In Chapter 8, we cover …

- Population versus sample
- How to sample badly
- Simple random samples
- Inference about the population
- Other sampling designs
- Cautions about sample surveys
- The impact of technology
1 Motivation of this chapter

- Sometimes we have data that describe a group of individuals and want to learn what the data say.

- Sometimes we have specific questions but no data to answer them.

- For example,

  1. Suppose our question is “What percent of college students think that people should not obey laws that violate their personal values?”

  2. To answer the question, we interview undergraduate college students.

  3. We cannot afford to ask all students.

  4. So we put the question to a sample chosen to represent the entire student population.

- We should choose a sample that truly represents the opinions of the entire population.
The distinction between population and sample is basic to statistics. To make sense of any sample result, you must know what population the sample represents.

- The **population** in a statistical study is the entire group of individuals about which we want information.
- A **sample** is the part of the population from which we actually collect information. We use information from a sample to draw conclusions about the entire population.
- A **sampling design** describes exactly how to choose a sample from the population.

The first step in planning a **sample survey** is to say exactly what **population** we want to describe.

The second step is to say exactly what we want to measure, that is, to give exact definitions of our variables.

The researchers then use **statistical techniques** to make conclusions about the population based on the sample.
Example

Each month, the census bureau mails survey forms to 250,000 households asking questions about the people living in the household and about such things as motor vehicles and housing costs. Telephone calls are made to households that don’t return the form. In one month, responses were obtained from 240,000 of the households contacted. (1-2)

1. The sample is
   a. the 250,000 households initially contacted.
   b. the 240,000 households that respond.
   c. the 10,000 households that did not respond.
   d. all U.S. households.

2. The population of interest is
   a. the residents in the suburb that support the new recreation center.
   b. the 250,000 households contacted.
   c. only U.S. households with phones.
   d. all U.S. households.
The most important government sample survey in the United States is the monthly Current Population Survey (CPS) conducted by the Bureau of the Census for the Bureau of Labor Statistics. The CPS contacts about 60,000 households each month.
A 45,000-pound truckload of potatoes is considered for purchase by a potato chip company. The company selects 150 pounds of potatoes from five points in the shipment for inspection. If the fraction of acceptable potatoes is high enough in the 150-pound selection of potatoes, the shipment will be purchased.

What is the population?

a) all potatoes in the world
b) all potatoes in the United States
c) all potatoes in the truckload
d) all potatoes in the 150-pound selection
A 45,000-pound truckload of potatoes is considered for purchase by a potato chip company. The company selects 150 pounds of potatoes from five points in the shipment for inspection. If the fraction of acceptable potatoes is high enough in the 150-pound selection of potatoes, the shipment will be purchased.

What is the population?

a) all potatoes in the world
b) all potatoes in the United States
c) all potatoes in the truckload
d) all potatoes in the 150-pound selection

The correct answer is C.
Population vs. Sample (2 of 3)

A 45,000-pound truckload of potatoes is considered for purchase by a potato chip company. The company selects 150 pounds of potatoes from five points in the shipment for inspection. If the fraction of acceptable potatoes is high enough in the 150-pound selection of potatoes, the shipment will be purchased.

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What is the sample?

a) all potatoes in the world
b) all potatoes in the United States
c) all potatoes in the truckload
d) all potatoes in the 150-pound selection

The correct answer is D.
A professor wants to know how undergraduate students at X University feel about food services on campus, in general. She obtains a list of email addresses of all 15,000 registered undergraduates from the registrar’s office and mails a questionnaire to 300 students selected at random. Only 150 questionnaires are returned.
What is the size of the population?

a) 300 students
b) 150 students
c) 15,000 students
d) 450 students
A professor wants to know how undergraduate students at X University feel about food services on campus, in general. She obtains a list of email addresses of all 15,000 registered undergraduates from the registrar’s office and mails a questionnaire to 300 students selected at random. Only 150 questionnaires are returned.

What is the size of the population?

a) 300 students  
b) 150 students  
c) 15,000 students  
d) 450 students

The correct answer is C.
How to sample badly

- A sample selected by taking the members of the population that are easiest to reach is called a **convenience sample**.

- The design of a sample is **biased** if it systematically favors certain outcomes.

- Caution: People who take the trouble to respond to an open invitation are usually not representative of any clearly defined population.

- A **voluntary response sample** consists of people who choose themselves by responding to a general appeal. Voluntary response samples show bias, because people with strong opinions are most likely to respond.
Advice columnist Ann Landers asked her readers, "If you had it to do over again, would you have children?"

