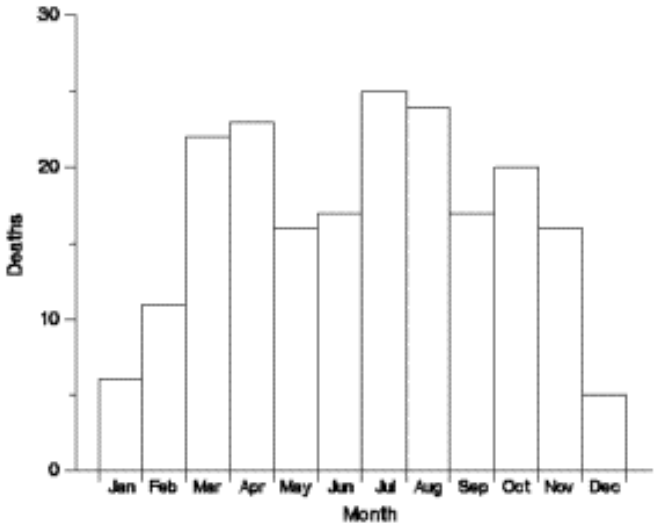
Example: Tractor related deaths in Georgia

Figure 1: Deaths associated with tractor injuries, by month of death



Example: Tractor related deaths in Georgia

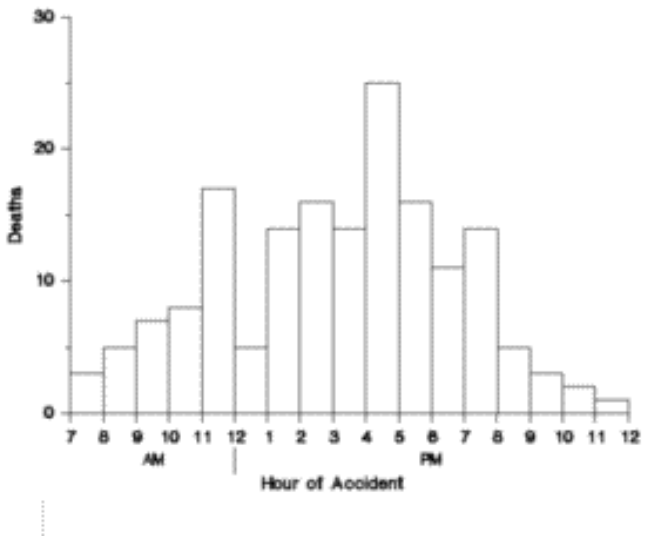
Figure 1: Deaths associated with tractor injuries, by month of death



Peaks during spring and fall. Due to planting and harvest?

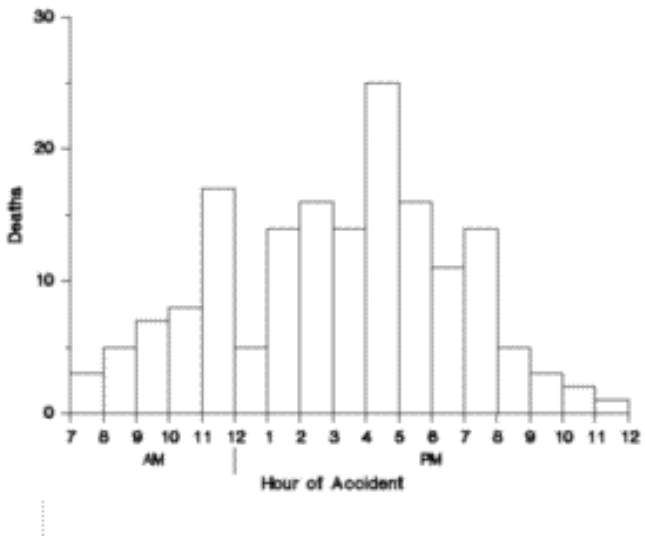
Example: Tractor related deaths in Georgia

Figure 2: Deaths associated with tractor injuries, by time of day



Example: Tractor related deaths in Georgia

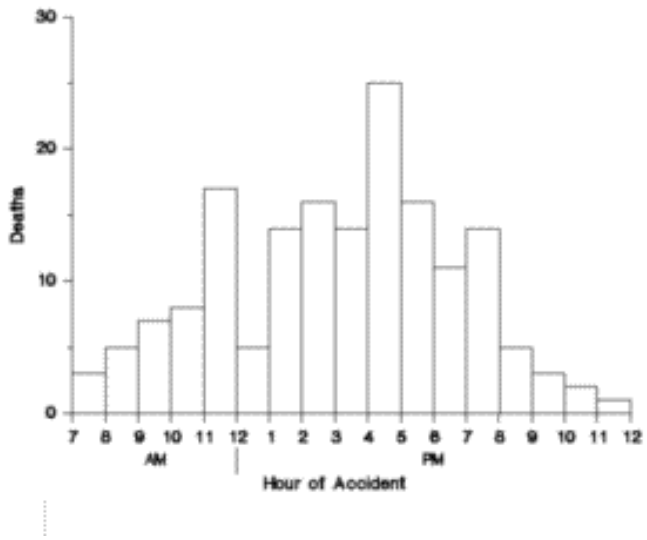
Figure 2: Deaths associated with tractor injuries, by time of day



Increasing before lunch. Fatigue?

