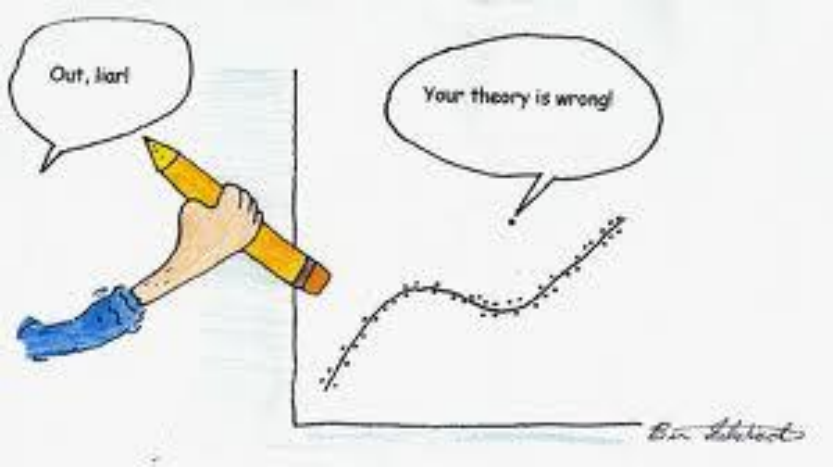
Chapter 1:
Introduction to Statistics



Name _____

Period _____

1.1 Review and Preview

Data: collections of observations

→ Ex: measurements, genders, survey responses

Statistics: The science of planning studies and experiments, obtaining data, & then organizing, summarizing, presenting, analyzing, interpreting, & drawing conclusions based on the data

Common & Important Goal of Statistics: to learn about a large group by examining data from some of its members

Population: the complete collection of ALL measurements or data that is being studied

→ Ex: scores, people, measurements, etc.

Census: collection of data from every member of the population

Sample: a subcollection of members selected from a population

*It is critical to obtain sample data that are representative of the population being studied

→ The data must be collected in an appropriate way (ie: random sampling); otherwise the data is useless.

→ Ex: If you surveyed your graduating class by asking them to write their annual income & mail it back to you, the responses won't be representative of the population.

Ex: The Gallup corporation collected data from 1013 adults in the United States. Results showed that 66% of the respondents worried about identity theft.

→ What is the population?

→ What is the sample?

→ What was the objective of this study?

1.2 Statistical and Critical Thinking

Key Elements in a Statistical Study:

Prepare Data:

1. Context
    - What does the data mean? What is the goal of the study?
2. Source of the Data
    - Are the data from a source with a special interest so that there is pressure to obtain results that are favorable to the source?
3. Sampling Method
    - Were the data collected in a way that is unbiased?

Analyze Data:

4. Graph the Data
5. Explore the Data
    - Were there any outliers? How is the data distributed? Are there missing data? What important statistics summarize the data?
6. Apply Statistical Methods
    - Use technology to obtain results

Form Conclusions:

7. Statistical Significance
    - Do the results have statistical significance?
        - Achieved in a study when we a get a result that is very unlikely to occur by chance
    - Do the results have practical significance?
        - Common sense may suggest that the finding does not make enough of a difference to justify its use or to be practical

Ex: Determine whether there is a relationship between IQ score and brain volume.

IQ	96	87	101	103	127	96	88	85	97	124
Brain Volume (cu. cm)	1005	1035	1281	1051	1034	1079	1104	1439	1029	1160

Context: The data in the table consists of measured IQ scores and measured brain volumes from 10 different subjects suggesting a possible hypothesis: People with larger brains tend to have higher IQ scores.

Source of the Data: "Brain Size, Head Size, and IQ in Monozygotic Twins" article written by M.J. Tramo, W.C., Loftus, T.A. Stukel, J.B. Weaver, and M.S. Gazziniga

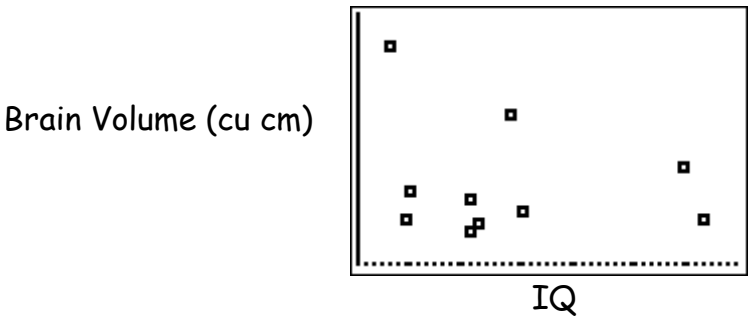
→ Researchers are from reputable medical schools & hospitals

→ Would not gain by putting a spin on the results

→ When physicians who conduct clinical experiments of the efficacy of drugs receive funding from drug companies, they have an incentive to obtain favorable results

Sampling Method: Subjects were recruited and paid for their participation, all were between the ages of 24 and 43, all had at least a high school education, and no subjects' medical history included neurologic or psychiatric disease.