A few weeks later, her column was headlined: “70% OF PARENTS SAY KIDS NOT WORTH IT.”

The people who responded felt strongly enough to take the trouble to write Ann Landers. Their letters showed that many of them were angry at their children.

These people don't fairly represent all parents.

A statistically designed opinion poll on the same issue a few months later found that 91% of parents would have children again.
To assess the opinion of students at the Ohio State University about campus safety, a reporter for the student newspaper interviews 15 students she meets walking on the campus late at night who are willing to give their opinion. (5-7)

5. The sample is
   a. all those students walking on campus late at night.
   b. all students at universities with safety issues.
   c. the 15 students interviewed.
   d. all students approached by the reporter.

6. The method of sampling used is
   a. simple random sampling.
   b. the Gallup Poll.
   c. voluntary response.
   d. a census.

7. The sample obtained is
   a. a simple random sample of students feeling safe.
   b. a stratified random sample of students feeling safe.
   c. a probability sample of students with night classes.
   d. probably biased.
Sampling Badly (1 of 2)

Samples obtained by interviewing customers at an expensive restaurant are likely to be ________.

a) too small to be useful
b) biased
c) random samples
Sampling Badly (1 of 2) (answer)

Samples obtained by interviewing customers at an expensive restaurant are likely to be ________.

a) too small to be useful
b) biased
c) random samples

The correct answer is B.
In 1993, presidential candidate Ross Perot appeared on television to voice his opinions on government reform. To gauge public opinion, Perot urged viewers to fill out the survey appearing in that week’s issue of *TV Guide*. Of the approximately 1.4 million respondents, 98% agreed with Ross Perot’s platform on health care reform.

What type of sampling method was used?

a) a convenience sample  
b) a voluntary response sample  
c) a simple random sample  
d) a stratified sample  
e) a multistage sample
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What type of sampling method was used?

a) a convenience sample  
**b) a voluntary response sample**  
c) a simple random sample  
d) a stratified sample  
e) a multistage sample

The correct answer is B.
Simple random samples

- **Random sampling**, the use of chance to select a sample, is the central principle of statistical sampling.

- A **simple random sample (SRS)** of size $n$ consists of $n$ individuals from the population chosen in such a way that every set of $n$ individuals has an equal chance to be the sample actually selected.

- In practice, people use random numbers generated by a computer or a calculator to choose samples. If you don’t have technology handy, you can use a table of random digits.
How to choose an SRS

• A **table of random digits** is a long string of the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 with these properties:
  • Each entry in the table is equally likely to be any of these 10 digits.
  • The entries are independent of each other. That is, knowledge of one part of the table gives no information about any other part.

Using Table B to choose an SRS

• Step 1: Label. Give each member of the population a numerical label of the same length.

• Step 2: Table. Read consecutive groups of digits of the appropriate length from Table B.

Your sample contains the individuals whose labels you find.
SRS example

Use the random digits provided to select an SRS of four hotels.

01 Aloha Kai  02 Anchor Down  03 Banana Bay  04 Banyan Tree  05 Beach Castle
06 Best Western  07 Cabana
08 Captiva  09 Casa del Mar  10 Coconuts  11 Diplomat  12 Holiday Inn
13 Lime Tree  14 Outrigger
15 Palm Tree  16 Radisson  17 Ramada  18 Sandpiper  19 Sea Castle
20 Sea Club
21 Sea Grape
22 Sea Shell  23 Silver Beach  24 Sunset Beach  25 Tradewinds  26 Tropical Breeze
27 Tropical Shores  28 Veranda

69051  64817  87174  09517  84534  06489  87201  97245

Our SRS of four hotels is 05 Beach Castle, 16 Radisson, 17 Ramada, and 20 Sea Club.
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Simple Random Sample (1 of 2)

We want to select a simple random sample of 5% of the voters exiting a polling station. Which of the following would not produce a simple random sample of these voters?

a) Starting with a randomly chosen first voter, stop every 20th person exiting from the station; ask them to fill out a survey.

b) For each person exiting the station, randomly draw a number between 1 and 20; if the number drawn is 1, ask the person to fill out a survey.

c) Put the names of all registered voters in a box; stir the names; draw out 5% of the names; ask people whose names were drawn to fill out a survey.

d) Ask all voters to fill out a survey; shuffle the surveys 10 times; select the 5% of the surveys that are on top of the pile.
Simple Random Sample (1 of 2) (answer)

We want to select a simple random sample of 5% of the voters exiting a polling station. Which of the following would not produce a simple random sample of these voters?

