An Introduction to Epidemiology

"Disease does not occur randomly, but rather in patterns that reflect the operation of underlying factors." ***(Friis and Sellers, pg 128)***

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Today's Objectives

Gain an understanding of basic epidemiologic concepts including:

- The historical foundations of epidemiology
- The changes in human morbidity and mortality over time and how that impacted on the discipline
- Methods of epidemiological research including study design
- Use of 2 X 2 tables to calculate risk and in measuring screening test accuracy
- Understand the terms Reliability and Validity
- Establish a causal relationship and argue your position
- Establish a vision for your future career in the discipline and the demands society will be placing on the profession.

The Lecture Outline

1. Epidemiology Defined
2. Historical Considerations
3. Descriptive and Analytic Epidemiology
4. Measurement of Morbidity and Mortality
5. Screening and Prevention
6. Study Designs and Measures of Association
7. Causal Relationships and Measuring Evidence
8. What Does the Future Hold?

1. Epidemiology Defined

- The classical definition of Greek origin
  - Epi – upon
  - Domos – the people
  - Ology – the study of
  - "the study of epidemics"
- Seven Uses of Epidemiology
  - To study the history of the health of the population
  - To diagnose the health of the community
  - To study the working of health services
  - To estimate from the group experience what are individual risks
  - To identify syndromes
  - To complete the clinical picture of chronic disease
  - To search for causes

Epidemiology and Medicine – What are the differences?

- Epidemiology – looks at the population
- Medicine – looks at the individual

However, the disciplines are becoming more linked:

- Epidemiology is becoming more "medicalized"
- While medicine is increasingly looking to epidemiologic principles of study design and population based focus

2. Historical Considerations

For the period prior to the industrial revolution (400BC – 1600):

- Hippocrates began the conversation to dispel demons as the cause of disease and injury.

During the age of enlightenment and the industrial revolution several individuals began to define the discipline:

- John Graunt – began to count (births, deaths, men, women), designed the first life table (pct of residents surviving at a certain age.)
- John Snow – the father of epidemiology – proposed the Waterborne Theory to postulate why people were getting sick from a specific well in central London.

Snow's methods represent the modern foundation of epidemiological study

- Compared cholera rates by neighborhood – ecological studies
- Compared disease rates in exposed and unexposed persons (people who drew water from the Broad Street pump) – cohort studies
- Compared water source in infected and uninfected persons – case/control studies

2. The transition of Epidemiology and the 20th Century

Many of the health departments founded in the United States in the 1700s were formed to respond to cholera outbreaks.

The 20th century brought a refocus of causes of mortality from acute and contagious to chronic and life style related morbidity.

- In 1900 people died from Tuberculosis, influenza, diarrhea and cholera.
- In 1990 people succumb to heart failure, COPD, malignancies and stroke.

What caused the transition – Public Health initiatives

- Antibiotics – Probiotics
- Birth Control
- Prenatal and Neonatal care
- Improved nutrition – especially newborn nutrition
- Sanitation
- An improved standard of living

(adapted from Friis and Sellers, pg 47-48.)

3. Descriptive and Analytical Concepts

Descriptive: Who, what, when and where of the health event

- Who – age, gender, sociodemographics, occupation
- What – disease, injury, death
- When – time, seasonality, secular trends
- Where – place, neighborhood, city, county, census tract
- Distribution – frequency of the event and pattern of the frequency

Analytical – determinants of disease:

- Understand factors that influence the occurrence of health related event
- Understand the "how" and "why" aspects of the event

3. Descriptive and Analytical Concepts

What guides the epidemiologist to formulate a hypothesis, e.g. the salmonella contamination originated from fecal contamination?

Mill's Canons of inductive reasoning:

1. The method of difference: all the factors in two or more places are the same except for a single factor.

2. The method of agreement: a single factor is common to a variety of different settings.

3. The method of concomitant variation: the frequency of a disease varies according to the potency of a factor and the linked association suggest that the factor is the causative agent for the disease.

