Lecture 1

Benefits of Using Statistics

Thought Question 1:

A recent newspaper article concluded that ***smoking marijuana*** at least three times a week ***resulted in lower grades*** in college.

How do you think the researchers came to this conclusion? Do you believe it? Is there a more reasonable conclusion?

Thought Question 2:

Theory: ***On average, men have lower resting pulse rates than women do.***

How could you go about trying to prove or disprove that? Would it be sufficient to measure the pulse rates of one member of each sex? Two members of each sex? What information about men's and women's pulse rates would help you decide how many people to measure?

Thought Question 3:

Suppose you were to learn that the ***large state university*** in a particular state graduated more students who eventually went on to become **millionaires** than any of the ***small liberal arts colleges*** in the state.

Would that be a fair comparison?
How should the numbers be presented in order to make it a fair comparison?

Simpson's episode:

- Homer is questioned about his newly formed vigilante group

  Newscaster: Since your group started up, petty crime is down 20%, but other crimes are up.

  Such as heavy sack beating which is up 800%. So you're actually increasing crime.

  Homer: You can make up statistics to prove anything. 43% of people know that.

A single death is a tragedy, a million deaths is a statistic.

Joseph Stalin (1879-1953)

Definition

- Simple: Statistics are numbers measured for some purpose

- **Statistics is a collection of procedures and principles for gaining and analyzing information in order to help people make decisions when faced with uncertainty.**

Uncertainty

- How long will I live?
- When should I marry?
- What is a good occupation to choose?
- Where should I live?
- What should I eat?
- Should I party? Study harder?
- What should I do this summer?
- What will happen to me?
- …….

Data and Uncertainty

- Past events and processes can help us understand the future

- If we gather data in sensible ways, we can use the data (information) to help make decisions with uncertain outcomes.

Uncertainty and Descriptive Data

- Should I get married? I fear divorce!!!

Imagine a survey of every town in Northern CA that asks every person questions about their relationship history.

Chico = 30% divorce rate

San Francisco = 80% divorce rate

Describing this data is useful!

Uncertainty and Inference

- We often cannot get all of the people to answer our questions.
- If we conduct proper samples, we can make inferences about the entire population.
- Thus, we can address the divorce rate question without talking to everyone, and thus we can get more information.
- **Once again, this information makes the world more certain!**

Statistical Issues in Life

Jessica Utts- Seeing Through Statistics

How can I **increase my chances** of winning the lottery?

I feel like the "experts" are always coming up with conflicting information about what's good or bad for you. Why does the latest study always seem to **contradict previous wisdom**? Chocolate/wine is good!!

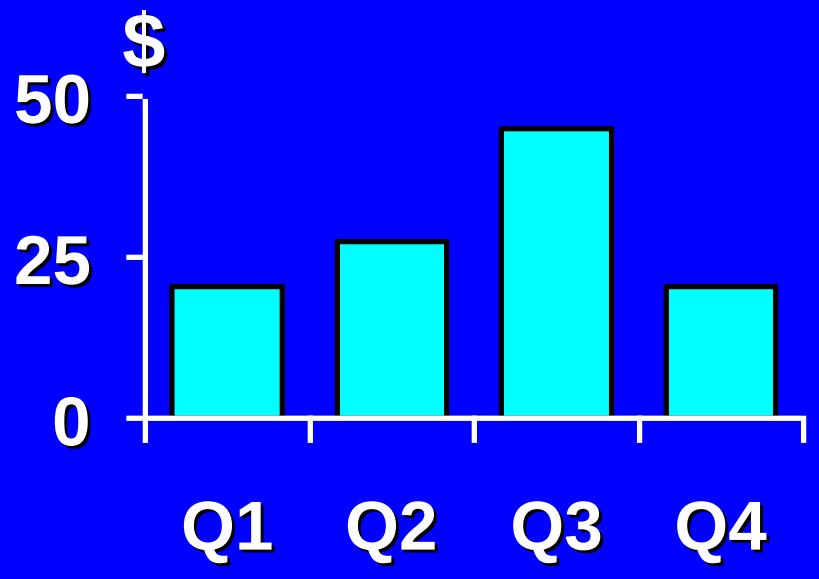
In public opinion polls, how can a **few thousand people** possibly represent the millions of people in a country?

