PSQF 4143: Section 1

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Introduction to Statistics

- What is statistics?
  - Statistics is the science of gaining information from numerical data
- The root of statistics comes from numerical data
  - Produce data
  - Organize data
  - Draw conclusions from data

Descriptive Statistics

- Descriptive statistics aim to summarize or explore the data
  - Tell a story of data analysis
- These statistics can take the form of graphics, tables, or single numerical summaries
- Examples of this include:
  - Make summary statements about the data, on average...
  - Explore the distribution of the data, where do the bulk of the data fall?
  - Explore similarities or differences between groups

Inferential Statistics

- Inferential statistics aim to quantify uncertainty in the data and use probability to understand how likely a hypothesis is.
- Many inferential techniques aim to answer questions that explore the relationship between two or more variables.
- Inferential statistics are useful because it is common in an experiment to not have data on everything.
  - Example: Imagine testing for the presence of bacteria at a beach.
  - Example: Imagine exploring the relationship between amount of sleep the night before a test and the performance on a test.

Data Uncertainty

- Data vary
- As a result, conclusions on uncertain data are also uncertain.
- Statistics is a tool to help us quantify the uncertainty and use that to make meaningful conclusions.
- Statistics helps us determine if a result is spurious (uncertain) or meaningful.

Scaffolding for Research

- Think back to the scientific method from science classes in high school.
    1. Research Question
    2. Statistical Question
    3. Data Collection
    4. Data Analysis
    5. Statistical Conclusion
    6. Research Conclusion

Questions for Statistics

- The following are useful questions to always have in mind when considering a statistical technique:
    - What assumptions underlie the technique?
    - When and where is the technique valid?
    - What are the advantages and disadvantages of the technique relative to others?
    - What interpretations can be made based on the technique?
    - What are the common problems associated with the technique?

Variables vs Constants

- Variables:
    - vary
    - are commonly represented by symbols, x, y, z
    - need to be measured. Measurement of a variable is the process of assigning numbers or labels to characteristics of people, objects, or events according to a set of rules.
- Constants:
    - do not vary
    - are commonly represented by symbols, a, b, c

Types of variables

- Qualitative variables:
  - represent categories
  - are not numbers
  - but can be represented with numeric symbols
  - can be ordered or unordered
- Quantitative variables:
  - reflect numeric quantities
  - can be discrete or continuous

Levels of Measurement

- Nominal Measurement:
  - represent mutually exclusive categories
  - are commonly represented with labels
  - can be represented with numeric labels
  - is not meaningful to manipulate mathematically
  - carries no meaningful order
- Ordinal Measurement:
  - carries all information from nominal measurement
  - represent mutually exclusive categories that are ordered
- Interval Measurement:
- carries all information from nominal and ordinal measurement
- represent equal distance between equivalent gaps
- 0 is not meaningful
- can now perform linear transformations meaningfully
- Ratio Measurement:
- carries all information from nominal, ordinal, and interval measurement
- but now 0 measn the absence of the phenomenon
- can only be transformed by multiplying

Measurement in the Social Sciences

- When measuring variables with an instrument or questionnaire, there is commonly a lack of equal intervals or an absolute zero.
- Examples: creativity, problem solving, attitude toward statistics, achievement
  - The distances between adjacent scores based on an instrument are likely not equal.
  - For an achievement test, if an individual can not answer any questions, that does not mean they have a total absence of ability/achievement.

Measurement of Ordered Variables

- The purpose of measurement is to differentiate among individuals or objects on a variable.
- To do this, rules must be established to assign values to a specific variable.
- When the rules for a measurement process are not widely accepted, we must adopt a two-step measurement process.

Two Step Measurement Process

1. Develop a *conceptual* definition.
    - This is abstract or a theoretical definition
2. Develop an *operational* definition

- More concrete
- Based on the conceptual definition
- Commonly defines rules to allow for the measurement of the phenomenon.

Two Step Measurement Process Example

- Consider the variable motivation
- Conceptual Definition
    - The general desire or willingness of someone to do something
- Operational Definition
    - Give a list of 50 statements of tasks.
    - Then ask each individual to indicate the extent they enjoy doing each task - from strongly do not enjoy to strongly enjoy.

Reliability

- A measurement process is reliable if *repeated measurements* on the *same individual* give the same (or similar) results.
- Examples:
    - If a second set of 50 similar tasks were given to the same individuals, would individuals order the tasks similarly?
    - If the same set of 50 tasks were given to the same individuals, would the students be order the tasks similarly?

Validity

- A variable is a valid measure of a property if it is relevant or appropriate as a representation of that property.
- Is the ordering of individuals based on a particular operational definition the same as (or similar to) the ordering based on a different operational definition?
- A common question to test validity is to ask ourselves whether the measure reflects the construct of interest.
  - More simply, are we measuring what we want or something else?

Real Limits

- The real limits of a score extend from one-half of the smallest unit of measurement below the value of the score to one-half unit above
- Examples:
  - Consider a distance of 85 inches, measured to the nearest inch (the smallest unit of measurement is one inch).
    - The real limits of 85 extend from 84.5 to 85.5.
    - As such, a score of 85 inches actually represents all values between 84.5 and 85.5.
  - Suppose we measure length to the nearest tenth of an inch
    - A measurement of 2.3 inches - what are the real limits?
    - 2.25 to 2.35 inches.
- Unfortunately there are exceptions.
  - Age is one example
- No score can ever fall right on a real limit, because we calculate real limits by taking half of the smallest unit of measurement.

Real Limits 2

- Example:
  - Consider grade point averages in the interval from 2.60 to 2.79.
    - The smallest unit of measurement is one-hundredth.
    - The lower and upper real limits of the interval are 2.595 and 2.795 respectively.

Population vs Sample

- Population:

  - The complete set of observations about which a researcher wishes to draw a conclusion.
  - A descriptive index of a population is referred to as a *parameter*.
  - Population Parameter

- Sample:
  - Part of the population about which a researcher wishes to draw a conclusion.
  - A descriptive index of a sample is referred to as a *statistic*.
  - Sample Statistic

Random Sample

- A random sample is a sample obtained such that each individual has an equal chance of being selected at any stage of the sampling process.
- Also, each possible sample of the same size has an equal probability of being selected from the population.
- A population is defined by the interest of the investigator.

Inferential Statistics

- With inferential statistics, we are interested in estimating population parameters from sample statistics.
- An essential assumption in inferential statistics is that samples are drawn randomly from a particular population.
- If several random samples of the same size are drawn from the same population, the samples will most likely differ, and therefore their characteristics (statistics) will vary from sample to sample.
- The variation is due to chance variation associataed with random sampling.
  - This is commonly called sampling error.
- The larger the random sample from the population, the less the variation between samples.
- In general larger random samples will provide a more precise estimate of what is true about a population.