Quantitative Research Methods Training

Sponsored by the Chickasaw Nation and the Oklahoma Shared Clinical and Translational Resources

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Acknowledgements

- Julie Stoner, PhD
- Sydney Martinez, PhD
- Amanda Janitz, PhD
- Michael Peercy, MPH, MT(ASCP)H
- Bobby Saunkeah, RN, MSHCE, CIP
- Tasha Matthews

- Some of these materials were developed as part the Association of American Indian Physicians' Data Into Action training, funded by the Centers for Disease Control and Prevention through the support of Cooperative Agreement Number 1U38OT000133.
- CDC Principles of epidemiologydemiology in Public Health Practice https://www.cdc.gov/ophss/csels/dsepd/.html

Grant support provided through National Institutes of Health, National Institute of General Medical Sciences [Grant 2U54GM104938-06, PI Judith James] and National Institutes of Health, National Institute on Minority Health and Health Disparities [Grant 1R25MD011564, PI Julie Stoner/Courtney Houchen].

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Objectives

1. Define epidemiology and epidemiologic measures of disease burden
2. Define and interpret descriptive statistics and charts
3. Identify pitfalls in data interpretation and data summaries
4. Use Excel to create data tables and charts

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ACTIVITY 1:
What are you doing with data?
Does it affect your everyday life?

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Epidemiology in the news

The weed-killing chemical involved in a Monsanto lawsuit was found in Cheerios and Quaker Oats products. Here's how worried you should be.

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EPIDEMIOLOGY HISTORY, DEFINITION, AND USES

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John Snow: Pioneer of Epidemiology

https://oeta.pbslearningmedia.org/asset/envh10_vid_johnsnow/

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Epidemiology defined

- The study of factors affecting the health and illness of populations, and serves as the foundation and logic of interventions made in the interest of public health and preventive medicine
  - Wikipedia
- The study of the distribution and determinants of health related states in specific populations, and the application of this study to control of health problems
  - A Dictionary of epidemiology

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Roles of epidemiology

- **Monitor**
  - Population health status, its determinants, and its threats
- **Diagnose and Investigate**
  - Health problems and hazards
  - Determinants of health and disease
  - Disparities and inequities
  - Methods to prevent disease and promote health
- **Evaluate programs**

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Role of epidemiology

- **Count** cases or health events, and describe in terms of time, place, and person.
- **Divide** the number of cases by an appropriate denominator to calculate rates.
- **Compare** these rates over time or for different groups of people.

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Role of epidemiology

Can help to answer questions like these:

- **Who** is getting sick?
- **Where** are they getting sick?
- **When** are they getting sick?
- **What** is making them sick?
- **How** are they getting sick?
- **Why** are they getting sick?

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Who?

- Gender
- Age
- Race/ethnicity
- Religion
- Socioeconomic status (SES)
- Behaviors
- Occupation
- …

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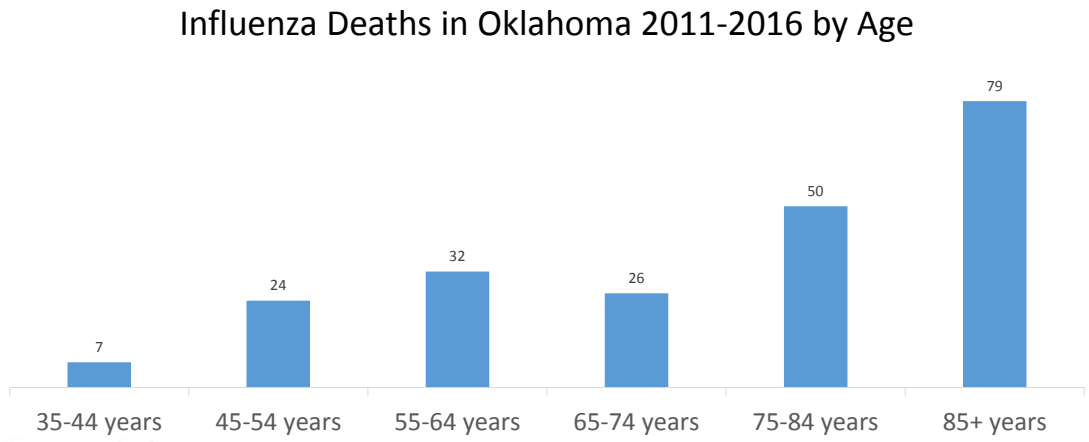
Disease displayed by age



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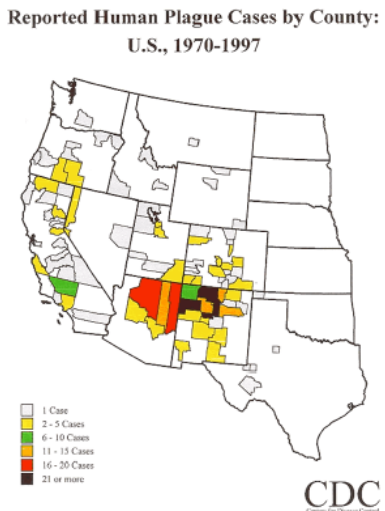
Where?