I had a vivid dream about a plane crash and the next day there was one. That **couldn't have just happened by chance**, could it?

I don't think it's fair that my auto insurance is so high just because I'm a young male. I've never had an accident or a ticket. My sister had a speeding ticket, so why does she **pay so much less**?

Descriptive Statistics

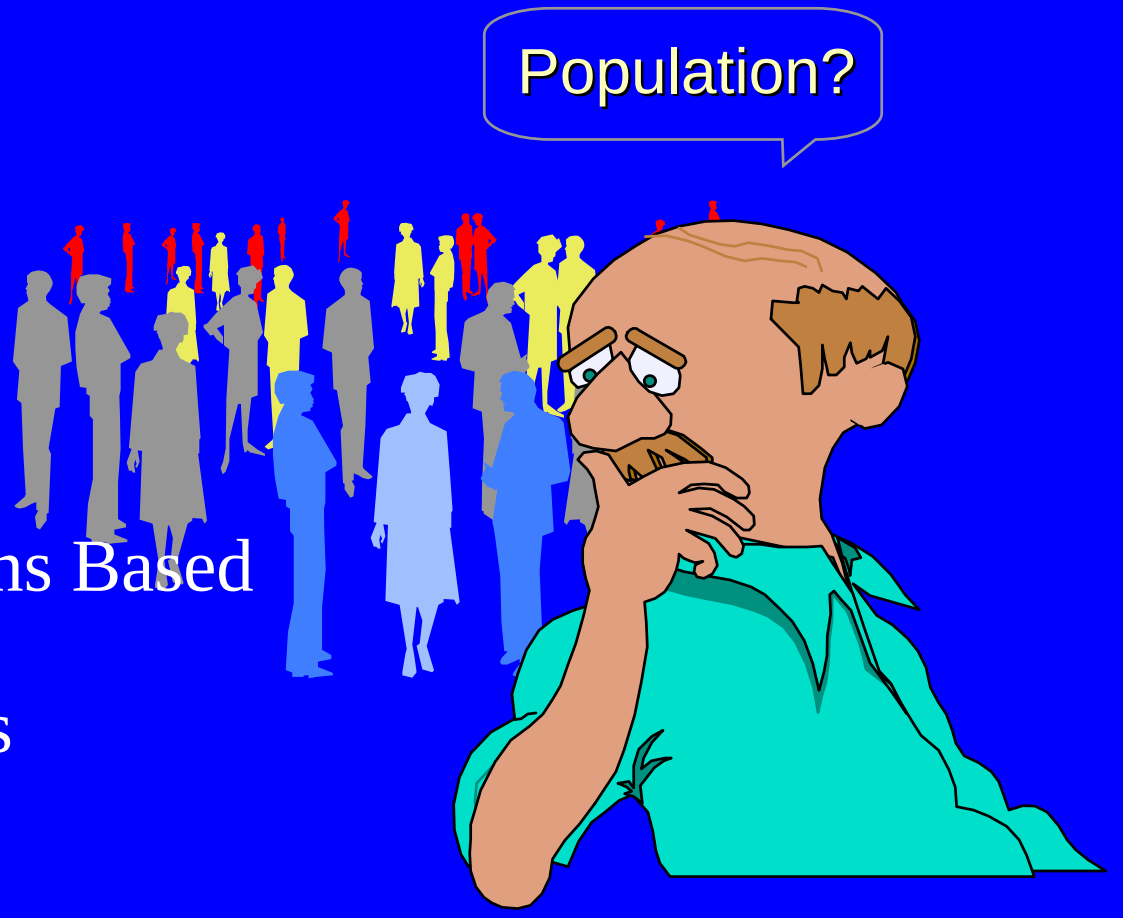
- 1. Involves
  - Collecting Data
  - Presenting Data
  - Characterizing Data
- 2. Purpose
  - Describe Data



$\bar{X} = 30.5 \quad S^2 = 113$

Inferential Statistics

- 1. Involves
  - Estimation
  - Hypothesis Testing
- 2. Purpose
  - Make Decisions Based on Population Characteristics



Case Study 1.1 *Who Are Those Speedy Drivers?*

- **Question:** What's the fastest you have ever driven a car? _____ mph.
- **Data:** 87 male and 102 female students from large statistics class at University.