4. The method of residues: subtracting causal factors to determine which individual factor or set makes the greatest impact on a dependent variable.

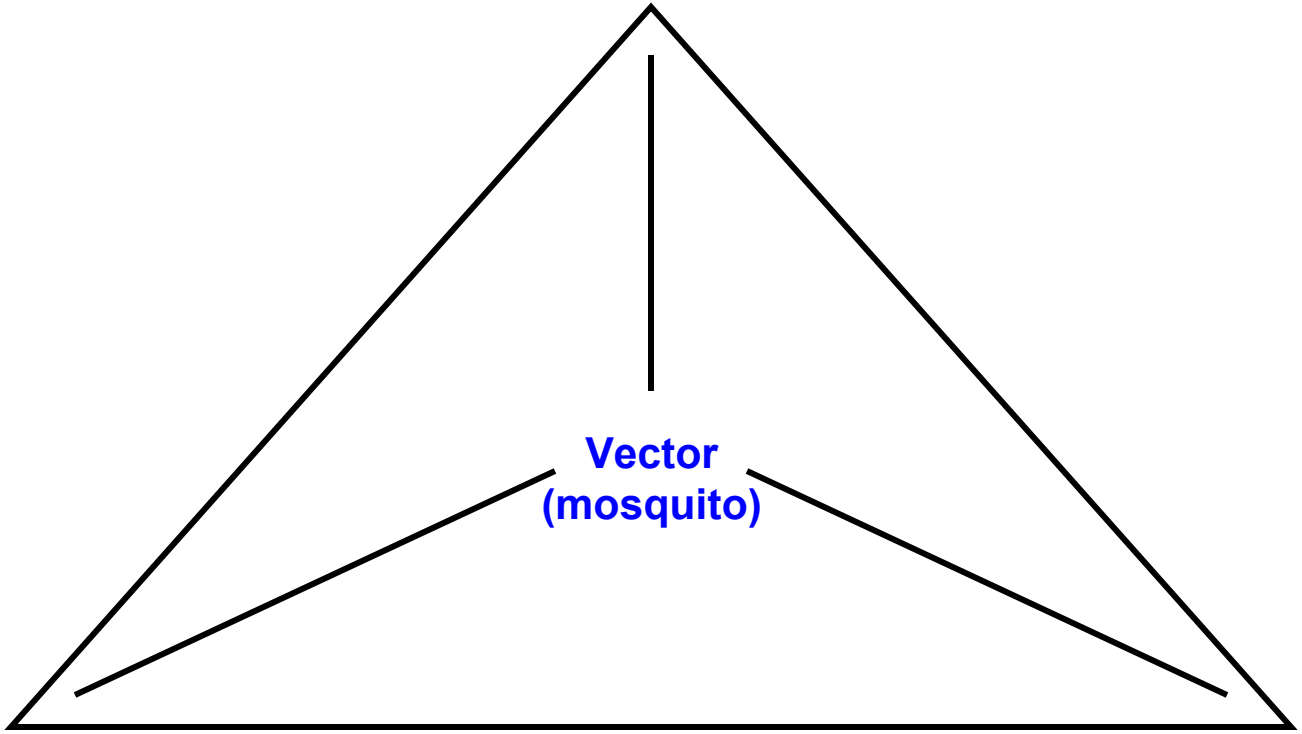
Adapted from Friis and Sellers, pg 130 – 131.

4. Measures of Morbidity and Mortality

Objectives

- Examine host – disease relationships and disease transmission modes
- Systematically investigate an epidemic outbreak
- Define and differentiate incidence and prevalence
- Measure key indices of morbidity and mortality

Epidemiologic Triad of Disease – malaria



Public Health Surveillance

Applications

- Estimate the magnitude of the problem
- Determine the geographic distribution of illness
- Portray the nature history of disease
- Detect epidemics / define a problem
- Generate hypothesis – stimulate research
- Evaluate control measures
- Monitor changes in infectious agents
- Detect changes in health practice
- Facilitate planning