- State?
- County?
- Tribe?
- Hospital?
- …



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When?

- Days
- Months
- Years
- Seasons
- Events
- How long an individual is sick
- How long an individual is infectious
- …

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Disease displayed by time and place

https://www.cdc.gov/flu/weekly/usmap.htm

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TYPES OF EPIDEMIOLOGIC STUDIES

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Types of epidemiologic studies

- **Non-experimental**
  - Ecologic study
  - Cross-sectional studies
  - Case-control studies
  - Cohort studies (prospective or retrospective)
  - …and many others!!!
- **Experimental**
  - Clinical trials
  - Field trials
- **Community intervention**

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Ecologic studies

- **Group/aggregate level data on exposure and outcome**
- **Example:**
  - Percent of households with guns and homicide rate among 13 countries
- **Advantages**
  - Quick and inexpensive
  - Useful for hypothesis generating
- **Limitations**
  - Cannot infer to the individual
  - Information on confounders not usually available
  - Doesn't demonstrate causal relationship

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Koepsell & Weiss, 2003

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Cross-sectional studies

- **Prevalence Study** – Study using a cross section or sample of a population.
- **Examples**
  - Community health assessments; Behavioral Risk Factor Surveillance System
- **Advantages**
  - Measured at individual level
  - Often sample general population (generalizable)
  - Short time needed for study
- **Limitations**
  - Not good for rare diseases or diseases of short duration
  - Prevalence data (not incidence data)
  - Difficult to determine temporality/causal relationship

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Koepsell & Weiss, 2003; CDC

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Case-control studies

- Select cases and controls and compare past exposures
- **Example**
  - National Birth Defects Prevention Study
- **Calculate Odds Ratio**
- **Advantages**
  - Rare diseases, common exposures
  - Quicker and cheaper than cohort study
- **Limitations**
  - More potential sources of bias than cohort (different types of bias)
  - Difficult to establish temporality if use prevalent cases
  - Appropriate control group difficult to find

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Koepsell & Weiss, 2003; NBDPS

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Cohort studies

- Follow exposed and unexposed individuals over time for outcome
  - Prospective vs. retrospective
  - Calculate odds ratio, risk ratio, rate ratio
- **Example:** Framingham Heart Study
- **Advantages**
  - Better establish temporality
  - Assess multiple outcomes
  - Incidence data
- **Limitations**
  - Expensive and time consuming

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Koepsell & Weiss, 2003; Framingham Heart Study

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Clinical trials

- Experimental Study: Study factor assigned by investigator
  - Study intervention vs. placebo or standard of care
  - Randomization or conducted in clinical setting
- Example: Risk of opportunistic infection among patients with recent HIV infection treated with either zidovudine or a placebo
- Advantages
  - Control of confounding and bias
  - Prospective
  - Most rigorous method in human populations
- Limitations
  - Not feasible for all study questions
  - Bias due to participant non-compliance
  - High cost
  - Setting is artificial

Rothman, 2002

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How would you design a case-control study of the association between cardiovascular disease and cigarette smoking?

How would you design a cohort study of the association between cardiovascular disease and cigarette smoking?

How would you design a study to determine the effectiveness of a new smoking cessation program on cardiovascular disease prevention?

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DEVELOPING MEASURES

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Developing measures

1. **Define the event of interest**
   Ex: diagnosis of TB, eating recommended number of vegetables, using seat belt.
2. **Define population of interest**
   Ex. Oklahomans, teens 15-19, individuals who have attempted suicide
3. **Count number of events and size of population**
4. **Time period of interest**
   Ex. years, months, weeks
5. **Constant (K)** use to put in perspective and makes various measures easier to understand

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Measures of frequency

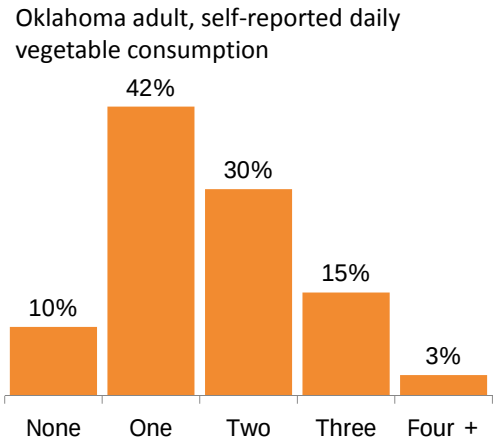
- **Proportion:** ratio in which the numerator is included in the denominator
  - **percentage** is proportion*100 (ie .25 proportion =25%)
- **Ratio measure:** one subgroup in a population divided by another subgroup
- **Rate measure:** frequency of defined events in specified population for given time period

Measures of frequency

- **Constant, K:** arbitrary number included in rate for expressing and comparing rates in similar population units
- **Average population:** Population size at mid-point of the time period.
- **Person-time:** Combines population at risk with time.

