Alpacas are certainly a nontraditional pet choice, but they can make great pets if you have the right environment, such as a farm.
Many people have pets, but a relatively smaller number of people own alpacas. If you want to know something about owning an alpaca, you would probably get more helpful information from the subset (called sample) of alpaca owners, than from the entire population of pet owners. Good, random samples, however, can help you understand a large population.
Animal researchers can learn about a large group of animals just by studying a small group of them.

By studying a smaller group of animals, the researchers can save time, money, and resources. For the smaller group, or sample, to accurately represent the entire group, the researchers must be careful in how they select those animals. For example, if the researchers are interested in the average weight of all the elephants in a refuge area, their sample should include both male and female elephants of all ages.

There are many ways to choose a sample. Some methods are quick and easy to perform but are likely to lead to samples that do not reflect the entire group being studied. These methods are fine when the results of the sample won’t affect a serious study. Suppose a magazine poll asks teenagers to choose their favorite movie of the year. Because the results will be used for fun, it doesn’t matter if more girls than boys respond.

Other sampling methods may take more time to set up but are more likely to lead to representative samples. Representative samples are important in many fields, such as politics, science, and medicine.

- A politician in a tight race for mayor might use the results of a survey to determine whether he will spend another million dollars on his advertising campaign.
- An environmental scientist might use the results of soil samples to recommend a ban on a certain fertilizer.
- A team of doctors might use the results of a sample study to determine whether a new drug is safe.

Unrepresentative Samples

The president of a new animal shelter plans to send a gift to people who donate a minimum amount of money. To help determine that amount, she plans to survey a sample of townspeople, asking how much they are likely to donate per year.

The following sampling methods are likely to lead to unrepresentative samples because they do not represent all of the townspeople. Think about why.

- She surveys her friends and family who live in the town.
- She surveys a group of high school students who live in the town.
**Random Samples**

A *random sample* gives everyone an equal chance of being chosen, which greatly increases the possibility of a representative sample.

There are 237 animals in an animal shelter. To create a random sample of 15 animals to highlight on its pet adoption website, the president assigns each animal a number and then uses a table of random digits.

Here’s part of the Table of Random Digits found on pages A-3 and A-4. The numbers can be read in any order and in any direction, but they are usually read from left to right and top to bottom.

111 58043 39340 71797 19710 31745 69753 59189 21854
112 37697 24731 53600 43295 83819 49237 67017 17926
113 10311 43137 24736 90584 43692 48335 98715 10551
114 19724 50552 14851 69355 37856 20190 07579 99328
115 64628 88781 35241 19739 31439 55383 59304 07965

In creating her sample, the president will read the table, noting when a number matches one of the numbers assigned to an animal. The first 15 animals with matching numbers will become part of the sample. Because the digits in the table are random, so is the sample.

The president can also divide the animals into groups, such as dogs, cats, and other, and use the table to randomly select a certain number of animals from each group, which is called a *stratified random sample*.

**Applying It**

In this chapter, you will learn how to identify unrepresentative samples and how to create representative samples. You will also learn the notation that is used to distinguish between measures obtained from samples and measures obtained from the entire group.
Preparing for the Chapter

Review the following skills to prepare for the concepts in Chapter 5.

► Determine whether a set is a subset of another set.
► Find the mean and standard deviation of a data set.
► Interpret and use the ± symbol.
► Determine every nth value in a given range of numbers.
► Find an experimental probability.

Problem Set

Tell whether Set A is a subset of Set B, Set B is a subset of Set A, or neither is a subset of the other.

1. Set A: {2, 3, 5, 7, 11}  
   Set B: {2, 4, 5, 6, 7, 10, 11}
2. Set A: the whole numbers  
   Set B: the integers
3. Set A: the residents of Ohio  
   Set B: the residents of the United States
4. Set A: the residents of Pennsylvania  
   Set B: the residents of Philadelphia
5. Set A: the teen girls in the United States  
   Set B: the teen boys in the United States
6. Set A: the teen girls in the United States  
   Set B: all girls in North America
7. Set A: the residents of Wyoming  
   Set B: all registered voters in Wyoming

Find the mean of the data set.

8. 15, 40, 40, 75, 25
9. 36.8, 16.4, 19, 22.7, 37.9, 25.4
10. 12, 17, −5, 0, 14, −1, 8, 6, −3, 0
11. 108, 203, 164, 178, 192, 215, 209

Find the standard deviation of the data set.