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b) For each person exiting the station, randomly draw a number between 1 and 20; if the number drawn is 1, ask the person to fill out a survey.
c) Put the names of all registered voters in a box; stir the names; draw out 5% of the names; ask people whose names were drawn to fill out a survey.
d) Ask all voters to fill out a survey; shuffle the surveys 10 times; select the 5% of the surveys that are on top of the pile.

The correct answer is A.
Simple Random Sample (2 of 2)

Which of the following is not true about simple random samples?

a) All individuals have the same chance of being selected.
b) Every sample of size $n$ has the same chance of being selected.
c) Individuals can be selected more than one time in a sample.
Simple Random Sample (2 of 2) (answer)

Which of the following is not true about simple random samples?

a) All individuals have the same chance of being selected.
b) Every sample of size $n$ has the same chance of being selected.
c) Individuals can be selected more than one time in a sample.

The correct answer is C.
Exercise

Import customs officials sometimes randomly select crates of cargo for close, but time-consuming, inspection. Suppose there are nine crates of cargo from the following companies, and customs officials will randomly select four for close inspection. (8-9)

1. Ravenburg  
2. Corsair  
3. Sapphire  
4. Dallhoise  
5. Baggate  
6. Strommond  
7. Cherryport  
8. Foxwood  
9. Bamboro

To do this, use the numerical labels attached to the previous names and the following list of random digits. Read the list of random digits from left to right, starting at the beginning of the list.

748803 12009 45287 71753 98236 66419 84533 11793 20495 05907 11384

8. The simple random sample is
   a. 7488.
   b. 7483.
   d. Cherryport, Foxwood, Bamboro, and Strommond.
Other sampling designs

- The basic idea of sampling is straightforward: Take an SRS from the population and use your sample results to gain information about the population. Sometimes, there are statistical advantages to using more complex sampling methods.

- One common alternative to an SRS involves sampling important groups (called strata) within the population separately. These “sub-samples” are combined to form one stratified random sample.

- To select a ***stratified random sample***, first classify the population into groups of similar individuals, called ***strata***. Then choose a separate SRS in each stratum, and combine these SRSs to form the full sample.

- Another example is ***multistage samples***.
Multistage Sample

- several stages of sampling are carried out
- useful for large-scale sample surveys
- samples at each stage may be SRSs, but are often stratified
- stages may involve other random sampling techniques as well (cluster, systematic, random digit dialing, ...)

Stratified Random Sample

Example
Suppose a university has the following student demographics:

- Undergraduate: 55%  
- Graduate: 20%  
- First Professional: 5%  
- Special: 20%

A stratified random sample of 100 students could be chosen as follows: select a SRS of 55 undergraduates, a SRS of 20 graduates, a SRS of 5 first professional students, and a SRS of 20 special students; combine these 100 students.
Example

10. At a large university a simple random sample of 5 female professors is selected and a simple random sample of 10 male professors is selected. The two samples are combined to give an overall sample of 15 professors. The overall sample is
   a. a simple random sample.
   b. biased due to imbalance.
   c. a stratified sample.
   d. all of the above.

Exercise

11. A public opinion poll in Ohio wants to determine whether registered voters in the state approve of a measure to ban smoking in all public areas. The researchers select a simple random sample of 50 registered voters from each county in the state and ask whether they approve or disapprove of the measure. This is an example of
   a. a systematic county sample.
   b. a stratified sample.
   c. a multistage sample.
   d. a simple random sample.
Suppose you want to estimate the proportion of students at a large university that approves of the new health care bill. You take an SRS of 200 of the 25,000 undergraduate students and an SRS of 100 of the 5,000 graduate students. This overall sample is:

a) a voluntary response sample.
b) a simple random sample.
c) a stratified sample.
d) a multistage sample.
e) None of the answer options is correct.
Suppose you want to estimate the proportion of students at a large university that approves of the new health care bill. You take an SRS of 200 of the 25,000 undergraduate students and an SRS of 100 of the 5,000 graduate students. This overall sample is:

a) voluntary response sample.
b) a simple random sample.  
**c) a stratified sample.**
d) a multistage sample.  
e) None of the answer options is correct.