Percentages

- ¼=0.25=25%
- ½ =0.50=50%



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A note about converting fractions or rates

- 0.159
  - 15.9 percent (per 100)
  - 1590 per 10,000

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Measuring burden of disease

- Morbidity
  - Incidence
  - Prevalence
- Mortality
  - Total Mortality Rate
  - Cause Specific Mortality Rate
  - Case Fatality Rate

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Morbidity (illness) measures

Incidence

- Number of events per number of people per period of time (usually one year)
- May be reported per **person year as *incidence density***
- Usually refers to **new** cases of illness or disease
- Can be percent or proportion

Prevalence

- Number of events per number of people per period of time (usually one year)
- Usually refers to **existing** cases of illness or disease
- Can be percent or proportion

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Incidence proportion

- Number of new cases of a disease or condition in a population over a specific time
  - Ex: # new cancer cases, # youth begin smoking

$$I = \frac{Number\ of\ NEW\ cases}{Total\ population\ at\ risk}$$

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Prevalence

- Number of people with a disease or condition at a specific time in a population
  - Ex: # with diabetes, # of smokers, # of colds, # cancer patients

$$P = \frac{Number\ of\ new\ and\ existing\ cases}{Total\ population}$$

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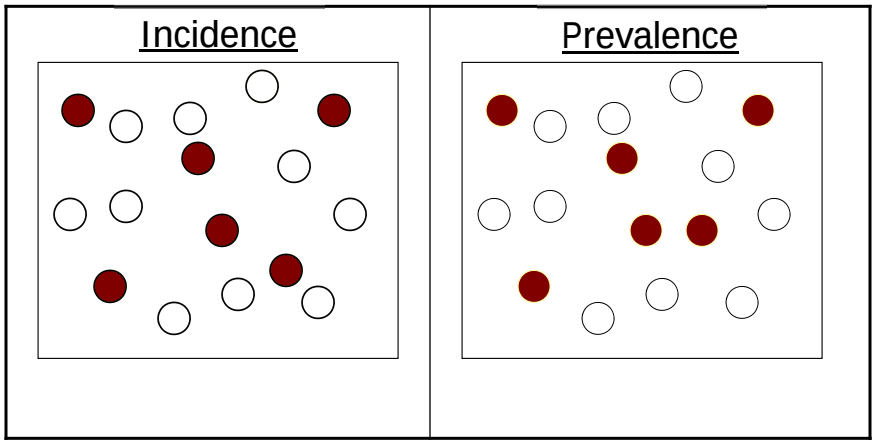

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Calculating incidence and prevalence

- The fictitious town of Neverland has 50,000 residents. In 2012, 782 people were diabetic, and 56 people were diagnosed with diabetes
- What is the incidence and prevalence of diabetes for people who live in Neverland in 2012?

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Calculating incidence and prevalence

- **Incidence**:
  - 56 new cases/50,000 people/year
  - 0.00112 cases/person/year or 112 cases per 100,000 people per year
- **Prevalence**
  - (782+56)/50,000
  - 0.01676 or 1.68% or 1,676 per 100,000

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Mortality (death) rates

Mortality rate = $\frac{\text{(\# deaths due to certain cause)}}{\text{(\# of people in } \textbf{population of interest}\text{)}}$

- All causes
- Grouped causes (cancers)
- Specific causes (lung cancer)

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Mortality data

- Source – Death Certificates
  - Immediate cause
  - Contributory cause
  - Underlying cause
- Comparisons of Mortality Rate
  - Populations by race, sex, or age group
  - Time periods – secular trends
  - Crude vs age-adjusted mortality

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Mortality rates - example

	Community A			Community B		
Age	No. of Deaths	Mid-year Pop.	Rate	No. of Deaths	Mid-year Pop.	Rate
Young	1	1000	1	10	5000	2
Middle	15	3000	5	40	4000	10
Old	50	5000	10	20	1000	20
Total	66	9000	7.3	70	10000	7.0

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Mortality rates - example

	Community A			Community B		
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Old	50	5000	10	20	1000	20
Total	66	9000	7.3	70	10000	7.0

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Activity 2

In groups of 2-3, using the epidemiologic concepts we have discussed, describe death rate patterns from the "unusual event".

- how do death rates vary between men and women overall?
- among the different socioeconomic classes?
- among men and women in different socioeconomic classes?
- among adults and children in different socioeconomic classes?

Can you guess what type of situation might result in such death rate patterns?