12. 3, 3, 3, 3, 3
13. 0, 5, 10, 15, 20
14. 14, 21, 34, 79, 27
15. 13, 8, 16, 10, 4, 17, 17, 12, 12, 15

Write the two numbers represented by the expression.

16. 56 ± 4
17. 35.75 ± 0.15
18. 21% ± 6%
19. 108.8 ± 9.9
20. −16 ± 2
21. \[ \frac{5}{2} \pm \frac{1}{4} \]
Write the pair of numbers as a single expression with the \( \pm \) symbol.

22. 32 and 42  
24. 194 and 276  
26. \(-9.6 \) and \(-4.4\)  
23. 77\% and 85\%  
25. 85.5 and 100.5  
27. \(3 \frac{1}{6}\) and \(3 \frac{1}{2}\)

List the set of numbers described.

28. every 15th number, starting from 1 and ending at 90  
29. every 10th number, starting at 3 and not exceeding 85  
30. every fifth number between 1 and 40, starting at 22 and picking up at 0 once 40 is reached  
31. every fifth number between 1 and 60, starting at 49 and picking up at 0 once 60 is reached

A spinner is divided into four equal sections numbered 1, 3, 4, and 8. Maggie spun the spinner 75 times. The table shows her results.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>1</th>
<th>3</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Spins</td>
<td>18</td>
<td>23</td>
<td>20</td>
<td>14</td>
</tr>
</tbody>
</table>

32. What is the theoretical probability of Maggie spinning an even number?  
33. What is the experimental probability of Maggie spinning an even number?

An experiment involves rolling a number cube three times and finding the sum of the outcomes. Jeanine performs five trials of the experiment. The table shows the results.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Trial 4</th>
<th>Trial 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2, 2, 6</td>
<td>1, 5, 3</td>
<td>4, 3, 4</td>
<td>5, 1, 2</td>
</tr>
<tr>
<td></td>
<td>5, 4, 6</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

34. What is the experimental probability of Jeanine rolling a sum of 10 or greater?
Sample and Population

If you can’t study the entire group of objects that you are interested in, then study just some of them.

Distinguishing Between a Sample and a Population

A population is an entire set of members that you want to know something about. The set can be large or small, and it can be made up of people or objects. Here are examples of populations:

• Every resident in the United States
• Every library card holder in San Antonio, Texas
• Every lion in a nature preserve
• Every apple in an orchard

A sample is a subset of a population. It is common to study samples when a population is very large and studying each member would be impossible, costly, or time-consuming.

A science professor is considering sending some of the university’s science students on a field trip to another country. He wants to know how many of the 918 science students at his university would participate in such a trip. He surveys 83 of the science students and finds that 34 of them would participate.

Who makes up the population?

The 918 science students at that university make up the population. Ideally the professor would be able to survey each of them, but his schedule does not allow him time to survey each student, especially those who have other professors.

Who makes up the sample?

The 83 students who the professor surveys make up the sample.

Finding and Using Sample Means

A group of biology students is studying Mexican free-tail bats in a local cave. They capture a dozen bats from the cave, record their wingspans in centimeters, and then release them. The wingspans are 31 centimeters, 36 centimeters, 34 centimeters, 32 centimeters, 33 centimeters, 33 centimeters, 29 centimeters, 35 centimeters, 30 centimeters, 34 centimeters, 35 centimeters, and 30 centimeters. Estimate the average wingspan of all the bats in the cave.
The sample mean is a good estimate of the population mean. To find the sample mean, divide the sum of the wingspans in the sample by the number of bats in the sample: \( \frac{392}{12} \approx 32.7 \).

Based on this sample, it is fair to estimate that the average wingspan of all the bats in the cave is about 33 centimeters.

**Finding and Using Sample Proportions: Fractions**

A university prepares to send 520 biology test kits to overseas students. An assistant randomly inspects 40 of the kits and finds that 5 have outdated instructions. About how many kits in the shipment have outdated instructions?

Find the proportion of test kits in the sample with outdated instructions: \( \frac{5}{40} = \frac{1}{8} \)

Because \( \frac{1}{8} \) of the test kits in the sample have outdated instructions, it is fair to estimate that \( \frac{1}{8} \) of the test kits in the entire shipment have outdated instructions. That is \( \frac{1}{8} \cdot 520 \), or 65, test kits.

