Sample Surveys

11.3 - Collecting Data

Stratified Sampling

- Simple random sampling is not the only fair way to sample.
- More complicated designs may save time or money or help avoid sampling problems.
- All statistical sampling designs have in common the idea that chance, rather than human choice, is used to select the sample.

11.3 - Collecting Data

Stratified Sampling (cont)

- Designs used to sample from large populations are often more complicated than simple random samples.
- Sometimes the population is first sliced into homogeneous groups, called strata, before the sample is selected.
- The simple random sampling is used within each stratum before the results are combined.
- This common sampling design is called stratified random sampling.

11.3 - Collecting Data

Cluster and Multistage Sampling

- Sometimes stratifying isn't practical and simple random sampling is difficult.
- Splitting the population into similar parts or clusters can make sampling more practical.
  - Then we could select one or a few clusters at random and perform a census within each of them.
  - This sampling design is called cluster sampling.
  - If each cluster fairly represents the full population, cluster sampling will give us an unbiased sample.

11.3 - Collecting Data

Cluster and Multistage Sampling (cont)

- Cluster sampling is not the same as stratified sampling.
  - We stratify to ensure that our sample represents different groups in the population, and sample randomly within each stratum.
    - Strata are homogeneous, but differ from one another.
  - Clusters are more or less alike, each heterogeneous and resembling the overall population.
    - We select clusters to make sampling more practical or affordable.

11.3 - Collecting Data

Systematic Samples

- Sometimes we draw a sample by selecting individuals systematically.
  - For example, you might survey every 10th person on an alphabetical list of students.
- To make it random, you must still start the systematic selection from a randomly selected individual.
- When there is no reason to believe that the order of the list could be associated in any way with the responses sought, systematic sampling can give a representative sample.

11.3 - Collecting Data

Cluster and Multistage Sampling (cont)

- Sometimes we use a variety of sampling methods together.
- Sampling schemes that combine several methods are called multistage samples.
- Most surveys conducted by professional polling organizations use some combination of stratified and cluster sampling as well as simple random sampling.

11.3 - Collecting Data

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A statistics teacher wants to know how her students feel about an introductory statistics course. She decides to administer a survey to a random sample of students taking the course. She has several sampling plans to choose from. Name the sampling strategy in each.

a. There are four ranks of students taking the class: freshmen, sophomores, juniors, and seniors. Randomly select 15 students from each class rank. — Stratified

b. Randomly select a class rank (freshmen, sophomores, juniors, and seniors) and survey every student in that class rank. — Cluster

c. Each student has a nine-digit student number. Randomly choose 60 numbers. — Simple

d. Using the class roster, select every fifth student from the list. — Systematic

Collecting Data

11.3 - Collecting Data

Self-Selected Sample

- For a self-selected sample, members of a population can volunteer to be in the sample.(aka voluntary sample)

11.3 - Collecting Data

What can go wrong? (Sampling badly)

- Sample Badly with Volunteers:
  - In a voluntary response sample, a large group of individuals is invited to respond, and all who do respond are counted.
    - Voluntary response samples are almost always biased, and so conclusions drawn from them are almost always wrong.
  - Since the sample is not representative, the resulting voluntary response bias invalidates the survey.

11.3 - Collecting Data

What can go wrong? (Sampling badly) (cont)

- In convenience sampling, we simply include the individuals who are convenient.
  - Unfortunately, this group may not be representative of the population.
  - Convenience sampling is a widespread problem in the business world—the easiest people for a company to sample are its own customers.

11.3 - Collecting Data

What else can go wrong? (cont)

11/29

- Work hard to avoid influencing responses.
  - Response bias refers to anything in the survey design that influences the responses.
  - For example, the wording of a question can influence the responses:

11.3 - Collecting Data

12/29

Practice

Management at a retail store is concerned about the possibility of drug abuse by people who work there. They decide to check on the extent of the problem by having a random sample of the employees undergo a drug test. Several plans for choosing the sample are proposed. Name the sampling strategy in each.

Name and describe the kind of bias that might be present if the management decides that instead of subjecting people to random testing they'll just…

a. Hold department meetings and drug test the employees that attend.

Convenience sample; bias: under or overcoverage. We are sampling the employees that show up, which might not be representative of the entire retail staff.

b. Offer additional employee discounts for those employees who agree to be drug tested.