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Table 1.1 Deaths and Death Rates for an Unusual Event, by Sex and Socioeconomic Status

		Socioeconomic Status			
Sex	Measure	High	Middle	Low	Total
Males	Persons at risk	179	173	499	851
	Deaths	120	148	441	709
	Death rate (%)	67.0	85.5	88.4	83.3
Females	Persons at risk	143	107	212	462
	Deaths	9	13	132	154
	Death rate (%)	6.3	12.6	62.3	33.3
Both sexes	Persons at risk	322	280	711	1313
	Deaths	129	161	573	863
	Death rate (%)	40.1	57.5	80.6	65.7

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Table 1.2 Deaths and Death Rates for an Unusual Event, by Age and Socioeconomic Status

		Socioeconomic Status		
Age Group	Measure	High/Middle	Low	Total
Adults	Persons at risk	566	664	1230
	Deaths	287	545	832
	Death rate (%)	50.7	82.1	67.6
Children	Persons at risk	36	47	83
	Deaths	3	28	31
	Death rate (%)	8.3	59.6	37.3
All Ages	Persons at risk	602	711	1313
	Deaths	290	573	863
	Death rate (%)	48.2	80.6	65.7

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Age Adjustment
AKA Age Standardization

- Allows for better comparison of populations with different age profiles or distributions
- Important for health issues that disproportionately affects different age groups (cardiovascular disease, leukemia, car accidents)

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Case Fatality Rate

Case fatality rate = $\frac{\text{(\# of deaths due to certain cause)}}{\text{(\# of people } \textbf{affected by same cause}\text{)}}$

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Case Fatality Rate

- **Swine flu (H1N1)**
  - As of August 6, 2009: 1,462 deaths from 177,457 cases
  - 1,462/177,456 = 0.0082 or 0.82%
- **Breast cancer**
  - In one study, from 2000 to 2004, 71 deaths from 244 cases
  - 71/244 = 0.2910 or 29.10%

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Years of Potential Life Lost

- Years of potential life lost (YPLL)
  - Lost years of life before "standard" age of death
- Reference age=75
  - Age at death= 60 ➡ YPLL(75)=75-60=15
  - Age at death= 6 months ➡ YPLL(75)=75-.5=74.5
  - Age at death=80 ➡ YPLL(75)=0
- There may be different reference ages for different populations

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Ratio Measures

- Odds ratio
- Risk Ratio
- Rate Ratio

	Sick/Outcome Occurred/Effect Present	Not Sick/Outcome Did Not Occur/No Effect Present
Exposed/Risk Factor Present/Intervention	a	b
Not Exposed/Risk Factor Not Present/Control	c	d

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Ratio Measures

a = number of persons exposed and with disease

	Sick/Outcome Occurred/Effect Present	Not Sick/Outcome Did Not Occur/No Effect Present
Exposed/Risk Factor Present/Intervention	a	b
Not Exposed/Risk Factor Not Present/Control	c	d

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Ratio Measures

b = number of persons exposed but without disease

	Sick/Outcome Occurred/Effect Present	Not Sick/Outcome Did Not Occur/No Effect Present
Exposed/Risk Factor Present/Intervention	a	b
Not Exposed/Risk Factor Not Present/Control	c	d

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Ratio Measures

c = number of persons unexposed but with disease

	Sick/Outcome Occurred/Effect Present	Not Sick/Outcome Did Not Occur/No Effect Present
Exposed/Risk Factor Present/Intervention	a	b
Not Exposed/Risk Factor Not Present/Control	c	d

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Ratio Measures

d = number of persons unexposed and without disease

	Sick/Outcome Occurred/Effect Present	Not Sick/Outcome Did Not Occur/No Effect Present
Exposed/Risk Factor Present/Intervention	a	b
Not Exposed/Risk Factor Not Present/Control	c	d

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Ratio Measures

a + c = total number of persons with disease

	Sick/Outcome Occurred/Effect Present	Not Sick/Outcome Did Not Occur/No Effect Present
Exposed/Risk Factor Present/Intervention	a	b
Not Exposed/Risk Factor Not Present/Control	c	d

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Ratio Measures

b + d = total number of persons without disease

	Sick/Outcome Occurred/Effect Present	Not Sick/Outcome Did Not Occur/No Effect Present
Exposed/Risk Factor Present/Intervention	a	b
Not Exposed/Risk Factor Not Present/Control	c	d

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Risk ratio

$$\text{Risk ratio} = \frac{\text{Risk of disease in exposed group}}{\text{Risk of disease in comparison group}}$$

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Risk ratio

$$\text{Risk ratio} = \frac{a/a+b}{c/c+d}$$

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Example case

In an outbreak of varicella (chickenpox) in Oregon in 2002, varicella was diagnosed in 18 of 152 vaccinated children compared with 3 of 7 unvaccinated children.

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Example case

	Chickenpox	No chickenpox
Vaccinated	a = 18	b = 134
Not vaccinated	c = 3	d = 4

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Example case

Risk of varicella among vaccinated children = 18 / 152 = 0.118 = 11.8%

Risk of varicella among unvaccinated children = 3 / 7 = 0.429 = 42.9%

Risk ratio = 0.118 / 0.429 = 0.28

	Chickenpox	No chickenpox
Vaccinated	a = 18	b = 134
Not vaccinated	c = 3	d = 4

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Example case

The risk ratio is less than 1.0, indicating a decreased risk or protective effect for the exposed (vaccinated) children. The risk ratio of 0.28 indicates that vaccinated children were only approximately one-fourth as likely (28%, actually) to develop varicella as were unvaccinated children.