An outbreak investigation – the recent salmonella outbreaks

1. Define the Epidemic/Outbreak
   - Numerator (cases)
     - What is the disease
     - Serological characteristics
     - Known causes
   - Denominator (population at risk)
   - Calculate incubation period
   - Calculate attack rates
2. Examine distribution
   - Time
   - place
3. Identify relevant variables or their combination
4. Develop hypothesis
5. Test hypothesis
6. Recommend control measures

Definition of key terms

Attack Rate =

$$\frac{\text{exposed persons who ate spinach and got sick}}{\text{exposed persons who ate spinach and did not get sick}}$$

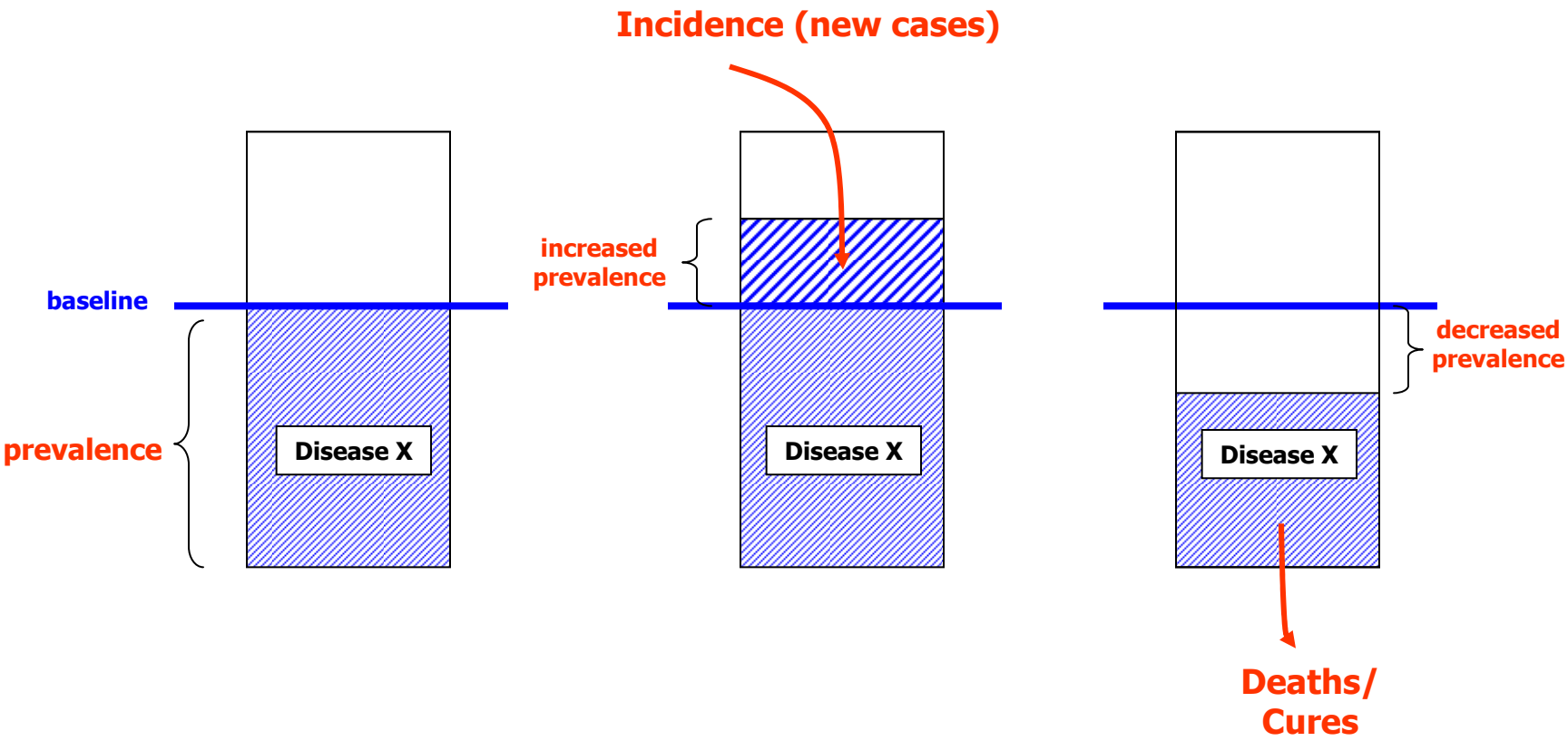
Incidence Rate =

$$\frac{\text{\# of } \textbf{\textit{new}} \text{ cases of disease occurring during a specific period}}{\text{\# of persons at risk of developing the disease during that same period}}$$

Prevalence Rate =

$$\frac{\text{\# of cases of disease occurring during a specific period}}{\text{\# of persons in the population at that same period}}$$

A Diagram to Illustrate Incidence and Prevalence



Prevalence = Incidence X Duration of Disease

Mortality

Selected Mortality Indicators you may recognize:

- Crude death rate
- Cause specific mortality rate
- Infant mortality – typically a benchmark of the health of a country
- Neonatal mortality – hospitals use this to compare their OB service
- Case fatality rate

Crude death Rate (annual mortality rate, all causes) =

$$\frac{\text{number of deaths X 1000}}{\text{number of persons at mid year}}$$

Where mortality meets morbidity

Case Fatality Rate = $\frac{\text{\# of deaths from a specific disease (mortality)}}{\text{\# of persons with specific disease (morbidity)}}$

An example: 600 people have skin cancer

9 of them die from the cancer

Case fatality rate = (9/600) X 100% = 1.5%

5. Screening and Prevention

Objectives

- Define screening and levels of prevention
- Measure reliability
- Measure validity