The correct answer is C.
A sample selected by taking the members of the population that are easiest to reach is called a ___________ sample, which often produces ___________ data.

a) convenience; representative
b) simple random; representative
c) convenience; unrepresentative
d) simple random; unrepresentative
A sample selected by taking the members of the population that are easiest to reach is called a __________ sample, which often produces __________ data.

a) convenience; representative  
b) simple random; representative  
c) **convenience; unrepresentative**  
d) simple random; unrepresentative

The correct answer is C.
Other Sampling Designs (3 of 4)

Which of the following sampling schemes describes a multistage sample of 200 undergraduate students at a large university?

a) Obtain a list of the undergraduate students at the university; assign consecutive numbers to the students on the list; use a random number table to select 200 students.

b) Obtain lists of all freshmen, sophomores, juniors, and seniors; use a random number table to randomly select 50 students from each list.

c) Randomly select 10 departments; within each department, randomly select 20 undergraduate students.
Which of the following sampling schemes describes a multistage sample of 200 undergraduate students at a large university?

a) Obtain a list of the undergraduate students at the university; assign consecutive numbers to the students on the list; use a random number table to select 200 students.

b) Obtain lists of all freshmen, sophomores, juniors, and seniors; use a random number table to randomly select 50 students from each list.

c) Randomly select 10 departments; within each department, randomly select 20 undergraduate students.

The correct answer is C.
Other Sampling Designs (4 of 4)

Which of the following is not an example of random sampling?

a) a voluntary response sample
b) a simple random sample
c) a stratified sample
d) a multistage sample
e) All of the answer options are random samples.
Which of the following is not an example of random sampling?

a) a voluntary response sample  
b) a simple random sample  
c) a stratified sample  
d) a multistage sample  
e) All of the answer options are random samples.  

The correct answer is A.
### Cautions about sample surveys

- Good sampling technique includes the art of reducing all sources of error.

- **Undercoverage** occurs when some groups in the population are left out of the process of choosing the sample.

- **Nonresponse** occurs when an individual chosen for the sample can’t be contacted or refuses to participate.

- A systematic pattern of incorrect responses in a sample survey leads to **response bias**.

- The **wording effects** comprise the most important influence on the answers given to a sample survey.
Impact of technology

- The expense of using personal interviews to do surveys has led to most studies being conducted with technology-based data collection.

Issues

- Random-digit dialing has grown increasingly useful as the proportion of homes with no landline has increased.

- Web surveys are used more frequently, but are difficult to do well.
Cautions (1 of 5)

A Gallup poll sponsored by the disposable diaper industry asked:

“It is estimated that disposable diapers account for less than 2% of the trash in today’s landfills. In contrast, beverage containers, third-class mail, and yard waste are estimated to account for about 21% of the trash in landfills. Given this, in your opinion, would it be fair to ban disposable diapers?”

From which type of bias does this poll suffer?

a) under-coverage bias
b) non-response bias
c) response bias
d) question wording bias
e) interviewer bias
Cautions (1 of 5) (answer)

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From which type of bias does this poll suffer?

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b) non-response bias
c) response bias
d) question wording bias
e) interviewer bias

The correct answer is D.
Bias can occur in both random and non-random samples.

a) true
b) false
Cautions (2 of 5) (answer)

Bias can occur in both random and non-random samples.

a) true
b) false

The correct answer is A.
Cautions (3 of 5)

Using a local telephone book to select a simple random sample could introduce what type of bias?

a) under-coverage bias
b) non-response bias
c) response bias
d) question wording bias
e) interviewer bias
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a) under-coverage bias
b) non-response bias
c) response bias
d) question wording bias
e) interviewer bias

The correct answer is A.
Cautions (4 of 5)

If people tend to respond differently to a question depending on whether the interviewer is male or female, which type of bias is present?

a) under-coverage bias
b) non-response bias
c) response bias
d) question wording bias
e) interviewer bias
Cautions (4 of 5) (answer)

If people tend to respond differently to a question depending on whether the interviewer is male or female, which type of bias is present?

a) under-coverage bias
b) non-response bias
c) response bias
d) question wording bias
e) interviewer bias

The correct answer is E.
Cautions (5 of 5)

Although web surveys are becoming more frequent, many of them still suffer from which type of bias?

a) volunteer response bias
b) under-coverage bias
c) non-response bias
d) All of the answer options are correct.
Cautions (5 of 5) (answer)

Although web surveys are becoming more frequent, many of them still suffer from which type of bias?

a) volunteer response bias  
b) under-coverage bias  
c) non-response bias  
d) All of the answer options are correct.

The correct answer is D.