Example: Tractor related deaths in Georgia

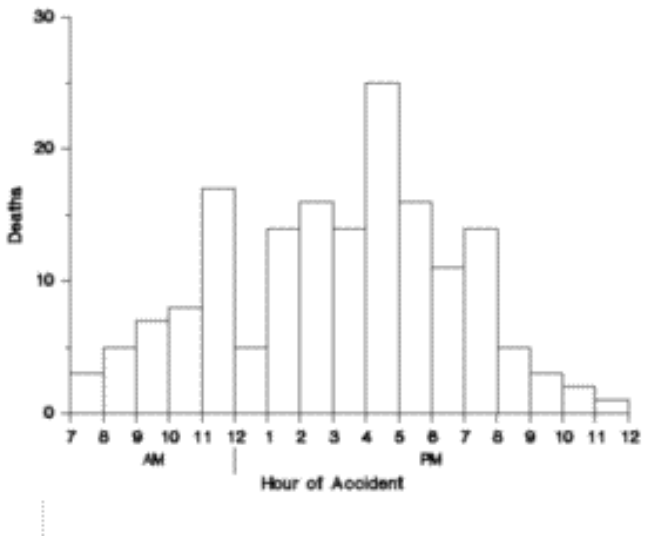
Figure 2: Deaths associated with tractor injuries, by time of day



Increasing before lunch. Fatigue?
Peak at 4-5. Fatigue? Hunger? Darkness?

Example: Tractor related deaths in Georgia

Figure 2: Deaths associated with tractor injuries, by time of day



Increasing before lunch. Fatigue?
Peak at 4-5. Fatigue? Hunger? Darkness?
Children home from school.

Example: Tractor related deaths in Georgia

Figure 3: Deaths associated with tractor injuries, by age

Peak in older age group. Tractor users older? Less likely to survive an accident?
Small peak for school-age group.

Inferential Studies

Inferential epidemiology test hypotheses using

- Observational study
  - cross-sectional
    -data represent a point in time
  - cohort
    -subjects selected according to exposure
  - case-control
    -subjects selected according to outcome: cases and controls (necessarily restrospective)
- Randomized experiment

Cross-sectional studies

- Cross-sectional studies are primarily surveys
- intended to look at prevalence rates and risk factors
- Example: National Health and Nutrition Examination Survey (NHANES)
- Example: Wisconsin Epidemiologic Study of Diabetic Retinopathy
- Example: Baltimore Eye Survey

Example: NHANES

- to assess the health and nutritional status of adults and children in the US
- combines interviews and physical examinations (including lab tests)
- responsible for producing vital and health statistics for the US
- sample of about 5,000 persons from 15 counties each year
- determine the prevalence of major diseases and risk factors
- the basis for national standards of height, weight, blood pressure, etc.

Example: NHANES

Major Findings:

- pediatric growth charts
- Federal nutrition recommendations, school lunch programs
- iron fortification of grain and cereal products (1973)
- iodine fortification of salt has virtually eliminated goiter and stillbirths
- Recommended Daily Allowance (RDA) of vitamins and minerals
- vaccine policy (e.g. 1-in-4 females aged 14-59 infected with HPV, 2003-04)

Example: NHANES

Major Findings:

- prevalence estimates of
  - malnutrition, obesity
  - cholesterol, hypertension
  - diabetes, arthritis, osteoporosis
  - hepatitis, HPV, other infectious diseases
  - dental health, visual health
  - exposures to lead, mercury, asbestos

Smaller, more targeted cross-sectional studies:

- Wisconsin Epidemiologic Study of Diabetic Retinopathy
  - studied prevalence of retinopathy among diabetics
  - identified risk factors such as hyperglycemia or hypertension
- Baltimore Eye Survey
  - confirmed that rate of primary open-angle glaucoma in black Americans was found to be four to five times higher than whites
- European Youth Heart Study
  - physical activity levels should be higher than current guidelines to prevent CVD risk factors.

Cohort studies

- A *cohort* is a group of people who share something in common
  - students enrolled in Stat 2160 in Spring 2012
  - premenopausal women in Kalamazoo 20 years and older
  - baby boomers
  - adult men and women residents of Framingham, Massachusetts
- the cohort may be chosen according to exposure patterns, but must be identified *before* disease status has been determined (this is crucial)
- determination of disease status may be prospective or retrospective
- allows calculation of relative risk

Cohort studies

- Example: A Cohort Study of Childhood Asthma Followed to Adulthood
  - children born from April 1972 through March 1973 in Dunedin, New Zealand
  - assess risk factors for persistence and relapse
- Example: A Retrospective Cohort Study of Measles, Mumps, and Rubella Vaccination and Autism
  - 537,303 children born in Denmark from January 1991 through December 1998
  - risk of autism was similar in MMR vaccinated and unvaccinated children

- Example: Framingham Heart Study
  - began in 1948 with 5,209 adults from Framingham, Mass.
  - now on its third generation of participants (1971 and 2002)
  - assess risk factors for cardiovascular disease
- Example: Nurses' Health Study
  - began in 1976, has followed 121,700 female registered nurses
  - assess risk factors for cancer and cardiovascular disease

Example: Framingham Heart Study

Major Findings:

1960s Smoking, high cholesterol and BP increase risk of coronary heart disease (CHD).
Exercise decreases risk, obesity increases it.