Graph the Data:



Explore the Data: One outlier of an IQ of 85 and a brain volume of 1439, there is no missing data, the data does not appear to follow any type of pattern between IQ or brain volume—certainly not increasing.

Apply Statistical Methods: Correlation coefficient was found to be -0.22 using the TI graphing calculator indicating a very weak, negative correlation

Conclusion: There is not enough data or evidence to conclude there is a relationship between IQ and brain volume.

Pitfalls of Analyzing Data:

→ *Voluntary response sample (self-selected sample):* the respondents themselves decide whether to be included

- Ex: polls conducted through the internet, mail, or telephone
- Ex: readers of Newsweek magazine are asked to respond online to the question: "Will you still use Napster if you have to pay a fee?"
- Conclusions can only be made about those who respond, not the population

→ *Correlation & Causality:* when we find a statistical association between two variables, we cannot conclude that one of the variables is the cause of the other

- Ex: wealth & IQ

→ *Reported Results*: When collecting data from people, it is more accurate to take measurements yourself rather than asking subjects to record results

- Ex: If you measure people's weights, they will probably differ from the weights the same people would tell you

→ *Small samples:* conclusions should not be based on samples that are too small

- Ex: The Children's Defense Fund published "Out of School in America" where it reported that among high school students in this region, 67% were suspended at least 3 times

- Just because a sample is large, doesn't mean it was collected in an appropriate way

→ *Loaded Questions:* survey questions can be intentionally worded to elicit a desired response

- Ex: Even though it's the poor who receive welfare, only 19% agreed that too little money is being spent when the word "welfare" was used, but 63% agreed when it was worded "assistance to the poor"

→ *Order of Questions:* the order of questions can sway readers to respond one way or another

- Ex: When asked what contributes more to air pollution—traffic or pollution, more people blamed which ever was presented first.

→ *Nonresponse:* someone either refuses to respond to a survey question or the person is unavailable

- High refusal rate because of persistent telemarketers

- Sugging: sales pitch that initially sounds like an opinion poll

→ *Missing Data:* sometimes data values are missing…

- At random
- Due to special factors

→ *Precise Numbers:* sometimes data that is given as a very precise number is incorrectly assumed as being accurate also

- It would be better to say there the number of adults in the U.S. is about 240 million, rather than stating that there are 241,472,385

→ *Percentages:* misleading or unclear percentages are used

- Percent means "divided by 100"
- To find the percent of a number:
  --Find 6% of 1200
- To change a fraction to a percent:
  --Express $\frac{3}{4}$ as a percent
- To change a decimal to a percent:
  --Express 0.25 as a percent
- To change a percent to a decimal:
  --Express 85% as a decimal
- Ex: If you take 100% of a quantity, you take it all.

1.3 Types of Data

Parameter: a numerical measurement describing some characteristic of a population

→ Ex: Of the total 3,250 pedestrian pushbuttons in NYC, 77% do not work.

Statistic: a numerical measurement describing some characteristic of a sample

→ Ex: Out of 877 executives surveyed, 45% said they wouldn't hire someone with a typo on their job application.

Ex: In a Harris poll, 2320 adults in the US were surveyed about body piercings and 5% of respondents said that they had a body piercing but not on the face. Based on the latest available data there are 241,472,385 adults in the US.

Parameter:

Statistic:

Categorical Data (also known as qualitative or attribute data): data that can be separated into different categories by a non-numeric characteristic

→ Ex: eyecolors or genders of professional athletes

→ Categorical data as numbers: The numbers 12, 74, 77, 76, 73, 78, 88, 19, 9, 23 and 25 were sewn on the jerseys of the starting offense for the New Orleans Saints (these numbers are substitutes for names and do not measure or count anything)

Quantitative Data: consist of numbers representing counts or measurements

→ Ex: heights or weights of supermodels

→ Use the appropriate unit of measure

→ *Three types of quantitative data*:

1. Finite Discrete Data: the number of possible values is a finite or countable number
   -- Ex: # of eggs a hen laid

2. Infinite Discrete Data: You could count the number of trials, but never reach success
   --Ex: you could roll a die

3. Continuous (or Numerical) Data: infinitely many possible values that correspond to some continuous scale that covers a range of values without gaps, interruptions, or jumps
   -- Ex: amount of milk from a cow

Another Way to Classify Data—Using 4 Levels of Measurement:

1. *Nominal:* data consists of names, labels, or categories only

   → Lack ordering & shouldn't be used for calculations
   → Ex: survey responses (yes, no, undecided), Social Security Numbers (are substitutes for names & do not count or measure anything)

2. *Ordinal:* data can be arranged in some order but differences between data values either can't be determined or are meaningless

   → Ex: ranking vacation destinations 1 to 5

3. *Interval:* data can be arranged in some order & the difference between any two data values is meaningful but there is NO natural zero or starting point

   → Ex: temperatures

   → Ex: the years 1000, 2008, 1776, 1492

4. *Ratio:* data can be arranged in some order, the difference between any two data values is meaningful, & there IS a natural zero starting point

   → Ex: prices of college textbooks

   → Ex: weights (in carats) or diamond engagement rings

   → zero starting points makes ratios meaningful

1.4 Collecting Sample Data

***If sample data are not collected in an appropriate way, the data may be so utterly useless that no amount of statistical torturing can salvage them.**

Observational Study: we observe & measure specific characteristics without attempting to modify the subjects being studied

Ex: Gallup poll

Experiment: application of some treatment & then observation of its effects on the subjects

→ *Experimental Units:* subjects in experiments

-- ex: clinical trial of the drug Lipitor

→ Experiments are often better than observational studies because they typically reduce the chance of having the results affected by some variable that is not part of the study (lurking variable)

--In an observational study, you may incorrectly conclude that ice cream causes drowning. When you notice temperature as the lurking variable and perform an experiment, where one group got ice cream and the other did not, you'd notice that ice cream consumption has no effect on drowning.

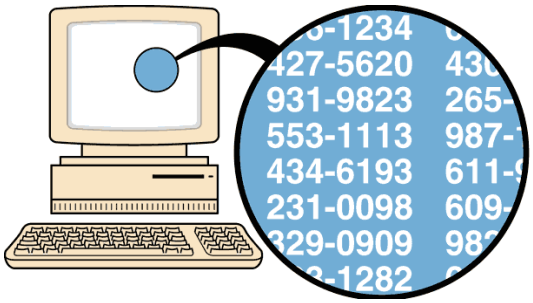
Common Methods of Sampling:

*It is essential to select the sample of subjects in such a way that the sample is likely to be representative of the larger population

- *Random sample:* members from the population are selected in such a way that each individual member has an equal chance of being selected

→ selected by many different methods

→ must be planned & carried out carefully



- *Simple random sample* (of size n): selected in such a way that every possible sample of the same size n has the same chance of being chosen

  Ex #1: A teacher selects 10 students by rolling a die and selecting the corresponding row (6 rows of 10 students)

  → random sample?

  → simple random sample?

  Ex #2: Consider a box with 100 marbles. You reach in and select 13 marbles. Is this a random sample or a simple random sample?

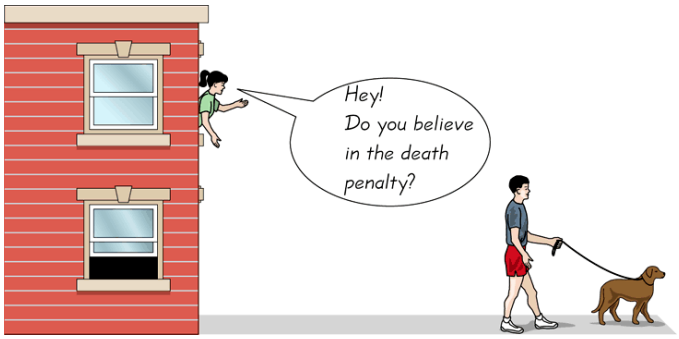
  Ex #3: For the Presidential election, you select a random sample of all voting precincts in your state and then interview all the voters as they leave the polling place. Is this a random sample or a simple random sample?