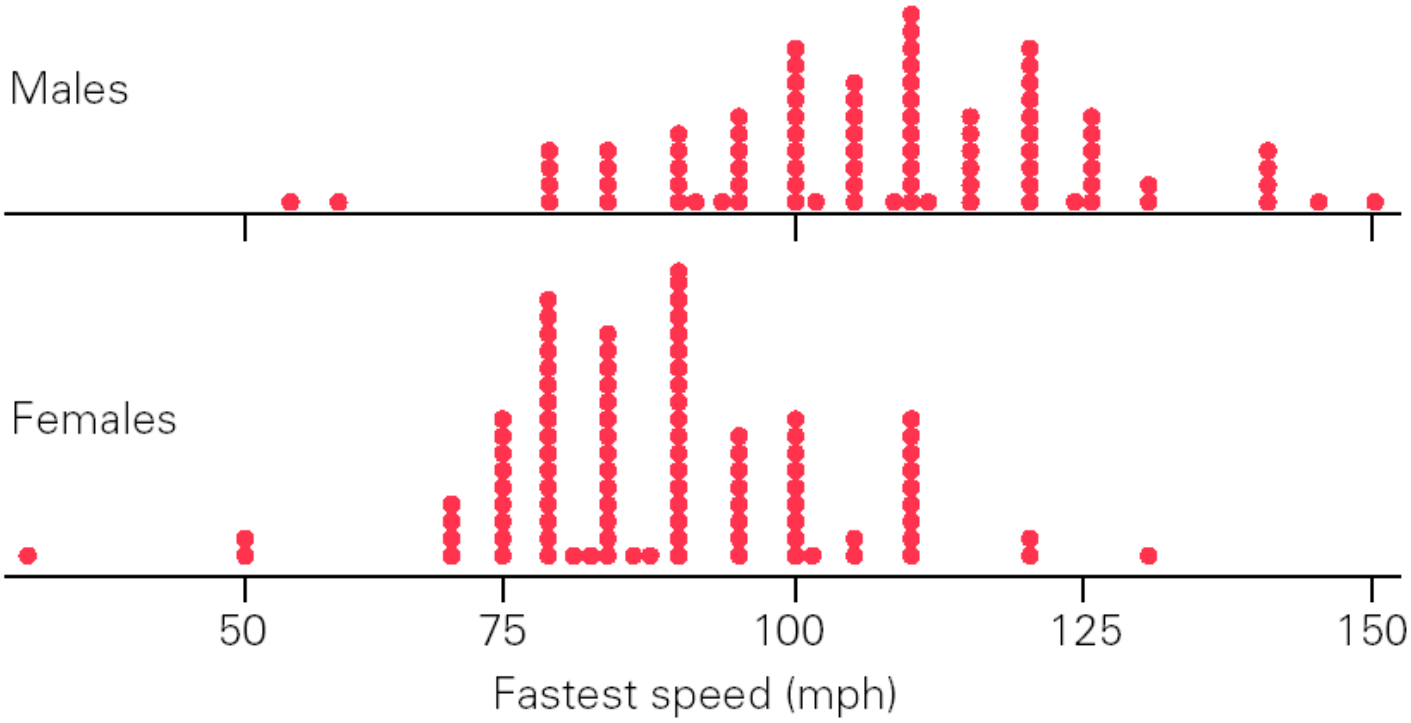
Males: 110 109 90 140 105 150 120 110 110 90 115 95 145 140 110 105 85 95 100 115 124 95 100 125 140 85 120 115 105 125 102 85 120 110 120 115 94 125 80 85 140 120 92 130 125 110 90 110 110 95 95 110 105 80 100 110 130 105 105 120 90 100 105 100 120 100 100 80 100 120 105 60 125 120 100 115 95 110 101 80 112 120 110 115 125 55 90

Females: 80 75 83 80 100 100 90 75 95 85 90 85 90 90 120 85 100 120 75 85 80 70 85 110 85 75 105 95 75 70 90 70 82 85 100 90 75 90 110 80 80 110 110 95 75 130 95 110 110 80 90 105 90 110 75 100 90 110 85 90 80 80 85 50 80 100 80 80 80 95 100 90 100 95 80 80 50 88 90 90 85 70 90 30 85 85 87 85 90 85 75 90 102 80 100 95 110 80 95 90 80 90

- ***Which gender has driven faster? How to summarize data?***

Case Study 1.1 *Who Are Those Speedy Drivers?*

- **Dotplot:** each dot represents the response of an individual student.