**Finding and Using Sample Proportions: Percents**

Sometimes it makes more sense to write the sample proportion as a percent.

After returning from a biology field trip, a professor asks a sample of the students whether they would return the following year. The table shows the results.

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>21</td>
</tr>
<tr>
<td>No</td>
<td>11</td>
</tr>
<tr>
<td>Unsure</td>
<td>6</td>
</tr>
</tbody>
</table>

A total of 80 students went on the trip. Estimate how many would say No if they were asked whether they would return the following year.

First find the percent of students in the sample that would not return. Divide the number who responded No by the total number in the sample: \( \frac{11}{38} \approx 29\% \).

Second find 29\% of the number in the population: \( 0.29 \cdot 80 = 23.2 \).

Based on the sample, it is fair to estimate that about 23 of the 80 students would say No to returning the following year.
Problem Set

Describe the population and the sample.

1. A landscaper is considering using flat river rock to build a retaining wall. He buys all his materials from Al’s Decorative Rock. Al lets the landscaper take a dozen flat river rocks back to his worksite to see whether they will be suitable for his project.

2. Greg wants to move out of his dormitory and into an apartment near his college. His parents agreed, on the condition that the rent is no more than 25% of the cost of dorm living. To get an idea of rent amounts for one-bedroom apartments, Greg looks at listings in a local newspaper and on an Internet site.

3. A pediatrician suspects that pollution from a factory built in 2000 is affecting the growth of local children. From her files, she selects and compares the growth rates of 20 of her current patients who were born after 2000 and 20 of her previous patients who were born before 1982.

A researcher wants to know the average weight of all the beavers in a park. He selects and weighs 10 randomly selected beavers. The beavers’ weights, to the nearest pound, are 38, 27, 40, 36, 32, 29, 43, 43, 33, and 36.

6. Describe the population and the sample.

7. Find the sample mean.

8. Estimate the mean weight of all the beavers in the park.

A veterinarian visits a cat shelter housing 432 cats. Of the 42 randomly selected cats that she studies, she finds that 14 cats suffer from separation anxiety. Of those, 10 cats were orphaned as a kitten.

9. Describe the population and the sample.

10. What proportion of cats in the sample suffers from separation anxiety?

11. Estimate the number of cats in the shelter that suffer from separation anxiety.

There are 1125 members in a mountaineering club. The club’s secretary surveys 72 randomly selected members and finds that 63 members are in favor of holding a used-gear sale.

12. Describe the population and the sample.

13. What percent of the members in the sample are in favor of holding a used-gear sale?

14. Estimate the number of club members who would be in favor of holding a used-gear sale.
A representative of a new credit card company wants to know the average credit card balance of all students who have credit cards at a particular college. The representative surveys 15 credit card holders on the college campus. He finds that their balances, to the nearest dollar, are 214, 38, 0, 0, 626, 400, 0, 297, 712, 54, 315, 288, 416, 495, and 93.

15. Describe the population and the sample.  17. Estimate the average credit card balance of all credit card holders at the college.

16. Determine the sample mean.

A pet store owner has three tanks of goldfish; each tank holds about 75 fish. He collects and inspects 10 fish from each tank and finds that 3 fish have fin rot.

18. Describe the population and the sample.  20. Estimate the number of goldfish in the store that have fin rot.

19. What percent of the fish in the sample have fin rot?

All 150 algebra students in an online school took the same 10-point quiz. A sample of 15 students had the following quiz scores: 8, 9, 5, 8, 8, 5, 4, 7, 5, 7, 8, 6, 6, 10, and 8.

21. Describe the population and the sample.  22. What percent of students in the sample earned 70% or higher on the quiz?

23. About how many of all the algebra students earned below 70% on the quiz?
Bias in Sampling

A sample does not always reflect the true nature of the population it was selected from.