❖ *Systematic Sampling:* we choose some starting point & select every k^{th} element in the population

→ Ex: every 3rd person who enters

❖ *Convenience Sampling:* we simply use results that are very easy to get

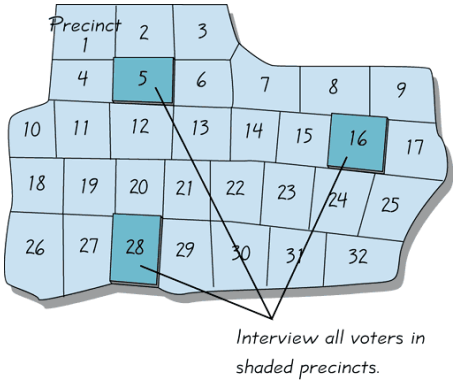
→ Ex: sample only those in this class



❖ *Stratified Sampling:* subdivide the population into at least two different subgroups so that subjects within the same subgroup share the same characteristics, then we draw a sample from each subgroup

❖ *Cluster Sampling:* divide the population area into sections or clusters then randomly select some of those clusters & then choose all the members from those selected clusters

→ Cluster sampling uses all members from a sample of clusters; whereas, stratified sampling uses a sample of members from all subgroups (& often reduces variation in the results).



❖ *Multistage Sampling:* selection of a sample in different stages that might use different methods of sampling

→ Very complicated sampling design but it is more practical & less expensive than a simpler design

→ Used by the US Census Bureau

3 Types of Observational Studies:

1. Retrospective Study (also called case-control study): data are collected from the past by going back in time through examination of records, interviews…

→ collect data about the resulting characteristic that is of concern

→ Ex: collect data about a group of drivers who died in car crashes & a group of drivers who did not die in car crashes

2. Cross-Sectional Study: data are observed, measured, & collected at one point in time

3. Prospective Study (also called longitudinal or cohort): data are collected in the future from groups sharing common factors (called cohorts)

→ Follow groups with a potentially causative factor & those without it

→ Ex: a group of drivers who use cell phones & a group that does not

Three Factors in Designing Experiments:

1. Use randomization
2. Use replication
3. Control the effects of variables

Randomization: used when subjects are assigned to different groups through a process of random selection

→ Uses chance as a way to create two groups that are similar (flipping a coin)
→ Still possible for randomization to result in unbiased samples, especially if sample sizes are very small

Replication: the repetition of an experiment on more than one subject

→ Replication is effective when we have enough subjects to recognize the differences resulting from different treatments.

Controlling Effects of Variables:

→ *Confounding:* occurs in an experiment when you are not able to distinguish among the effects of different factors

- Results of the experiment may be ruined because of confounding
- Try to plan the experiment so confounding doesn't occur

→ *Blinding:* an experiment where one treatment group is given a particular drug & a second group is given a placebo that contained no drug at all

- Placebo effect: occurs when an untreated subject reports an improvement in symptoms

- Blinding: the subject doesn't know whether he is receiving the treatment or placebo

- Double blind: subjects & doctors don't know who received the treatment & who got the placebo

→ *Completely Randomized Experimental Design:* subjects are assigned to different treatment groups through a process of random selection

- Ex: flip a coin to determine which trees got fertilizer

→ *Randomized Block Design:* a group of subjects that are similar but blocks are different in the ways that may affect the outcome of the experiment

- Form blocks or groups of subjects with similar characteristics, then randomly assign treatments to the subjects within each block

- Ex: testing fertilizer on a block of trees in dry soil & a block in moist soil because the moisture content of the soil can affect tree growth

- Ex: make sure some trees in the moist soil have fertilizer & others don't so that you can determine if it was the fertilizer or moisture that was effective (watering, temperature, & sunlight must also be controlled)

→ *Matched Pairs Design:* compare two treatment groups by using subjects matched in pairs that are somehow related or have similar characteristics

Ex: Before/After: You can collect measurements from subjects before and after some treatment

Ex: Twins: One twin was given Crest and the other was given another toothpaste to test Crest

→ *Rigorously Controlled Design:* subjects are very carefully chosen so that those given each treatment are similar in the ways that are important to the experiment

- Ex: you are testing the effectiveness of a drug that lowers blood pressure. If the placebo group contains a 30-year old overweight, male, smoker who drinks heavily & consumes an abundance of salt & fat, the treatment group should also include a person with these characteristics

Sampling Error: occurs when the sample has been selected with a random method, but there is a difference between a sample result & true population result

- Error that comes from chance simple fluctuations

Nonsampling Error: occurs as a result of human error such as when the sample data are incorrectly collected, recorded, or analyzed

- Ex: selecting a biased sample; using a defective measure instrument; copying the data incorrectly

Nonrandom Sampling Error: the result of using a sampling method that is not random such as using a convenience or voluntary response sample