Voluntary response sample; bias: toward employees who shop at the store. Employees who do use drugs would probably not volunteer for any reason.

11.3 - Collecting Data

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Practice

Listed below are the names of 20 students who are juniors. Use the random numbers listed below to select five of them to be in your sample. Clearly explain your method.

01 - Adam	02 - Chris	03 - Dave	04 - Deirdre	05 - Dick
06 - Ellen	07 - Eric	08 - Joan	09 - John	10 - Judi
11 - Joy	12 - Kenny	13 - Laura	14 - Mary	15 - Paul
16 - Peter	17 - Rachel	18 - Rob	19 - Sara	20 - Stacey

Name and describe the kind of bias that might be present if the statistics teacher decides that instead of randomly selecting students to survey on how they feel about the course she just…

a. asks students to volunteer for the survey.

Voluntary response sample—the bias would probably be towards those students who say they enjoy the course.

b. **Gives the survey during one day because there is no lesson planned**

Convenience sample—the bias would probably be towards students who happen to attend class that day.

Experiments and Observational Studies

11.4 - Experimental Design

Observational Studies

- In an observational study, researchers don't *assign* choices; they simply observe them.
  - An example looked at a student of the relationship between music education and grades.
  - Since the researchers did not assign students to get music education and simply observed students "in the wild," it was an observational study.

11.4 - Experimental Design

Observational Studies (cont)

- Because researchers in the text example first identified subjects who studied music and then collected data on their past grades, this was a retrospective study.
- Had the researchers identified subjects in advance and collected data as events unfolded, the study would have been a prospective study.
- Observational studies are valuable for discovering ***trends*** and possible ***relationships***.
- However, it is not possible for observational studies to demonstrate a causal relationship.

11.4 - Experimental Design

Randomized, Comparative Experiments (cont)

- In general, the individuals on whom or which we experiment are called experimental units.
  – When humans are involved, they are commonly called subjects or participants.
- The specific values that the experimenter chooses for a factor are called the levels of the factor.
- A treatment is a combination of specific levels from all the factors that an experimental unit receives.

11.4 - Experimental Design

The Four Principles of Experimental Design

- 1. Control: – We control sources of variation other than the factors we are testing by making conditions as similar as possible for all treatment groups.
- 2. Randomize: Randomization allows us to equalize the effects of unknown or uncontrollable sources of variation.
- 3. Replicate: Repeat the experiment, applying the treatments to a number of subjects.
- 4. Block: Sometimes, attributes of the experimental units that we are not studying and that we can't control may nevertheless affect the outcomes of an experiment.

11.4 - Experimental Design

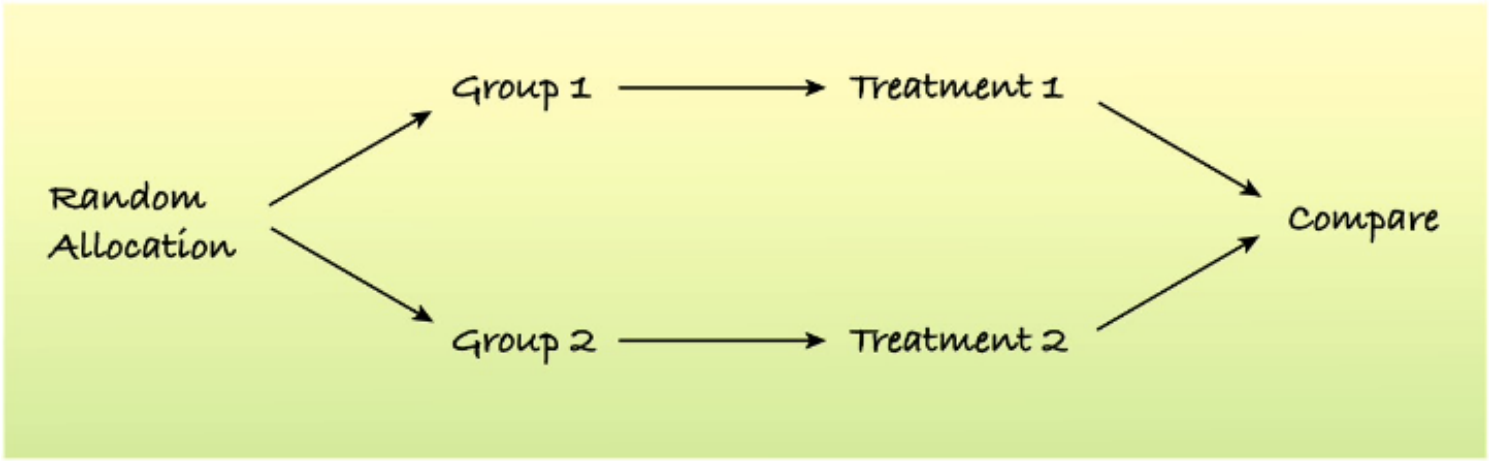
The Four Principles of Experimental Design (cont)