Sampling Techniques

These are three common ways to choose a sample from a population.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>In volunteer sampling,</td>
<td>A television newscaster asks viewers to respond to an online poll.</td>
</tr>
<tr>
<td>members choose whether or</td>
<td></td>
</tr>
<tr>
<td>not to be part of the</td>
<td></td>
</tr>
<tr>
<td>sample.</td>
<td></td>
</tr>
<tr>
<td>In convenience sampling,</td>
<td>A veterinarian inspects the teeth of the first five cats that approach</td>
</tr>
<tr>
<td>you select the members</td>
<td>her at a pet adoption center.</td>
</tr>
<tr>
<td>that are easiest, or most</td>
<td></td>
</tr>
<tr>
<td>convenient, to choose.</td>
<td></td>
</tr>
<tr>
<td>In systematic sampling,</td>
<td>Shirley uploads every fifth picture she took on a social networking</td>
</tr>
<tr>
<td>you select a starting</td>
<td>site.</td>
</tr>
<tr>
<td>point, and then choose</td>
<td></td>
</tr>
<tr>
<td>every nth member of the</td>
<td></td>
</tr>
<tr>
<td>population.</td>
<td></td>
</tr>
</tbody>
</table>

Bias in Sampling

A sample is biased if it is not representative of its population. The sampling technique used often causes the bias.

A farmer wants to know the depth of the roots in a certain crop of plants. Because they are nearest to his house, he digs up six plants along the southwest corner of the field and inspects their roots.

This is an example of convenience sampling. The sample is likely biased because all the plants come from the same area of the field. This area may receive more or less sunlight than other areas. The amount of sunlight a plant receives affects the plant’s growth and therefore its root system. Soil conditions may also differ in this part of the field.

Systematic sampling can yield an unbiased sample, but there are times when this is not the case. Suppose the farmer inspected every 25th plant in a field where each row contains 25 plants. If he starts from the beginning of a row, the sample would be biased because every 25th plant would be on the same side of the field.
A journalist wants to know whether townspeople approve of the use of pesticides on local crops. Here are just a few of the ways the journalist could choose a sample of townspeople that may be biased.

- Volunteer sampling: The journalist could post a question in a local paper and have readers mail their responses. However, only those townspeople who care strongly about the possibility of pesticides in their food or water supply would likely bother to mail a response.

- Convenience sampling: She could survey people as they register for a local running race. Runners tend to value fitness and health, and are more likely than the rest of the population to be concerned about how pesticides could affect their food and water.

- Systematic sampling: She could call every 20th person in the phonebook whose last name starts with A or B. However, this might exclude people from cultural backgrounds whose last names do not typically start with A or B.

**Bias in Questioning**

Bias may arise from the question or questioning technique used. For example, a question may give only one side of the story. Compare these questions.

<table>
<thead>
<tr>
<th>Biased toward a No response</th>
<th>Biased toward a Yes response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticides cannot be washed off of all foods, and pesticides leak into nearby waterways. Do you think our farmers should be allowed to put our health at risk by using pesticides?</td>
<td>If our farmers cannot control pests effectively, our local food production could drop by 35%, creating a food shortage and economic recession. Do you agree that our farmers need to use pesticides?</td>
</tr>
</tbody>
</table>

Here are other ways bias can arise from questioning:

- If a question is of a personal nature, respondents may lie to avoid embarrassment, particularly during face-to-face interviews. Consider making these surveys anonymous.

- If a question requires a numerical response, people tend to give rounded answers, leading to an unusual number of responses ending in 0. Give people time to look up facts. If a measurement is involved, consider measuring on the spot.

- Questions that are long and wordy may be skipped. If the question is confusing, people may respond No thinking it is “safer” than responding Yes. Use simple language.

- Questions with preselected answers to choose from may not allow for people to state their true thoughts if they have another answer in mind. Think about the needs of the survey before limiting responses.

**THINK ABOUT IT**

The first sampling method would also be biased toward those townspeople who read that paper. What if most of the readers were health professionals? parents? relatives of farmers?
Problem Set

Identify the type of sampling used as volunteer, convenience, or systematic.

1. The managers of a movie theater received complaints about squeaky chairs. So they walked up and down every row, testing every 10th chair.

2. Customers at a restaurant receive a survey card with their check. They are asked to rate the food, service, and value, and then drop the card in a box on their way out.

3. Dirk is a member of a mail movie rental club. After returning a movie, he receives an e-mail asking him to rate the movie on a scale of 1 to 5. His rating is averaged with the ratings of other viewers and displayed online.

4. A teacher at a driving school wants to know what drivers think about a new state law, so she surveys the students in her driving classes.

5. A teaching assistant scans every fifth paper from a pile onto his computer and into a plagiarism software detection program.

6. A reporter is doing a story on people’s views about violence in television shows. He sits at a table in the food court of a mall and chooses people as they walk by to survey.