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Interpreting Ratio Measures

- =1 ➡ No difference in risk/odds/rate between two groups
- >1 ➡ Higher risk/odds/rate in one group compared to another
- <1 ➡ Lower risk/odds/rate in one group compared to another

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ACTIVITY 3

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		Disease (HepA)	
		Y	N
Exposure (salsa)	Y	470	195
	N	30	305

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INTERPRETING DATA

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Interpreting Data

- Is the information what you expected?
- Are there differences over time?
- Is the measure bigger or smaller than:
  - another area
  - another group of people
  - another situation/circumstance

Spend time with and get to know your data!!!

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Interpreting Data

- What if something happened due to chance?
  - P-value
- How precise are your results?
  - Confidence interval

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P-value

- The probability of getting some test statistic by "chance"
- The smaller the p-value, the more significant your results because the smaller the probability that it can be observed by chance
- Is affected by size of sample

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Confidence Interval

- An interval estimate of some statistical measure
- Usually set at 95%
- Can be interpreted as: if this experiment was repeated, you would get results within a specific interval 95 times out of 100 times
- Is affected by size of sample
- For ORs and RRs, confidence intervals including 1 (for example, 0.95-1.30) do not represent a difference

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Characterizations of Good Data

- Accuracy
  - "Closeness of arrow to bull's eye"
- Validity
  - Are the data for measures you're interested in?
- Reliability
  - Information has stable and consistent collection processes
- Timeliness
  - Less than 5 years old is a good standard
- Relevance
  - Are you using them for the right purposes?
- Completeness
  - Quality measure

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Can the data be trusted?

- Validity!!
- Research/study agenda
- Sample size and sampling methods
- P-value
- Confidence interval
- Associations of research/publisher

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What is Validity?

- Internal (your study population)
  - The ability to really measure what is supposed to be measured
  - The degree to which a measurement (of study) reaches a correct conclusion and represents the truth
- External (the world)
  - Generalizability of results

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Internal Validity

- Any systematic error that results in an incorrect estimate (invalidity) of your population
- All research, evaluation, or study has bias
- Less bias ➡ Better representation of the truth!!
- 3 classes or types
  - Selection bias
  - Observation/Information bias
  - Confounding

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Threats to External Validity

- Can we generalize our study findings to those not included in the study?

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Gordis, 2004

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Association v. Causation

- Association is observed
  - Correlation, relationship, statistical dependence
  - Types of associations
    - Artifactual/spurious, non-causal, direct causal, non-direct causal
- Causation is inferred

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Gordis, 2004

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Comprehend and Scrutinize

- Study population (who and how many?)
- Study methodology
  - Sampling
  - Analysis
- Author disclosure
  - Health statistics are ALWAYS influenced by an individual's/organization's biases
- Relevancy and coherence of findings

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ORGANIZING DATA

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Organizing data

A **variable** can be any characteristic that differs from person to person

- Height
- Weight
- Gender
- Vaccine status

The **value** of a variable is the number or descriptor that applies to a particular person

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ID	Date of Diagnosis	Town	Age (Years)	Sex	Hosp	Jaundice	Outbreak	IV Drugs	IgM Pos
01	01/05	B	74	M	Y	N	N	N	Y
02	01/06	J	29	M	N	Y	N	Y	Y
03	01/08	K	37	M	Y	Y	N	N	Y
04	01/19	J	3	F	N	N	N	N	Y
05	01/30	C	39	M	N	Y	N	N	Y
06	02/02	D	23	M	Y	Y	N	Y	Y
07	02/03	F	19	M	Y	Y	N	N	Y
08	02/05	I	44	M	N	Y	N	N	Y
09	02/19	G	28	M	Y	N	N	Y	Y
10	02/22	E	29	F	N	Y	Y	N	Y

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ID	Date of Diagnosis	Town	Age (Years)	Sex	Hosp	Jaundice	Outbreak	IV Drugs	IgM Pos
01	01/05	B	74	M	Y	N	N	N	Y
02	01/06	J	29	M	N	Y	N	Y	Y
03	01/08	K	37	M	Y	Y	N	N	Y
04	01/19	J							Y
05	01/30	C							Y
06	02/02	D							Y
07	02/03	F	19	M	Y	Y	N	N	Y
08	02/05	I	44	M	N	Y	N	N	Y
09	02/19	G	28	M	Y	N	N	Y	Y
10	02/22	E	29	F	N	Y	Y	N	Y

Typically, each row is called a **record** or an **observation** and represents one person or case of disease

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ID	Date of Diagnosis	Town	Age (Years)	Sex	Hosp	Jaundice	Outbreak	IV Drugs	IgM Pos
01	01/05	B	74	M	Y	N	N	N	Y
02	01/06	J	29	M	N	Y	N	Y	Y
03	01/08	K	37	M	Y	Y	N	N	Y
04	01/19							N	Y
05	01/30							N	Y
06	02/02	D	23	M	Y	Y	N	Y	Y
07	02/03	F	19	M	Y	Y	N	N	Y
08	02/05	I	44	M	N	Y	N	N	Y
09	02/19	G	28	M	Y	N	N	Y	Y
10	02/22	E	29	F	N	Y	Y	N	Y

Each column is called a **variable** and contains information about one characteristic

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Organizing data

- Code values to numeric for ease of analysis
  - Gender: male = 1, female = 2
  - Town: Ada = 1, Holdenville = 2, Ardmore = 3, Sulphur = 4
- HOWEVER do not transform data from collection instrument to database/spreadsheet
- Create a codebook to document!