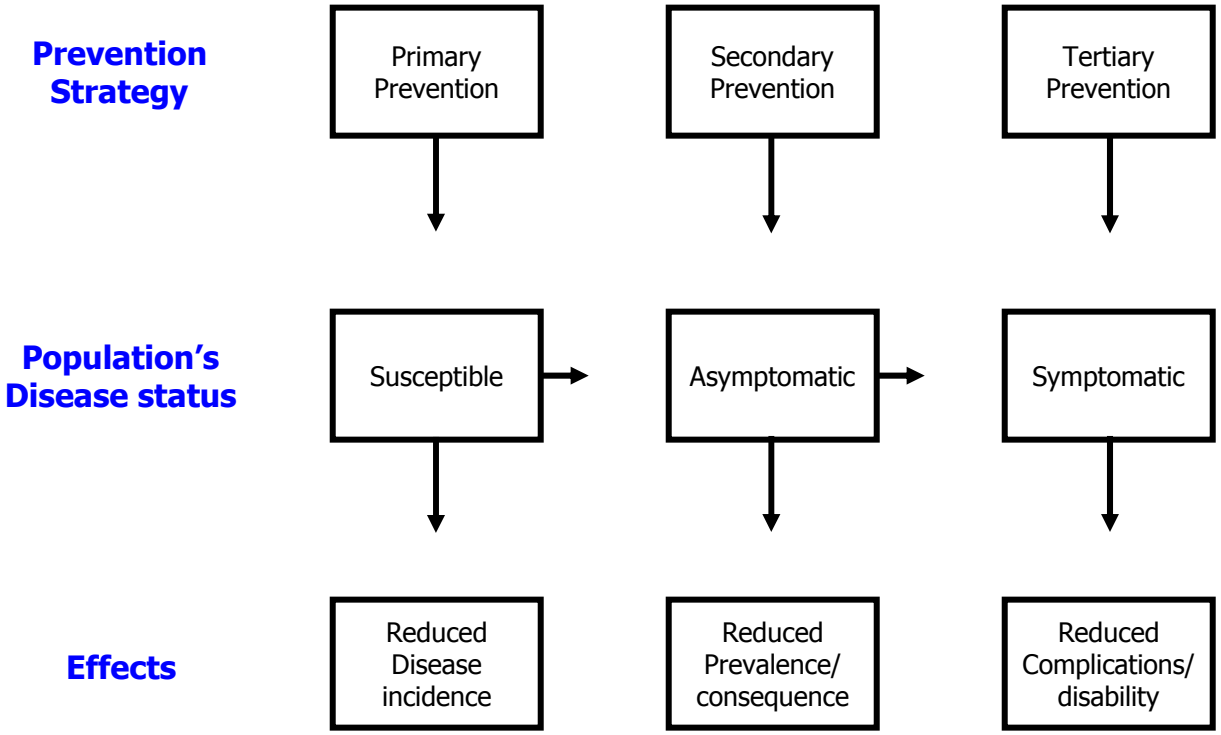
5. Screening and Prevention

Screening: Process of classifying people as to whether they are likely to have a disease. "Primary prevention of disease is the best approach.

Prevention: Several levels of prevention to consider

- Primary: Seeks to prevent new cases of a disease from developing in the population (examples include no smoking campaigns, sun blocks, prophylactics for STDs.)
- Secondary: Seeks to reduce the number of existing cases of a disease (examples include cancer screenings – mammography, colonoscopy)
- Tertiary: Seeks to limit the disability resulting from disease and improve functioning (examples include cardiac rehab, PT, OT)

Levels of Prevention



Adapted from Turnock, Public Health 3rd Ed. Pg94.

5. Screening and Prevention

Screening tests – when are they appropriate? (**BEFORE** symptoms develop)

- The disease is an important cause of morbidity and mortality
- Treatment is available
- The impact of the disease can be minimized before symptoms develop
- Prevalence of preclinical disease is high

What is a good screening test?

- Easy to administer (CRP, ABI, BNP)
- Results can be readily available (automated lab reporting)
- Test is inexpensive (ABI < $40)
- Test imposes minimal discomfort to the screenee (finger stick vs. phlebotomy)

5. Screening and Prevention

Screening tests must be:

- Reliable – the test consistently gives the same results
- Valid – ability of the test to distinguish between who has and who does not have the disease. Several terms specific to validity need to be addressed:
  - Sensitivity – correctly ID those with the disease
  - Specificity – correctly ID those who do not have the disease
  - Positive predictive value – proportion of individuals screened who actually have the condition.
  - Negative predictive value - that portion of individuals screened without the disease.
- How are screening tests "tested" for validity – the 2 X 2 table (always part of the epidemiologist's tool box.)

5. Screening and Prevention – the 2 X 2 table

Condition being screened

Screening	Present	Absent	Total	
Positive	a. True positive	b. False positive	a + b	$\frac{a}{a+b}$ (+) predictive value
Negative	c. False Negative	d. True Negative	c + d	$\frac{d}{c+d}$ (-) predictive value
Total	a + c	b + d	Σ a+b +c+d	

$\frac{a}{a+c}$ sensitivity

$\frac{d}{b+d}$ specificity

6. Study Design and Measures of Association

Objectives

- Examine different epidemiologic study designs
- Evaluate measures of association using different designs

6. Study Design and Measures of Association

How do epidemiologists conduct studies – two approaches: observational and experimental.

Observational – the researcher observes the association between exposure and outcome and does not control the conditions under which the study is conducted, i.e.: smoking and lung cancer

Experimental – the researcher controls the research conditions including:

- Who gets exposed
- Randomization of subjects (exposed, not exposed)
- Evaluation and follow-up
- Example: statins and lipid disease

6. Study Design and Measures of Association

In section 3 we touched on descriptive (who, what, when) vs. analytic epidemiology (determinants).