Case Study 1.1 *Who Are Those Speedy Drivers?*

•**Five-number summary**: the lowest value, the cutoff points for ¼ , ½, and ¾ of the data, and the highest value.

	Males (87 Students)		Females (102 Students)	
Median	110		89	
Quartiles	95	120	80	95
Extremes	55	150	30	130

•Note: ¾ of men have driven 95 mph or more, only ¼ of women have done so.

•**Moral:** *Simple summaries of data can tell an interesting story and are easier to digest than long lists.*

Three Steps for Conducting a Study

1. Get a representative sample.

Researchers would like to extend their results beyond just the participants in their research. Therefore, it is important that the people or objects in the study be representative of the larger group for which conclusions are to be drawn.

A **sample** is defined as the people or objects that are actually studied.

The **population** is the larger group from which the sample is drawn.

2. Get a large enough sample.

3. Decide whether the study should be an observational study or an experiment.

When we merely observe things about our sample, we are conducting an **observational study.**

When we randomly assign people to one of two (or more) groups we are conducting and **experiment.**

Case Study 1.2: *Does Aspirin Prevent Heart Attacks?*

Physicians' Health Study (1988)

5-year randomized experiment

22,071 male physicians (40 to 84 years old).

- Group 1: took ordinary ***aspirin*** tablet every other day.
- Group 2: took ***placebo*** (looked like aspirin but no active ingredients).

Subjects did not know which group they were assigned (called blinding).

Case Study 1.2: *Does Aspirin Prevent Heart Attacks?*

Condition	Heart Attack	No Heart Attack	Attacks per 1000
Aspirin	104	10,933	9.42
Placebo	189	10,845	17.13

Results:

- Heart attack rate in aspirin group only 55% of rate in placebo group.
- Randomization ⇨ other factors, such as amount of exercise, expected to be *similar* for both groups.
- Subjects were male physicians. Results may *not* extend to all males, nor to women.

1.3 Don't Be Deceived By Improper Use of Statistics

Example 1

- Business Magazine sent **2000 questionnaires** to readers about Republican primary: Chrysler president Lee Iacocca vs. VP George Bush.
- Based on **only first 200 respondents**, reported Iacocca would beat Bush 54% to 47%.
- **Sample not representative of population** of all people likely to vote: those who feel strongly about an issue most likely to respond.

Improper Use of Statistics

Example 2

- U.S. EPA study led to report that New Jersey ranked 22nd in its release of toxic chemicals.
- **Problem**: wrong units … ranking was based on **total pounds released**.
- Using appropriate rate of **pounds released *per square mile***, New Jersey ranked 4th on the list.
- Figures were misleading until adjusted for size.

Improper Use of Statistics

Example 3

- Article headline:
  "Study: Smoking May Lower Kids' IQs"
- Headline implication: a causal connection.
- Problem: results based on an observational study (since experiment would be unethical).
- Moral: ***Can't make causal connections from observational studies.***

Improper Use of Statistics

New study confirms too much pot impairs brain

"More evidence that chronic marijuana smoking impairs mental ability: Researchers at the University of Iowa College of Medicine say a test shows those who smoke seven or more marijuana joints per week had lower math, verbal and memory scores than non-marijuana users. Scores were particularly reduced when marijuana users held a joint's smoke in their lungs for longer periods." *San Francisco Examiner, 13 March 1993, p. D-1.*

Example 4

- Headline implication: a causal connection.
- Problem: based on an **observational study**
- Can conclude ***there is a relationship*** but ***cannot conclude a causal connection.***

Case Study 1.3: *A Mistaken Accusation of Cheating*

- Two students **accused of cheating on multiple choice medical exam** due to whispering during one part and wrong answers often matched each other.
- Licensing board estimated **odds of having answers as close as these two were < 1 in 10,000**.
- At trial, statistician showed agreement in this exam was no higher than in other exams.
- **Key:** two students were husband and wife, both from India. ***Licensing board incorrectly assumed they were just guessing.*** Instead, common mistakes were often the right answers for India background.
- Whispering had to do with status of sick child.

