

# Stat 201: Statistics I

## Chapter 1



date



# Chapter 1

## Introduction to Statistics

# Section 1.1

## Statistical and Critical Thinking

# What is statistics?

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“Statistics is the language of science.”

Statistics is also the language of...

- Politics (both campaigns and public policy)
- Economics
- Business
- Psychology and social sciences
- ...

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Statistics is involved in...

- Designing studies and experiments
- Collecting data
- Producing informative summaries of data
- Analyzing data
- Interpreting results (answering questions)



# Populations and samples

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A **census** is when data is collected from *every* member of a population.

A **sample** is a subset of a population used to represent the whole population.

# Population and sample examples

## Example

Population	Sample
The entire population of the United States	Respondents to an internet survey

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Population	Sample
The entire population of the United States	Respondents to an internet survey
Males over 40 who have high blood pressure	High blood pressure patients in a clinical trial
Students enrolled at Metro State in 2017	You (the students in this class)
Statistics classes in Minnesota	The summer semester statistics classes at Metro State

# Statistical thinking

## Prepare

- 1 Context
- 2 Source of the data
- 3 Sampling method

## Analyze

- 1 Graph the data
- 2 Explore the data
- 3 Apply statistical method

## Conclude

- 1 Significance



# Prepare: Context

- What do the data mean?
- What is the goal of the study?
- Can the data answer the question of interest?

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## Example

Suppose a group of researchers wants to study the association between intelligence and grades. So, they collect the GPAs of a random sample of students and measure their skull circumference. . .

## Note

This is not a completely made up example. Phrenology was the study of skull sizes and shapes, and was used as recently as the early 20th century to “prove” that non-white races were inferior and to diagnose mental illness.

# Prepare: Source of the data

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## Example

According to an article in the NY Daily News from June, 2014, titled, “Strip down: Sleeping naked is good for your relationship, survey says” (link)...

From a survey of 1000 British couples, “57% of those who reported sleeping in the buff said they felt happy, compared with 48% of pajama wearers and 43% of nightie wearers.”

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From a survey of 1000 British couples, “57% of those who reported sleeping in the buff said they felt happy, compared with 48% of pajama wearers and 43% of nightie wearers.”

- The survey was conducted by Cotton USA.

# Prepare: Sampling method

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## Example

- Call-in polls to radio or tv stations. . .
- Online surveys. . .
- Trending on twitter. . .

# Analyze

- 1 Graph the data
- 2 Explore the data
  - Are there any outliers?
  - What important statistics summarize the data?
  - How are the data distributed?
  - Are there missing data?
- 3 Apply statistical method

Most of the course concerns the analyze step.

# Conclude: Significance

- Do the results have statistical significance?
  - Statistical significance is a measure of how unlikely observed results are given certain assumptions.
  - Statistical significance is determined by many factors, including study design.
- Do the results have practical significance?
  - Do the results matter?

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## Example

A clinical trial shows a new drug lowers systolic blood pressure by an average of 3 mmHg. Results might be statistically significant, but are probably not practically significant.

# Potential pitfalls: Misleading conclusions

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## Example

Recall the sleeping naked study.

Though the article made the claim that sleeping naked **caused** happier relationships, the study merely pointed to an association.

There are many other possible explanations for that association. This study alone does not provide evidence for which explanation is “true”.

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  - Also known as: push polls

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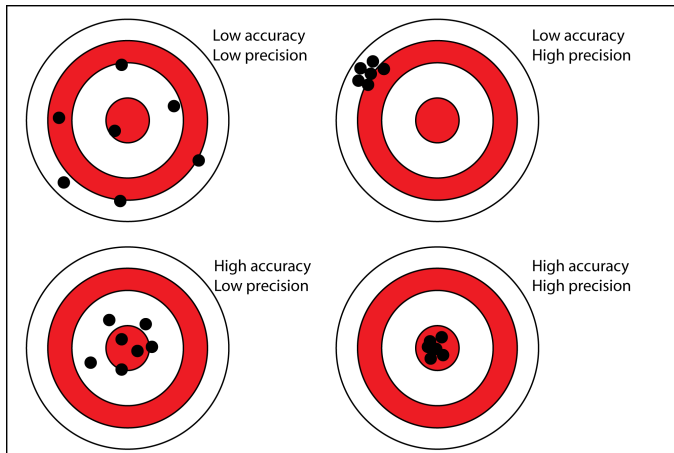
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- **Loaded questions** are those designed to elicit a particular response or to influence the subject.
  - Also known as: push polls
- The **order of questions** can influence responses.
- **Missing data** can introduce bias if there are characteristics shared by subjects who have missing data or those who do not.

# Potential pitfalls: Precise numbers

Precision is not the same thing as accuracy.



# Potential pitfalls: Percentages

Sometimes percentages are used in confusing ways. Remember, 100% of a thing is all of it. Percentages above 100, or phrases like “a reduction of 100%”, do not always have clear meanings.



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- 100% represents a whole, just as for proportions 1 represents a whole.
- It often doesn't make sense to talk about percentages greater than 100%.