- Descriptive study designs include the following observational studies – generate a hypothesis:
  - Case reports (observations of patients with stroke in the ED)
  - Case series
  - Cross – sectional studies (considering a slice of cases at a point in time)
  - Ecologic studies
  - Case – control studies
  - Retrospective studies (backward looking)

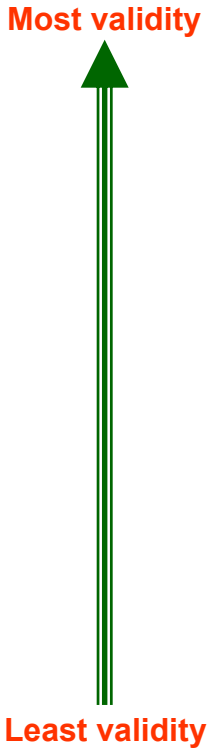
Two types of analytical studies – test a hypothesis

- Observational
  - Case control
  - Cohort (Framingham Heart)
- Experimental
  - Randomized controlled trial – focusing on the individual
  - Community interventions – focusing on the group

A randomized – blinded trial design

6. Study Design and Measures of Association

What type of trial is the most valid to make conclusions about disease etiology?



Experimental studies
- > controlled experimental/randomized trials
- > community trials

Prospective Cohort study
Retrospective Cohort study
Case – control study
Time series study
Cross sectional study
Ecologic study
Case (observational) study
Anecdotal (I read it in the news paper)

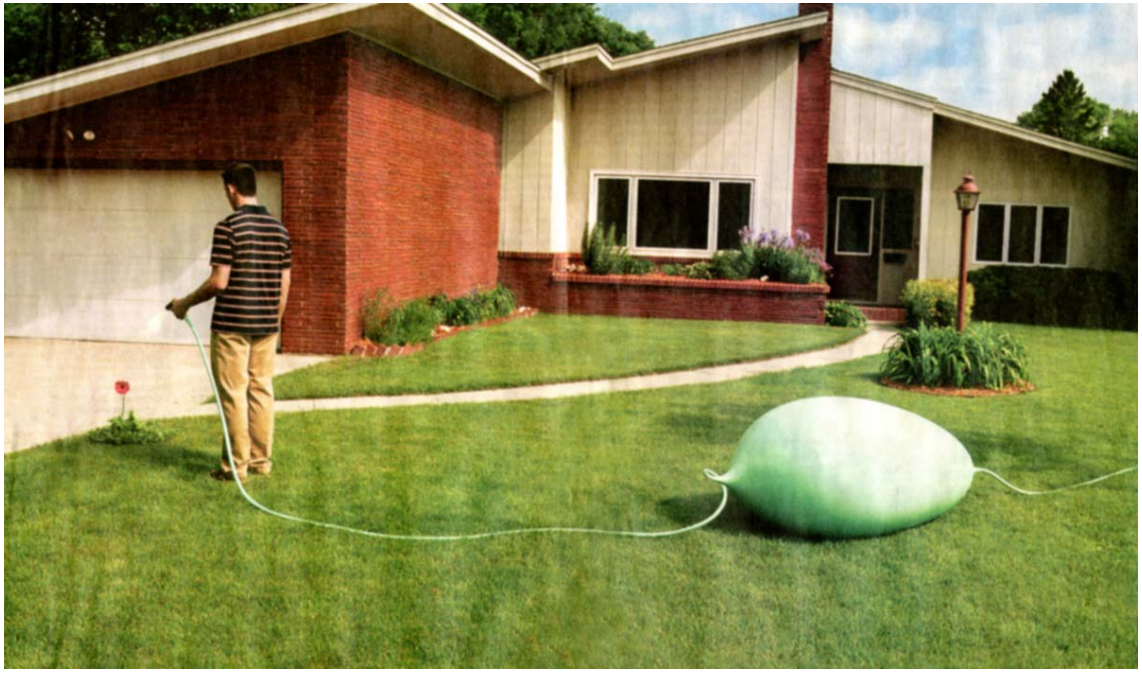
6. Study Design and Measures of Association

What is the goal of the various types of trials discussed? To measure the risk of an event or exposure on a defined group of individuals, i.e. what is the risk of hemorrhagic stroke from exposure to various diet supplements?

What does the epidemiologist mean by **Risk** ?