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ACTIVITY 4

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DISPLAYING DATA

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Displaying Data

- Important to disseminate/present research findings
- Visual aids can provide clear synthesis of findings
- Display data in tables or charts/graphs
- Data display should be self-explanatory and stand alone

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Choosing a Table or Chart

- Amount of data to be presented
- Level of detail needed
- Relationship within the data you wish to communicate
- Type of presentation
- Type of audience

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Tables

- Clear and simple summary using rows and columns
- Use to show many and precise numerical values in small space
- Primarily in manuscripts, technical reports, posters
- Often difficult to read in PowerPoint presentations

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Guidelines for Tables

- Rows and columns should have clear labels
- No unnecessary digits
- Lines or spaces separate items
- Ensure sufficient space between columns and rows
- Avoid messy or crowded tables – consider dividing into 2

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Table Titles

- Concisely describe purpose or content of table
- Should be clear and informative
- Descriptive of the data
  - Measures
  - Time frame
  - Place
  - Sample size (when appropriate)

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Table Footer

- Use asterisks or other symbols to highlight important information about variables or values in table and describe in footer
- E.g. significance levels, covariates in model, data source

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Table 1 Example

Table 1. Demographic Characteristics of a Sample of Employed Workers From the National Health Interview Survey ($n = 89,366$), 2004–2009[a]

Characteristic	No. of Subjects Interviewed	Weighted %
Gender		
Men	44,473	50.8
Women	44,893	49.2
Highest level of education		
Did not complete high school	11,088	9.8
High school graduate	23,285	25.8
Some college	27,611	31.9
Bachelor's degree	17,865	21.6
Master's degree	6,664	8.0
Professional school degree or doctoral degree	2,405	2.9
Race/ethnicity		
Hispanic	16,893	11.9
Non-Hispanic white	54,339	71.3
Non-Hispanic black	13,133	12.1
Non-Hispanic other	5,001	4.7

[a] Numbers may not sum to total because of missing data.

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Charts/Graphs

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http://ieatalp.weebly.com/

Charts/Graphs

- Uses bars, lines, or dots to visually represent data
- Use to show trends, patterns, and relationships across data set
- Use when general pattern is more important than exact data values
- Useful in oral and poster presentations, for non-technical audience but also manuscripts and technical reports

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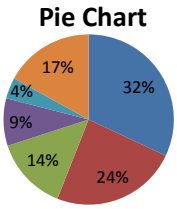
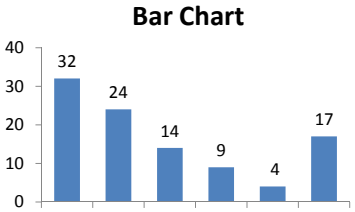
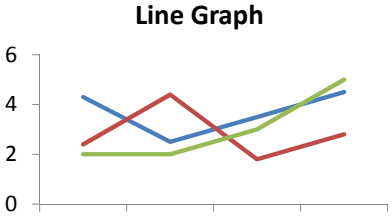
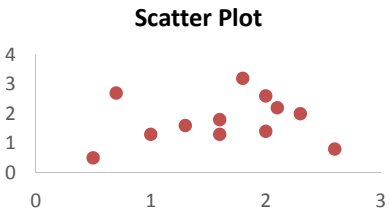
Types of Charts









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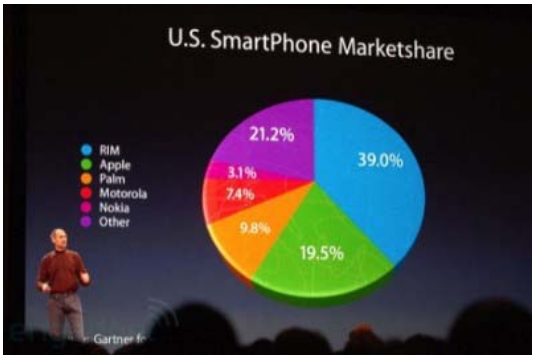
Pie Chart

- Displays parts to a whole
- Not easy for the audience to compare angles (heights and lengths of bars are easier)
- Can be deceiving



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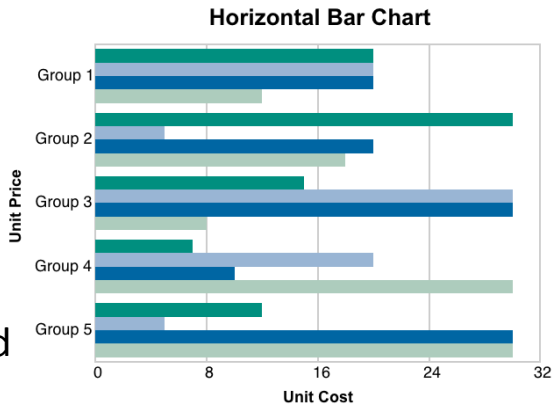
http://www.engadget.com/2008/01/15/live-from-macworld-2008-steve-jobs-keynote/