1.4 Summary and Conclusions

- There are both advantages and dangers of using statistical methods.
- Results of a study are not enough!
- You need to know how data were collected, who was asked, etc.
- Over the next several chapters, you will become an educated consumer of statistical information.

Chapter 2

Reading the News

Thought Question 1:

Advice columnists sometimes ask readers to **write and express their feelings** about certain topics.

Ann Landers asked whether they though engineers make good husbands.

Do you think the **responses** she got are **representative of public opinion**? Explain why or why not.

Thought Question 2:

Taste tests of new products are often done by having people **taste both the new product and an old familiar standard**.

Do you think the results would be **biased if the person handing the products to the respondents knew which was which**?

Explain why or why not.

Thought Question 3:

Nicotine patches are attached to the arm of someone who is trying to quit smoking and dispense nicotine into the blood.

Suppose you read a study showing **nicotine patches were twice as effective in getting people to quit smoking as "control" patches** (made to look like the real thing). Further, suppose you are a smoker trying to quit.

What questions would you want answered about how the study was done and its results before you decided whether to try the patches?

2.1 The Educated Consumer of Data

What Are Data?

Data = plural word referring to a ***collection of numbers*** or other pieces of information ***to which meaning has been attached***.

Numbers 1, 3, and 10 are not necessarily data, but **become data** when told these were **weight gains** in grams of 3 infants in Salk's heartbeat study.

Don’t Always Believe What You Read

Newspapers ***rarely*** present actual data.

Meaning attached to data and results **depends on how well info was obtained and summarized**.

2.2 Origins of News Stories

- Academic Conferences
- Published Articles in Scholarly Journals
- Government and Private Agency Research Reports
- University Media Office

2.3 How to be a Statistics Sleuth: Seven Critical Components

Component 1:

The ***source*** of the research and of the ***funding***.

Component 2:

The ***researchers*** who had ***contact*** with the participants.

Component 3:

The ***individuals*** or objects studied and how they were ***selected***.

Seven Critical Components *(cont.)*

Component 4:

The exact nature of the ***measurements*** made or ***questions*** asked.

Component 5:

The ***setting*** in which the measurements were taken.

Component 6:

Differences in the groups being compared, ***in addition*** to the factor of interest.

Component 7:

The ***extent*** or ***size*** of any claimed effects or differences.

Component 1:

The ***source*** of the research and of the ***funding***.

Three main reasons studies are conducted:

1. By Government/Private Companies to make wise policy decisions.
2. Universities/Institutes paid to ask/answer questions about the world around us.
3. Companies to convince consumers their program or product is better.

Not always easy to discover *who* funded research.

Ask: Would funding organization have a strong preference for a particular outcome?

Component 2:

The ***researchers*** who had ***contact*** with the participants.

- Know who actually had contact with participants and what message they conveyed.
- Participants often give answers or behave in ways to comply with desires of researchers.
- If possible, ‘blind’ interviewer and respondent.

Example of bad method: Sending uniformed police officers door to door to survey about illegal drug use.

Component 3:

The ***individuals*** or objects studied and how they were ***selected.***

- Results extend only to individuals similar to those in the study.
- Know how participants were enlisted for study.
- Responses from ***volunteers*** may differ in relevant ways from responses of non-volunteers.
- Voluntary responses to surveys often ***biased*** as only those who feel strongly likely to respond.

Component 4:

The exact nature of the ***measurements*** made or ***questions*** asked.

- Some things ***difficult to measure*** precisely.
- Need to know the ***exact definitions*** used.
- ***Wording/ordering*** of questions influences answers.
- Need to know the exact wording used.

Examples: How to define ‘eat breakfast’?
What if just juice or if eat snack at 11 am?
Question about ‘street people’ versus ‘families with no home’ might yield different responses.