- To Block:
  - We group similar individuals together and then randomize within each of these blocks, we can remove much of the variability due to the difference among the blocks.
  - Note: Blocking is an important compromise between randomization and control, but, unlike the first three principles, is not required in an experimental design.

11.4 - Experimental Design

Diagrams of Experiments

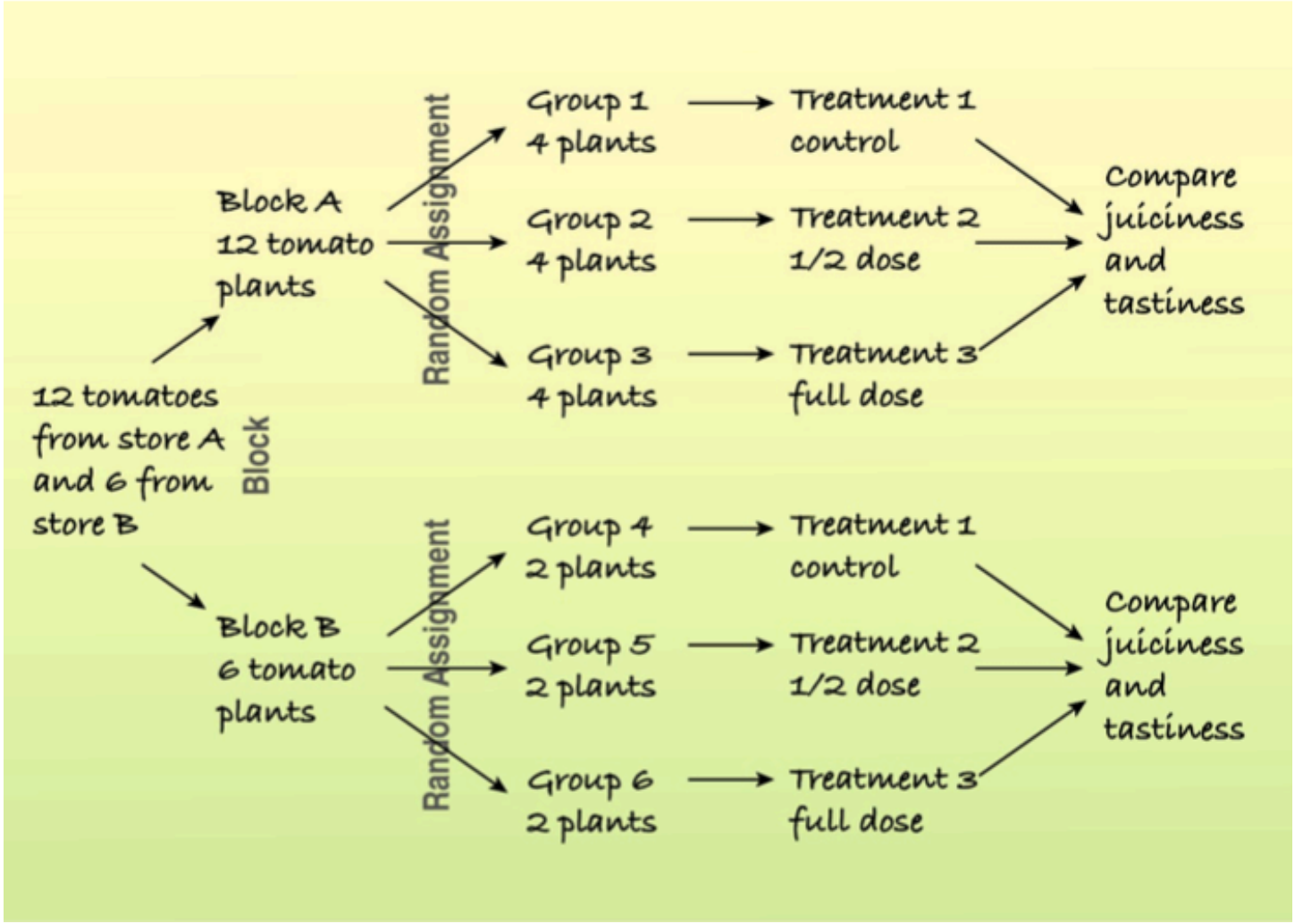
- It's often helpful to diagram the procedure of an experiment.
- The following diagram emphasizes the random allocation of subjects to treatment groups, the separate treatments applied to these groups, and the ultimate comparison of results:



11.4 - Experimental Design

Blocking (cont)

- Here is a diagram of a blocked experiment:



11.4 - Experimental Design

Control Treatments

- Often, we want to compare a situation involving a specific treatment to the status quo situation.
- A baseline (“business as usual”) measurement is called a control treatment, and the experimental units to whom it is applied is called the control group.

11.4 - Experimental Design

Blinding

- There are two main classes of individuals who can affect the outcome of the experiment:
  – those who could influence the results (subjects, treatment administrators, technicians)
  – those who evaluate the results (judges, treating physicians, etc.)
- When every individual in either one of these classes is blinded, an experiment is said to be single-blind.
- When everyone in both classes is blinded, the experiment is called double-blind.

11.4 - Experimental Design

Practice

An article in a local newspaper reported that dogs kept as pets tend to be overweight. Veterinarians say that diet and exercise will help these chubby dogs get in shape. The veterinarians propose two different diets (Diet A and Diet B) and two different exercise programs (Plan 1 and Plan 2). Diet A: owners control the portions of dog food and dog treats; Diet B: a mixture of fresh vegetables with the dog food and substitute regular dog treats with baby carrots. Plan 1: three 30-minute walks a week; Plan 2: 20-minute walks daily. Sixty dog owners volunteer to take part in an experiment to help their chubby dogs lose weight.

1. Identify the following:
   a. the subjects:

      60 chubby dogs

   b. the factor(s) and the number of level(s) for each:

      diet (two levels) and exercise (two levels)

   c. the number of treatments:

      four treatments (Diet A and Plan 1, Diet A and Plan 2, Diet B and Plan 1, Diet B and Plan 2)

   d. whether or not the experiment is blind (or double-blind):

      This design is at best single-blind, since the owners know which diet and exercise plan their dogs are on, but the evaluators do not have to be given this information.

   e. the response variable:

      weight loss

11.4 - Experimental Design

Placebos

- Often simply applying any treatment can induce an improvement.
- To separate out the effects of the treatment of interest, we can use a control treatment that mimics the treatment itself.
- A “fake” treatment that looks just like the treatment being tested is called a placebo.
  – Placebos are the best way to blind subjects from knowing whether they are receiving the treatment or not.

11.4 - Experimental Design

Practice

A group of people are concerned that the coach of a local high school men's and women's basketball teams alters the amount of air in the basketball to gain an unfair advantage over opponents during home games. The idea is that the basketballs are pumped up with one pound per square inch less air than required, and his teams practiced with these altered balls all week prior to home basketball games. Since these under-pumped basketballs would react differently, the team that practiced with these balls would have an unfair rebounding advantage when the balls bounced off the backboard and rim.

1. Describe how to use a retrospective study to determine if the home teams had an unfair rebounding advantage.

   A retrospective study is an observational study in which past games are reviewed to see how many rebounds the team when they had the altered basketballs versus when they had basketballs pumped up correctly. The difference in the number or percentage of rebounds made would be compared between the two types of basketballs.