7. A teen magazine article asks readers to go online and choose who they think should be the magazine’s celebrity of the year.

8. A quality control technician inspects every 10th pair of jeans produced in a clothing factory.

The president of a homeowner’s association wants to know whether homeowners would pay an increased fee to support new security measures. There are almost 700 homes in the association. She considers different sampling techniques. For each, identify the sampling technique, tell why the sample is likely biased, and explain who it would be biased toward.

9. She calls every 20th home between 8 a.m. and 3 p.m. on weekdays.

10. She visits each bus stop in the association area and surveys the parents that wait for the bus with their children.

11. She puts a note in the monthly newsletter for homeowners to send her an e-mail with their opinion.

A company employs 200 males and 200 females. On a list of the 400 employees at the company, the first employee’s name is male. The names alternate male/female throughout the entire list.

The manager collects a sample of the employees by selecting every 20th name on the list, starting at the top.

12. What is the size of the sample?

13. Toward which group of employees is the sampling technique biased? Explain.

14. Would the sampling technique be biased if the starting point were chosen randomly instead? Explain.

15. Would the sampling technique be biased if every 15th name were chosen instead? Explain.
An editor for a local newspaper asks the following question in a poll to be taken online: “Because hoof prints tear up our trails and leave them a muddy mess, do you think horseback riders should be banned from Sunshine Park?”

16. Toward which group or groups of people is the sampling technique biased?
17. What type of people are most likely to respond to this poll and why?

The leader of a biking group wants to know the fundraising activities in which its members would participate. He asks every biker that shows up for the next group ride, “Which would you do to raise money: sell T-shirts, sell raffle tickets, or participate in a 24-hour bike-a-thon?”

19. Toward which group of people is the sampling technique biased?
20. Name a disadvantage of the leader’s question.

Solve.

21. There are 30 seats in each of 12 rows in a theater. A middle aisle separates the rows evenly, 15 seats on each side. The seats are numbered from left to right and from top to bottom starting with the number 1. The person sitting in every 15th seat, counting from the top left, is surveyed about their comfort during the show. Explain why the sampling technique is biased.

22. A veterinarian concerned about pet obesity visits a pet store and asks customers what type of pets they have and how much they weigh. What would be the advantages of the veterinarian weighing pets instead? What would be the disadvantages?
Reducing Bias

To reduce the chance of bias in a sample, give everyone in the population an equal chance of being chosen.

Creating a Simple Random Sample

In a simple random sample, or SRS, every member of the population has an equal and known chance of being in the sample.

The simplest example of an SRS involves drawing names from a hat. Write the name of each member of the population on a slip of paper, put the papers in a hat, mix them up, and then draw papers without looking.

Another example of an SRS involves assigning a number to each member of the population and then using a calculator or computer to generate random numbers. A member becomes part of the sample if his or her number comes up. You can simulate this process by using a table of random digits. For this course, use the Table of Random Digits on pages A-3 and A-4.

THINK ABOUT IT

You cannot collect a simple random sample if you do not know the total number in the population.

HOW TO

To choose an SRS from a table of random digits

Step 1 Assign a unique numerical label to each member of the population. Each label must have the same number of digits.

Step 2 Start at any line in the table. Read the numbers from left to right, forming numbers with the same number of digits used in Step 1.

Step 3 If a number matches a label from the population, then assign that member to the sample. Stop when you meet the desired sample size.