Component 5:

The ***setting*** in which the ***measurements*** were taken.

Setting ⇨ ***when*** and ***where*** measurements taken and ***how*** respondents were contacted.

Examples:

- Opinions about locking away criminals would change after highly publicized murder case.
- Telephone calls in early evening would exclude those who work evenings or often eat out.
- Research in a lab or university office may not extend to a natural setting.

Component 6:

Differences in the groups being compared, ***in addition*** to the factor of interest.

If two or more groups are compared on a factor of interest, important to ***consider other ways the groups may differ*** that might influence the comparison.

Example: *Smoking marijuana and academic performance*

- Researcher may find people who smoke have *lower* test scores that those who do not.
- Difference might be explained by other ***extraneous factors***, such as motivation – those who smoke also less motivated to study even if they didn't smoke.

Component 7:

The ***extent*** or ***size*** of any claimed effects or differences.

Media may state a **treatment had an effect** or a difference was observed, but often **don't tell you the size** of effect or difference ⇨ hard to assess if results are of ***practical importance***.

Example: *Aspirin and Heart Attacks*

- Media reported taking aspirin every other day reduced the risk of heart attacks. Is it worthwhile to take aspirin?
- Better to say rate was reduced from 17 attacks per 1000 without aspirin to about 9.4 attacks per 1000 with aspirin.

2.4 Four Hypothetical Examples of Bad Reports

1. “Study Shows Psychology Majors Are Smarter Than Chemistry Majors”
2. “Per Capita Income of U.S. Shrinks Relative to Other Countries”
3. “Researchers Find Drug to Cure Excessive Barking in Dogs”
4. “Survey Finds Most Women Unhappy in Their Choice of Husbands”

Hypothetical News Article 1

STUDY SHOWS PSYCHOLOGY MAJORS ARE SMARTER THAN CHEMISTRY MAJORS

A fourth-year psychology student, for her senior thesis, conducted a study to see if students in her major were smarter than those majoring in chemistry. She handed out questionnaires in five advanced psychology classes and five advanced chemistry labs. She asked the students who were in class to record their grade-point averages (GPAs) and their majors. Using the data only from those who were actually majors in these fields in each set of classes, she found that the psychology majors had an average GPA of 3.05, whereas the chemistry majors had an average GPA of only 2.91. The study was conducted last Wednesday, the day before students went home to enjoy Thanksgiving dinner.

"Study Shows Psychology Majors Are Smarter Than Chemistry Majors"

Component 1: The ***source*** of the research and of the ***funding***.

- Senior thesis project conducted by psychology major, probably paid for by the student.
- Would she have reason to want the results come out the way they did?
- If properly conducted, motives of experimenter should be minimized.

“Study Shows Psychology Majors Are Smarter Than Chemistry Majors”

Component 2: The ***researchers*** who had ***contact*** with the participants.

- Appears only student conducting study had contact with respondents.
- Unclear if she told purpose of study.
- Any clues to desired outcome could bias results.

"Study Shows Psychology Majors Are Smarter Than Chemistry Majors"

Component 3: The ***individuals*** or objects studied and ***how*** they were selected.

- Measurements on advanced psychology and chemistry students that were in class/lab ***day before a holiday***.
- Less conscientious students more likely to leave early and miss class.
- Easier to make up class than a lab ⇨ larger proportion of students with low GPA absent from psychology class than from chemistry lab.
- Missing students ⇨ overestimate average GPA for psych. students more so than for chem. students.

"Study Shows Psychology Majors Are Smarter Than Chemistry Majors"

Component 4: The exact nature of the ***measurements*** made or ***questions*** asked.

- GPA was "self-reported" and some students may not know GPA or one group may be more likely to know exact value than the other.
- Better method ⇨ obtain GPA from registrar.
- Is GPA a standard measure? Is grading more competitive on one department than other?
- Does GPA measure intelligence?

"Study Shows Psychology Majors Are Smarter Than Chemistry Majors"

Component 5: The ***setting*** in which the measurements were taken.

- Measurements taken on ***day before a holiday*** and many students may have left early.
- Students with low grades more likely absent from psychology class than from chemistry lab.
- Students' responses were anonymous

  ⇨ no accountability for incorrect answers.