Bar Chart

- Uses horizontal or vertical bars to compare quantities of categorical data
- Bars do not touch
- Histograms are similar, but for continuous data and bars touch



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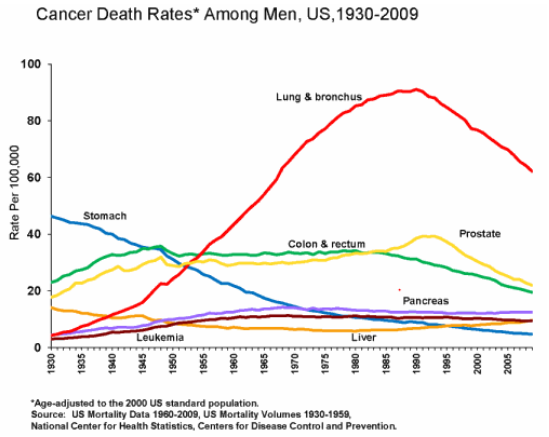
Line Graph

- Series of data points connected by straight lines
- Used to show change over some type of order (usually time)



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http://www.cancer.org/research/cancerfactsstatistics/cancerfactsfigures2013/cancer-statistics-2013-slide-presentation.pdf

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Guidelines for Charts/Graphs

- Clear and concise title
- Labels on x and y axis with variable and units of measure
- Scale should start at zero and be clearly marked
- Any break in scale should be labeled
- Avoid clutter and 3-D effects
- Use legend or proper labels on bars and lines

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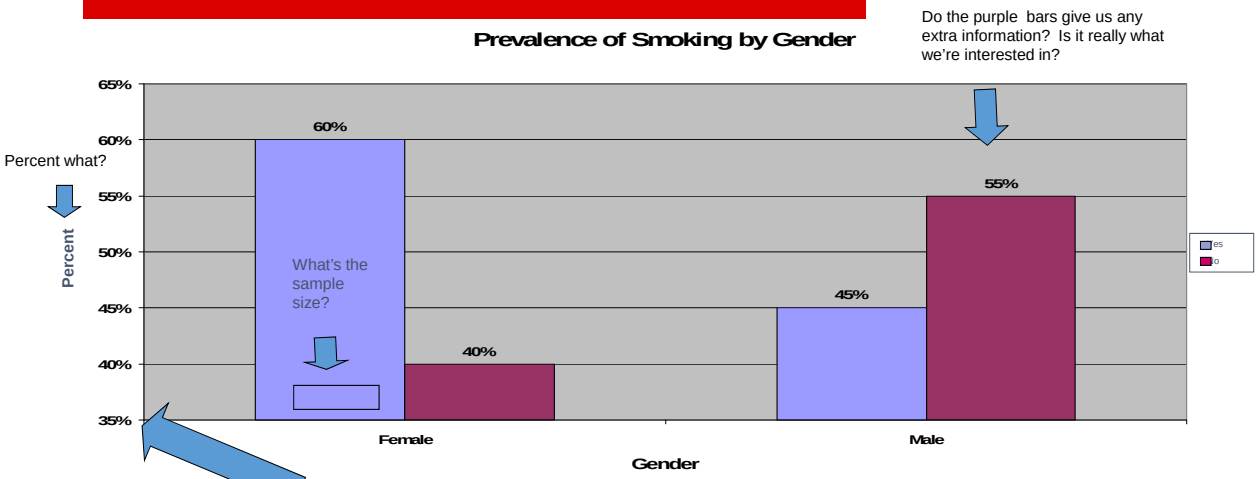
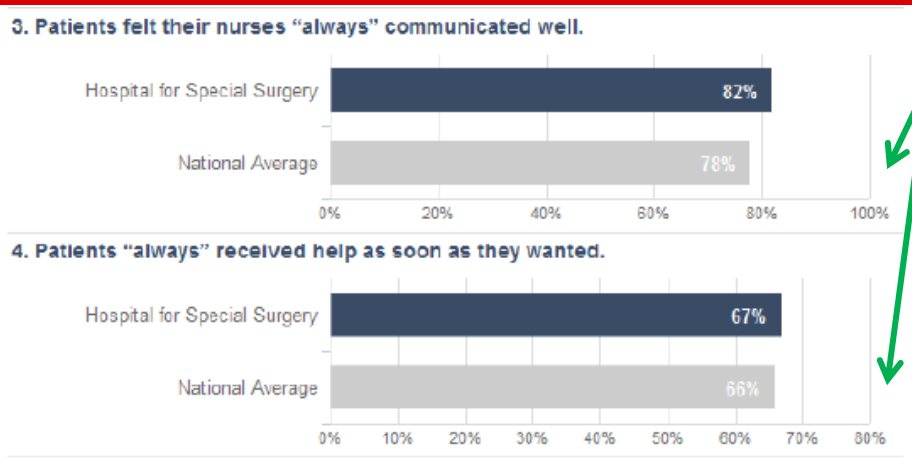
What changes do you suggest?