2. Describe how to use a prospective study to determine if the home teams had an unfair rebounding advantage.

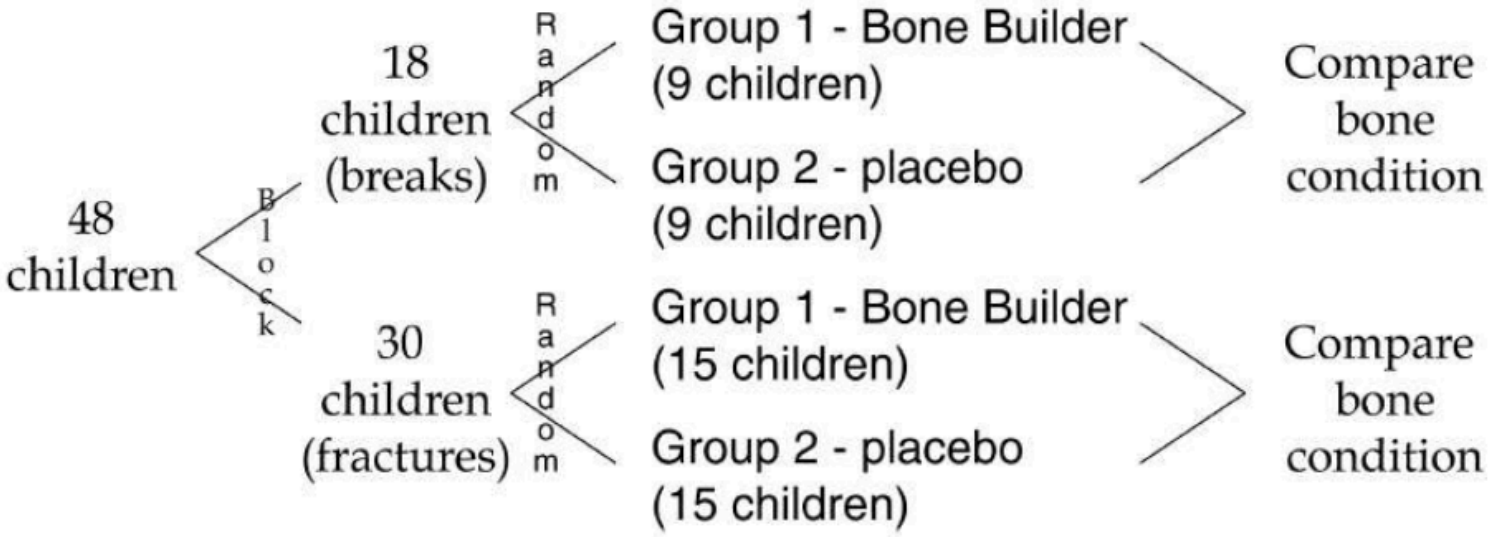
   A prospective study is an observational study in which teams are selected and then their future rebounds are recorded to see if they improve when they have the altered basketballs. The difference in the number or percentage of rebounds made would be compared between the two types of basketballs.

11.4 - Experimental Design

Practice

14. **Bone Builder** Researchers believe that a new drug called Bone Builder will help bones heal after children have broken or fractured a bone. The researchers believe that Bone Builder will work differently on bone breaks than on bone fractures. Bone Builder will be used in conjunction with traditional casts. To test the impact of Bone Builder on bone healing, the researchers recruit 18 children with bone breaks and 30 children with bone fractures. Design an appropriate experiment to determine if Bone Builder will help bones heal.

Bone Builder



11.5 - Making Inferences from Sample Surveys

Descriptive statistics - organization, summarization and display of data.

Inferential statistics - using a sample to draw conclusions about a population.

Here is the number of friends for a random sample of 30 teens. Find the sample mean $\bar{x}$.

Number of Friends				
305	237	261	374	341
257	243	352	330	189
297	418	275	288	307
295	288	341	322	271
209	164	363	228	390
313	315	263	299	285

mean = 294 friends

11.5 - Making Inferences from Sample Surveys

Sample size differences can produce different results.

Larger sample sizes tend to produce more accurate estimates.

Two candidates are running for class president. The table shows the results of four surveys of random students. Do you think the incumbent will be reelected?

Sample Size	Number of "Yes" Responses	Percent of Votes for Incumbent
10	7	70%
20	11	55%
30	13	43.3%
40	17	42.5%

11.5 - Making Inferences from Sample Surveys

Margin of Error Formula

When a random sample of size n is taken from a large population, the margin of error is approximated by

$$\text{Margin of error} = \pm\frac{1}{\sqrt{n}}.$$

This means that if the percent of the sample responding a certain way is p (expressed as a decimal), then the percent of the population who would respond the same way is likely to be between $p - \frac{1}{\sqrt{n}}$ and $p + \frac{1}{\sqrt{n}}$.

- In a survey of 1028 people in the US, 87% reported using the Internet. Give an interval that is likely to contain the exact percentage.

Between 83.9% and 90.1%