"Study Shows Psychology Majors Are Smarter Than Chemistry Majors"

Component 6: *Differences* in the groups being compared, ***in addition*** to the factor of interest.

- Factor of interest = student's major (psych vs chem)
- Would the surveyed students *differ* in ways other than choice of major?
- At some universities, students required to have certain GPA before they can become a psych major.
- Universities with a premed major might have the better science students in premed and not chemistry.

"Study Shows Psychology Majors Are Smarter Than Chemistry Majors"

Component 7: The ***extent*** or ***size*** of any claimed effects or differences.

Reported:

- 3.05 GPA for psychology
- 2.91 GPA for chemistry.

Not Reported:

- how many students in each group
- what % of all students in each major were represented
- how much variation among GPAs within each group

Hypothetical News Article 2

PER CAPITA INCOME OF U.S. SHRINKS RELATIVE TO OTHER COUNTRIES

An independent research group, the Institute for Foreign Investment, has noted that the per capita income of Americans has been shrinking relative to some other countries. Using per capita income figures from the *World Almanac* and exchange rates from last Friday's financial pages, the organization warned that per capita income for the United States has risen only 10% during the past 5 years, whereas per capita income for certain other countries has risen 50%. The researchers concluded that more foreign investment should be allowed in the United States to bolster the sagging economy.

“Per Capita Income of U.S. Shrinks Relative to Other Countries”

Component 1: The ***source*** of the research and of the ***funding***.

- An “***independent***” research group does not imply an ***unbiased*** research group.
- Last line illustrates ***possible motive*** for research.

Component 2: The ***researchers*** who had ***contact*** with the participants.

- Not relevant as no participants in the study.

"Per Capita Income of U.S. Shrinks Relative to Other Countries"

Component 3: The ***individuals*** or objects studied and ***how*** they were selected.

- Countries were compared to U.S. but we don't know which countries were used, and why.

Component 4: The exact nature of the ***measurements*** made or ***questions*** asked.

- Current exchange rates used with older income figures.
- All figures should be adjusted to comparable measures of spending power, taking inflation into account.

“Per Capita Income of U.S. Shrinks Relative to Other Countries”

Components 5, 6, and 7:

The ***setting*** in which the measurements were taken. ***Differences*** in groups being compared, ***in addition*** to the factor of interest. The ***extent*** or ***size*** of any claimed effects or differences.

- Not relevant here, except as already discussed (adjusting for inflation, etc.).

Hypothetical News Article 3

RESEARCHERS FIND DRUG TO CURE EXCESSIVE BARKING IN DOGS

Barking dogs can be a real problem, as anyone who has been kept awake at night by the barking of a neighbor's canine companion will know. Researchers at a local university have tested a new drug that they hope will put all concerned to rest. Twenty dog owners responded to a newspaper article asking for volunteers with problem barking dogs to participate in a study. The dogs were randomly assigned to two groups. One group of dogs was given the drug, administered as a shot, and the other dogs were not. Both groups were kept overnight at the research facility and frequency of barking was observed. The researchers deliberately tried to provoke the dogs into barking by doing things like ringing the doorbell of the facility and having a mail carrier walk up to the door. The two groups were treated on separate weekends because the facility was only large enough to hold ten dogs. The researchers left a tape recorder running and measured the amount of time during which any barking was heard. The dogs who had been given the drug spent only half as much time barking as did the dogs in the control group.

"Researchers Find Drug to Cure Excessive Barking in Dogs"

Component 1: The ***source*** of the research and of the ***funding***.

- Unclear ***motive*** for research. If funded by drug company, then incentive for favorable results.
- If properly conducted, motives should be minimized.

Component 2: The ***researchers*** who had ***contact*** with the participants.

- Not clear who or how long handlers were with dogs.
- If not the same handlers for both groups, differences in handlers could explain results.

"Researchers Find Drug to Cure Excessive Barking in Dogs"

Component 3: The ***individuals*** or objects studied and ***how*** they were selected.

- Used dogs whose owners volunteered them as problem dogs ⇨ they may differ from general population.
- Problem behavior in dogs may have varied.
- Can't extend results to all dogs or even all problem dogs.
- Randomization to groups ⇨ can extend to all dogs similar to those in study.