Y-axis doesn't start at zero. This distorts the graph and makes it seems that there are more than double the percent of female smokers than male smokers.

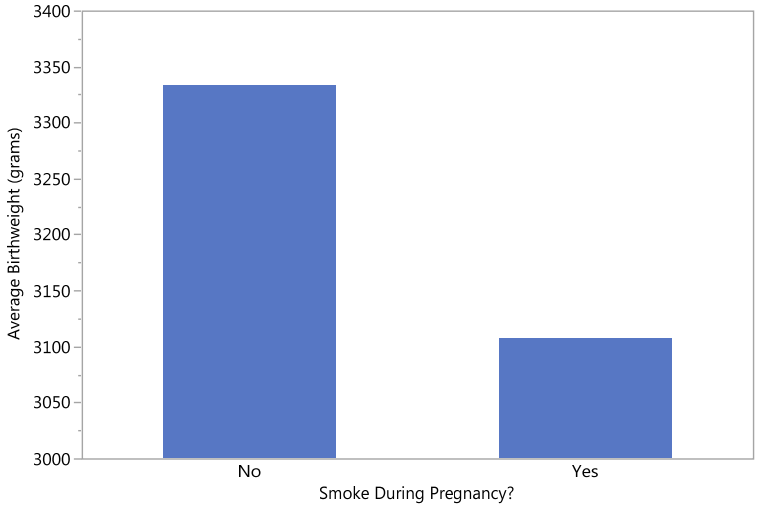
What changes do you suggest?



The scale differs between panels – level of satisfaction within a survey is lower for Question 4.

Citation: Robbins, N. 2014. Misleading Healthcare Graph. Forbes. https://www.forbes.com/sites/naomirobbins/2014/01/08/misleading-healthcare-graph/#438f10b76a17

North Carolina Births – smoking by birthweight



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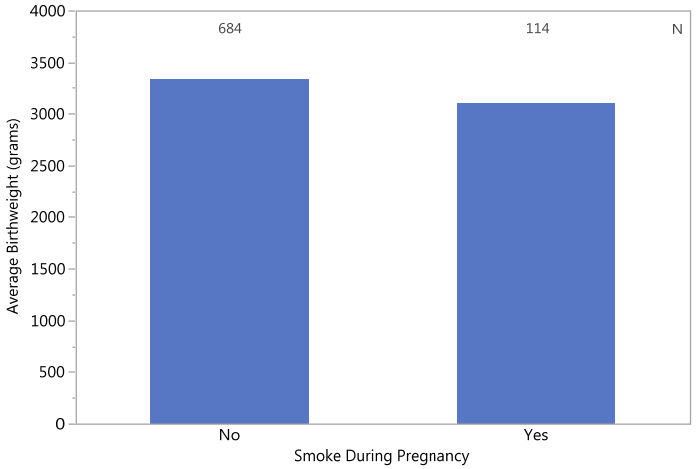
North Carolina Births – corrected



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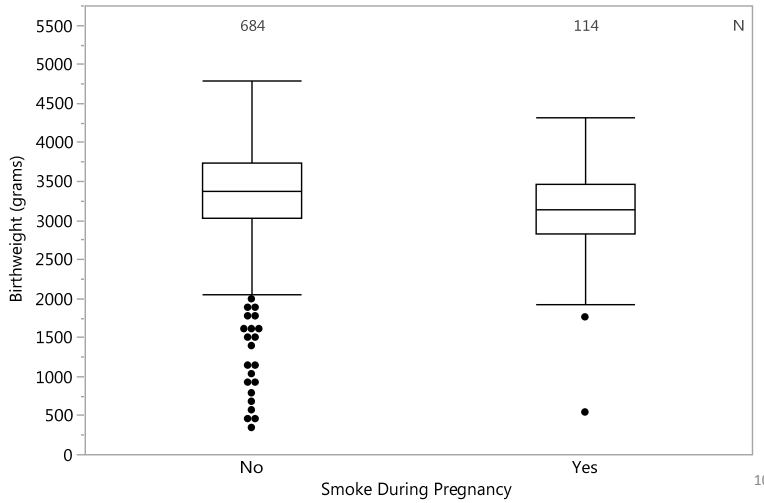
North Carolina Births – alternative graph



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Data Displays

- Choose table or chart based on purpose, audience, and type of data
- Data display should stand alone (titles, labels, legends)
- Ensure display portrays data accurately and in a way that is clear to audience and not deceiving

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Future topics

- Principles of data capture, processing/coding, and cleaning
  - Now that you have data, what are the first steps in preparing for the analysis?
  - Important steps in data cleaning – pitfalls and problems to avoid
- Accessing and analyzing publicly-available data
  - Lab/applied hands-on session
  - Data Into Action training
- Principles of statistical analysis
  - Relate to the type of data and type of research design
  - Stress interpretation
- Others?

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Thank you for having us!

Questions?

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