- Risk means the probability of an event occurring
- Absolute risk = incidence of a disease
- Excess risk = increase in incidence due to exposure (brain damage due to lead paint)
  - Attributable risk: the amount of incidence due to exposure (to lead paint)
- How do you measure risk? - depends on the study type
  - If a cohort study: risk ratio (relative risk) incidence of exposed / incidence of non exposed
    - Using the 2 X 2 table, a/(a+b) / c/(c+d)
  - If a case / control study: odds ratio
    - Using the 2 X 2 table: (a/c) / (b/d)
  - If RR is: < 1: protection > risk, > 1: risk in exposed > but is this causal?, =1: no association
  - If OR is: < 1: protective effect, > 1: exposure to cases > than controls, = 1: no association

The Importance of Measuring Risk

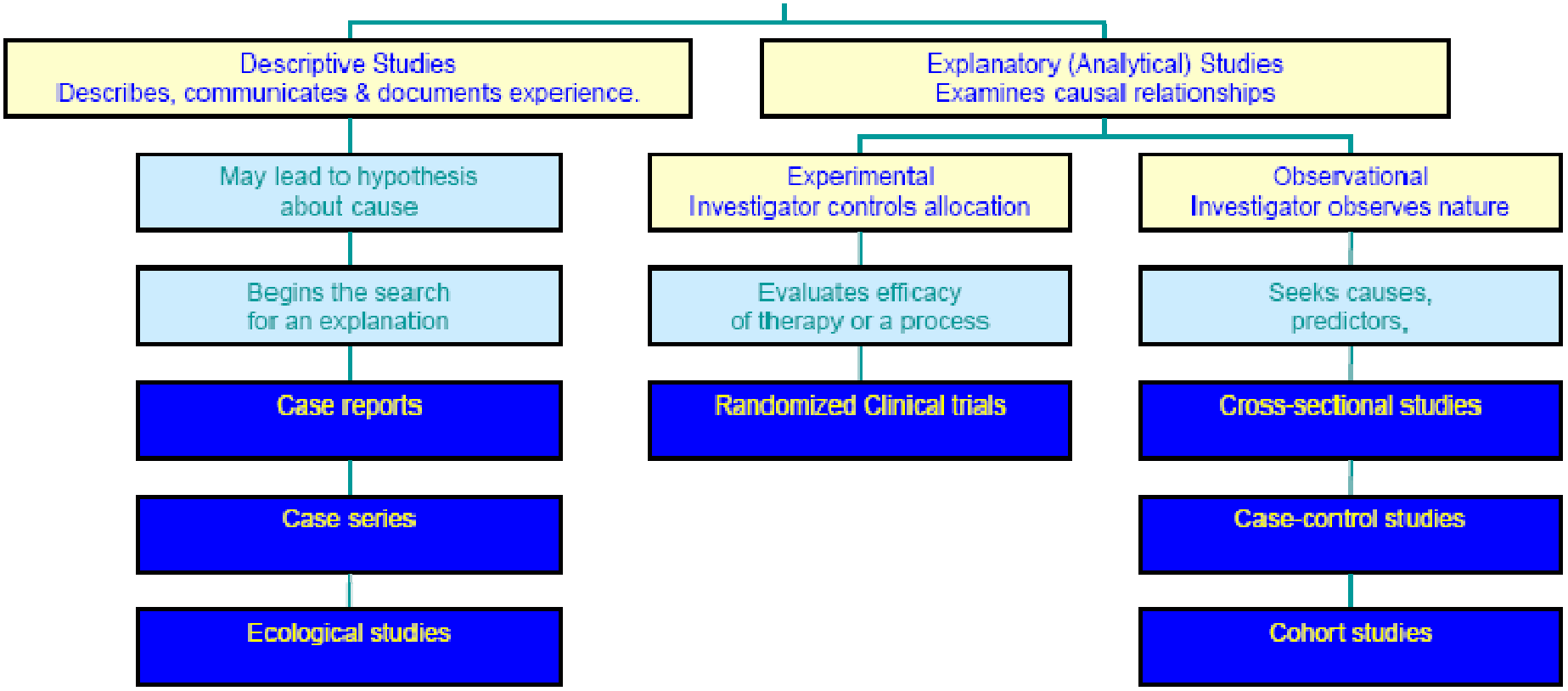


6. Study Design and Measures of Association

What flaws in study design or interpretation could affect results and our interpretation?