"Researchers Find Drug to Cure Excessive Barking in Dogs"

Component 4: The exact nature of the ***measurements*** made or ***questions*** asked.

- Measured amount of time barking as a group of dogs, so one barking dog in control group could get whole group barking and explain the results.
- Better to separate dogs and measure each individually.

Component 5: The ***setting*** in which the measurements were taken.

- Measured on separate weekends ⇨ could differ wrt weather conditions, traffic noise, etc.
- Measured outside of dogs' natural environment.

"Researchers Find Drug to Cure Excessive Barking in Dogs"

Component 6: ***Differences*** in the groups being compared, ***in addition*** to the factor of interest.

- ***Randomization*** ⇨ minimized overall differences in size, temperament, etc. for dogs in two groups.
- Experiment induced differences - measured on different weekends, no placebo shot to control group.

Component 7: The ***extent*** or ***size*** of any claimed effects or differences.

- Only told treated group barked ***half as much***.
  10 minutes vs 20 minutes or 4 hours vs 8 hours?

Hypothetical News Article 4

SURVEY FINDS MOST WOMEN UNHAPPY IN THEIR CHOICE OF HUSBANDS

A popular women's magazine, in a survey of its subscribers, found that over 90% of them are unhappy in their choice of whom they married. Copies of the survey were mailed to the magazine's 100,000 subscribers. Surveys were returned by 5000 readers. Of those responding, 4520, or slightly over 90%, answered no to the question: "If you had it to do over again, would you marry the same man?" To keep the survey simple so that people would return it, only two other questions were asked. The second question was, "Do you think being married is better than being single?" Despite their unhappiness with their choice of spouse, 70% answered yes to this. The final question, "Do you think you will outlive your husband?" received a yes answer from 80% of the respondents. Because women generally live longer than men, and tend to marry men somewhat older than themselves, this response was not surprising. The magazine editors were at a loss to explain the huge proportion of women who would choose differently. The editor could only speculate: "I guess finding Mr. Right is much harder than anyone realized."

“Survey Finds Most Women Unhappy in Their Choice of Husbands”

Components 1 through 7:

Fatal flaw = volunteer response survey

- Of 100,000 who received survey, only 5% responded.
- Most likely to respond = those with strong opinion.
- Strong reaction to first question (women who are unhappy with current situation) would drive people to respond.
- Results not representative of ‘most women’ or even most subscribers to magazine.

Case Study 2.1: *Who Suffers from Hangovers?*

Source: News Story 2 in Appendix, Original Source 2 on CD

Component 1: The ***source*** of the research and of the ***funding***.

- News story states researchers were ‘a team at the University of Missouri-Columbia’ and study was ‘supported by the NIH’ [*National Institutes of Health*].

Component 2: The ***researchers*** who had ***contact*** with the participants.

- Not clear from news story.
- Journal states participants were enrolled in Intro Psych courses, so professors may have had contact.

Case Study 2.1: *Who Suffers from Hangovers?*

Component 3: The ***individuals*** or objects studied and ***how*** they were selected.

- News story states 1,230 drinking college students, only 5 percent of whom were of legal drinking age.
- Journal adds participation fulfills a course requirement.

Component 4: The exact nature of the ***measurements*** made or ***questions*** asked.

- News story provides some detail, but Journal gives much more – listing the 13 symptoms, 5-point rating scale, and more.

Case Study 2.1: *Who Suffers from Hangovers?*

Component 5: The ***setting*** in which the ***measurements*** were taken.

- Not specific and unclear if questions given to large group of students at same time or individually; or if responses were given anonymously.

Component 6: ***Differences*** in the groups being compared, ***in addition*** to the factor of interest.

- **Male/Female** was factor of interest.
- Possible extraneous variable is **body weight** – does weight difference, not gender, account for difference in hangover severity?

Case Study 2.1: *Who Suffers from Hangovers?*

Component 7: The ***extent*** or ***size*** of any claimed effects or differences.

- News story does *not* report how much difference in hangover severity was found between men and women.
- Journal does *not* report a simple difference. Differences only emerged after controlling for other factors.