1970s Elevated BP increases risk of stroke.

1980s High levels of HDL cholesterol *reduces* risk of heart disease.

1990s Framingham Risk Score is published, and correctly predicts 10-year risk of future CHD events.

2000s Lifetime risk of developing elevated BP is 90%.
Lifetime risk for obesity is approximately 50%.
Social contacts are relevant to whether a person is obese.
Four risk factors for a precursor of heart failure are discovered.
Some genes increase risk of atrial fibrillation.
Parent dementia increases risk of poor memory.

Example: Nurses' Health Study

Major Findings:

	Breast Cancer	CHD/Stroke
Smoking	No association	Strong positive association
Oral Contraceptives	Current use increases risk	Current use increases risk
Alcohol	Increases risk	Reduces CHD risk
Diet	Red meat increases risk	Fish reduces risk of stroke. Nut/wholegrain reduce CHD risk Trans fats increase risk

Case-control studies

- Case-control studies select subjects according to disease outcome (cases and controls)
- then the investigator looks back to determine exposure or risk factors
- necessarily retrospective (there is no waiting for disease outcome)
- relative risk is not valid

Example: Effectiveness of Bicycle Safety Helmets

Thompson et al. (1989):

- Cases: 235 persons with bicycling head injuries, who sought emergency care at one of five hospitals
- Controls:

Example: Effectiveness of Bicycle Safety Helmets

Thompson et al. (1989):

- Cases: 235 persons with bicycling head injuries, who sought emergency care at one of five hospitals
- Controls: 433 persons who received emergency care at the same hospitals for bicycling injuries not involving the head

Example: Effectiveness of Bicycle Safety Helmets

Thompson et al. (1989):

- Cases: 235 persons with bicycling head injuries, who sought emergency care at one of five hospitals
- Controls: 433 persons who received emergency care at the same hospitals for bicycling injuries not involving the head

Results:

Head Injury: 7 percent were wearing helmets

No head injury: 24 percent were wearing helmets

Example: Effectiveness of Bicycle Safety Helmets

How effective are helmets in preventing head injury?

$$\text{RR} = \frac{.07}{.24} = .29 = \frac{P[\text{Helmet}|\text{Head Inj}]}{P[\text{Helmet}|\text{No Head Inj}]}$$

"Head injury reduces your risk of wearing a helmet by 71%"

Example: Effectiveness of Bicycle Safety Helmets

How effective are helmets in preventing head injury?

$$\text{RR} = \frac{.07}{.24} = .29 = \frac{P[\text{Helmet}|\text{Head Inj}]}{P[\text{Helmet}|\text{No Head Inj}]}$$

"Head injury reduces your risk of wearing a helmet by 71%"

We want:

$$\text{RR}^* = \frac{P[\text{Head Inj}|\text{Helmet}]}{P[\text{Head Inj}|\text{No Helmet}]}$$

Example: Effectiveness of Bicycle Safety Helmets

How effective are helmets in preventing head injury?

$$\text{RR} = \frac{.07}{.24} = .29 = \frac{P[\text{Helmet}|\text{Head Inj}]}{P[\text{Helmet}|\text{No Head Inj}]}$$

"Head injury reduces your risk of wearing a helmet by 71%"

We want:

$$\text{RR}^* = \frac{P[\text{Head Inj}|\text{Helmet}]}{P[\text{Head Inj}|\text{No Helmet}]}$$

But $\text{RR}^* \neq \text{RR}$.

Recall:

$$\text{Odds}(E|D) = \frac{P(E|D)}{1 - P(E|D)}$$

It is easy to show

$$\frac{\text{Odds}(E|D)}{\text{Odds}(E|\text{not D})} = \frac{P(E \cap D) \cdot P(E^c \cap D^c)}{P(E^c \cap D) \cdot P(E \cap D^c)} = \frac{\text{Odds}(D|E)}{\text{Odds}(D|\text{not E})}$$

Example: Effectiveness of Bicycle Safety Helmets

Implication?

$$\frac{\text{Odds[Head Inj|Helmet]}}{\text{Odds[Head Inj|No Helmet]}} = \frac{\text{Odds[Helmet|Head Inj]}}{\text{Odds[Helmet|No Head Inj]}}$$

$$= \frac{.07/(1-.07)}{.24/(1-.24)} = .25$$

"Wearing a helmet reduces your odds of head injury by 75%"