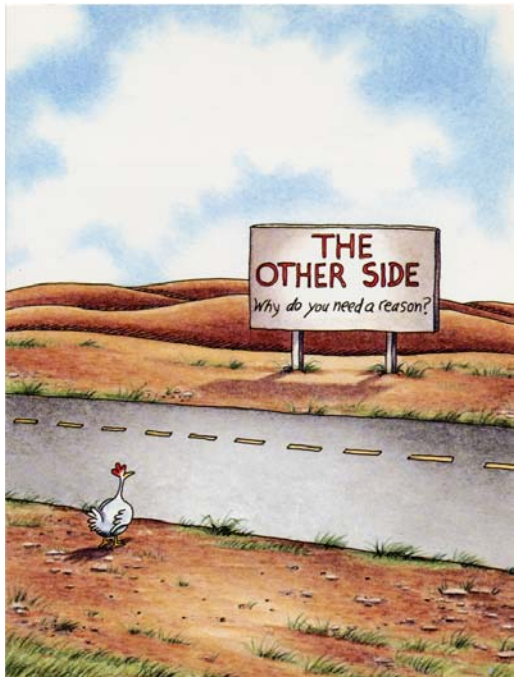
- Type I and II errors – relates to the acceptance or failure to reject the null (due to chance) hypothesis developed during trial design.
- Random error – deviation of results and inferences from the truth, occurring only as a result from the operation of chance.
- Confounding – a unique feature of the subjects has not been recognized and measured in the results. (NSAIDs are known to affect CRP levels which could make results look better then actual.)
- Bias – systematic non – random deviation of results, several examples from many:
  - Recall bias (maybe why results from the Yale Hemorrhagic Stroke Study focused on diet supplements rather than incidental use of cold remedies.)
  - Interview bias (poor interview technique, leading questions, poor interview design)
  - Selection bias (not random selection of subjects)
  - Family bias (family members can better tutor each member on recall)
  - Halo effect (tendency to rate results in a similar manner)

Study Design Classification



Adapted from Epidemiologic Study Designs – Walden University, PUBH 6120 2007

7. Causal Relationships and Measuring Evidence



Objectives

- Evaluate the cause – effect relationship between a risk factor and disease
- Explore a tool to evaluate evidence based interventions

7. Causal Relationships and Measuring Evidence

Criteria for evaluating a cause – effect relationship. The most comprehensive outlined by Austin Bradford Hill in 1965

- Temporal relationship – studying lipid disease requires time for lipid deposits to form
- Strength of association – the stronger the association the less likely the error
- Dose response relationship – the longer the exposure to radiation the higher the risk of cancer
- Replication of the findings – has the association been observed by other researchers?
- Biologic plausibility – given the knowledge of the day, is the conclusion valid
- Experiment – does a natural experiment support the causal relationship?
- Specificity of the association – the more specific the association, the tighter the conclusion
- Consistency with other knowledge – is the cause – effect relationship consistent with other studies?

8. What does the Future Hold?

- The Bureau of Labor Statistics estimates a 34 % growth rate for epidemiologists thru 2014. But, funding sources will make academic appointments very competitive.

- Worldwide disease outbreaks observed in the last 25 years are expected to increase in frequency due to urban density, poverty and human – animal cohabitation.

- Aging in the United States will result in significant societal changes. The Census Department estimates a net 7.6% drop in age cohorts 0 – 44 while cohorts >65 have a net growth of 6.1% (n = + 56MM)

- Hospitals and traditional healthcare delivery models will look to public health for solutions to chronic care management in disparate populations, currently being mismanaged in hospital ED departments.

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