# Percentages: Calculations

To convert from percentage to proportion, divide by 100:

$$56\% \Rightarrow \frac{56}{100} = 0.56$$

To convert from proportion to percentage, multiply by 100:

$$\frac{5}{8} = 0.625 \Rightarrow 0.625 \times 100 = 62.5\%$$

To find the quantity a percentage represents:

$$13\% \text{ of } 264 \Rightarrow \frac{13}{100} \times 264 = 34.32$$

To find the percentage a quantity represents:

$$135 \text{ out of } 475 \Rightarrow \frac{135}{475} \times 100 = 28.42 \dots \%$$

# Group work

- Get into groups of 2 - 4
- Introduce yourself. Tell your groups your major and why you are taking this class.
- For each question, read the scenario. Discuss and note some answers to part (a).
- Don't worry about getting exactly the right answers. Thinking about and discussing the question is more important.
- After about 15 minutes we will discuss as a class.

## Section 1.2

### Types of Data

# Parameters and statistics

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## Example

- The average height of adult men in the U.S. is 72 inches: **Parameter**
- The average height of 30 randomly selected male Metro State students is 68.5 inches: **Statistic**

# Types of data

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Also known as: Numeric

## Example

Class size, height, age, systolic blood pressure, temperature

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**Categorical** data are values representing groups or categories.

- Also known as: qualitative, attribute

## Example

Gender, state of residence, football player's numbers, pain scale

# Types of data: Quantitative

**Discrete** data have a finite, or countably infinite, number of possible values. There are gaps in the possible values.

## Example

Class size: can't have a class size of 22.5

# Types of data: Quantitative

**Discrete** data have a finite, or countably infinite, number of possible values. There are gaps in the possible values.

## Example

Class size: can't have a class size of 22.5

**Continuous** data have an infinite number of possible values. There are no gaps in possible values.

## Example

Height: a height of 70.2641... inches is possible (not necessarily useful, but possible)

# Levels of measurement

- Nominal
- Ordinal
- Interval
- Ratio

# Levels of measurement: Nominal

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## Example

- Gender: *male* or *female*
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## Example

- Gender: *male* or *female*
- State of residence: *Minnesota*, *Wisconsin*, etc.

## Hint

The root word *nom* means “name”.

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## Example

- Pain scale: *No pain* < *Moderate pain* < *Heavy pain*
- Grades: *A* > *B* > *C* > *D* > *F*

# Levels of measurement: Interval

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## Example

- Temperature: The difference between 101°F and 98.6°F is meaningful, but 0°F does not mean no temperature.
- Year: 2017 is four years after 2013, but year 0 does not mean no years.

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## Example

- Age: Someone who is 40 years old is *twice* as old as someone who is 20 years old. Zero does mean no age.
- Height: A tree that is 10 feet tall is *one third* as tall as a tree that is 30 feet tall. Zero does mean no height.



# Group work

- Get back into your groups.
- Discuss and note some answers to part (b) for each question.
- Remember, getting exactly the right answer is less important than the discussion.
- After about 15 minutes we will discuss as a class.

## Section 1.3

### Collecting Sample Data

- Recall, when we want to know something about a population and we can't collect data from the entire population, we can collect data from a subset, or a **sample**, of the population instead.

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- Therefore, how we pick our sample is very important in how valid the interpretation of our results are.

## Example

- Suppose an organization is interesting in the taco consumption by Metro State students. It would be difficult, if not impossible, to ask every student about their taco eating habits. A sample is needed.

## Types of samples: Random sample

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A **simple random sample** is a sample selected such that every possible sample of a specific size has an equal chance of being selected.

- These are the “best” kind of samples for producing valid, unbiased results, but they are not always easy to get.



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## Example

- Given an alphabetical list of students, use a random number generator to select a sample.

# Types of samples: Systematic sampling

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- Given an alphabetical list of students, select every fifth student until you have a sample of the desired size.

# Types of samples: Convenience sampling

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## Example

- Wander the halls before class, asking students who happen to walk by.
- Put a poll on the Metro State website.

# Types of samples: Stratified sampling

**Stratified sampling** is a method where the population is divided into groups and samples are selected from each group.

- Useful when you want to ensure that a factor of interest has enough representation, but it is not a random sample as we have defined it.

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## Example

- If we have particular interest in the taco consuming difference between graduate students and undergrads, select a sample from each group.

# Types of samples: Cluster sampling

**Cluster sampling** is a method where the population is divided into sections or clusters. Then, a number of clusters are randomly selected and all members of the clusters are included in the sample.

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## Example

- Choose 5 random classes, and survey all the students in those classes.

# Types of samples: Multistage sampling

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## Example

- Choose random classes by cluster sampling, and then take a simple random sample of students from each chosen class.

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In an **experiment** a change (treatment) is made to some or all of sample and then data is collected in order to detect changes.

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A **retrospective** study collects data from the past, whether from recollections or by examining records.

- Also known as: case-control

A **prospective** study follows subjects into the future to measure and collect data.

- Also known as: longitudinal study, cohort study



# Experiment design: Replication

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**Replication** is the repetition of the experiment on more than one individual or in more than one study.

- Experimental studies should have adequate sample sizes to ensure that observed effects are “true” effects and not due to individual characteristics or chance.
- Experimental studies should be, but rarely are, repeated by different researchers to verify results.

# Experimental design: Blinding

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- A **double blinded** study is one where both the subjects and the researchers administering treatment and gathering results don't know which treatment the subjects are receiving.

The **placebo effect** is a phenomenon where people who believe they are being treated demonstrate improvement.

# Experimental design: Randomization

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**Confounding variables** (or just confounders) are unmeasured and possible unknown factors that affect the experimental outcome.

# Group work

- Get back into your groups.
- Discuss and note some answers to part (c) for each question.
- After about 10 minutes we will discuss as a class.