The names of 25 African safari guides are shown. To randomly choose 6 guides for evaluation, a ranger numbered them as shown and started at line 116 in the table. Part of the table is copied below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issa</td>
<td>01</td>
</tr>
<tr>
<td>Edem</td>
<td>02</td>
</tr>
<tr>
<td>Omar</td>
<td>03</td>
</tr>
<tr>
<td>Saeed</td>
<td>04</td>
</tr>
<tr>
<td>Martin</td>
<td>05</td>
</tr>
<tr>
<td>Badu</td>
<td>06</td>
</tr>
<tr>
<td>Nwafo</td>
<td>07</td>
</tr>
<tr>
<td>Okeke</td>
<td>08</td>
</tr>
<tr>
<td>Emanuel</td>
<td>09</td>
</tr>
<tr>
<td>Joaquin</td>
<td>10</td>
</tr>
<tr>
<td>Kojo</td>
<td>11</td>
</tr>
<tr>
<td>Salma</td>
<td>12</td>
</tr>
<tr>
<td>Justin</td>
<td>13</td>
</tr>
<tr>
<td>Faida</td>
<td>14</td>
</tr>
<tr>
<td>Mawuli</td>
<td>15</td>
</tr>
<tr>
<td>Zahur</td>
<td>16</td>
</tr>
<tr>
<td>Asha</td>
<td>17</td>
</tr>
<tr>
<td>Khalid</td>
<td>18</td>
</tr>
<tr>
<td>Mazi</td>
<td>19</td>
</tr>
<tr>
<td>Bomani</td>
<td>20</td>
</tr>
<tr>
<td>Olorun</td>
<td>21</td>
</tr>
<tr>
<td>Adam</td>
<td>22</td>
</tr>
<tr>
<td>Neema</td>
<td>23</td>
</tr>
<tr>
<td>Bakari</td>
<td>24</td>
</tr>
<tr>
<td>Kasey</td>
<td>25</td>
</tr>
</tbody>
</table>

If you ignore the spaces as you read each row, the first five two-digit numbers in line 116 are 84, 30, 70, 50, and 17. The number 17 matches a label in the population, putting Asha in the sample. As you continue reading two-digit numbers, the next number in the population is 08, putting Okeke in the sample.
When you get to the end of a line, pick up on the next line. If you get to the end of the table and need more sample members, pick up at the top of the table. In other words, treat the digits as one long line of digits, only separated into rows and columns to make them easier to read.

Confirm for yourself that the ranger chose Asha, Okeke, Faida, Neema, Saeed, and Emanuel for evaluations.

Creating a Stratified Random Sample

In a stratified random sample, the population is divided into categories, and a simple random sample is selected from each category.

A ranger at a national park in Tanzania has a list of 1100 bird species recorded in the country. The first 400 on the list are those most commonly seen by tourists. The ranger wants a random sample of 8 birds, half of which are commonly seen.

He labels the population from 0001 to 1100 and starts at line 108. The first number is 0113, which corresponds to a commonly watched bird. The next number in the sample is 0564, a bird not commonly seen. He continues through the table until he has four in each group.

Part of the table is copied below. Confirm for yourself that the sample contains the birds numbered 0113, 0564, 1092, 0171, 1031, 0584, 0551, and 0890.

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>108</td>
<td>01136</td>
<td>12428</td>
<td>34626</td>
<td>91253</td>
<td>58427</td>
<td>75229</td>
<td>10693</td>
</tr>
<tr>
<td>109</td>
<td>34710</td>
<td>56471</td>
<td>29761</td>
<td>35322</td>
<td>15799</td>
<td>15728</td>
<td>72632</td>
</tr>
<tr>
<td>110</td>
<td>47942</td>
<td>57768</td>
<td>13870</td>
<td>71092</td>
<td>96351</td>
<td>16392</td>
<td>98138</td>
</tr>
<tr>
<td>111</td>
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<td>58858</td>
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</table>

Creating a Proportional Stratified Random Sample

Sometimes you may want the number selected from each category to be proportional to the total number of members in each population.

For example, if a population consists of 60% women and 40% men, then you might want the stratified random sample to reflect these proportions. So, in a sample of 10 people, you would want 6 to be women and 4 to be men.

In this case, you can use the Table of Random Digits to make sure that the groups are represented proportionally in the sample.
Problem Set

An employer assigns a two-digit number to each employee as shown. Use the Table of Random Digits on pp. A-3 and A-4 to solve.
Note: Names with an asterisk (*) represent females.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Gina*</td>
<td>06</td>
<td>Donald</td>
<td>11</td>
</tr>
<tr>
<td>02</td>
<td>Yonette*</td>
<td>07</td>
<td>Gretchen*</td>
<td>12</td>
</tr>
<tr>
<td>03</td>
<td>Bella*</td>
<td>08</td>
<td>Abel</td>
<td>13</td>
</tr>
<tr>
<td>04</td>
<td>Kojo</td>
<td>09</td>
<td>Tracy*</td>
<td>14</td>
</tr>
<tr>
<td>05</td>
<td>Juan</td>
<td>10</td>
<td>Kardell</td>
<td>15</td>
</tr>
<tr>
<td>06</td>
<td>Donald</td>
<td>11</td>
<td>Daphne*</td>
<td>16</td>
</tr>
<tr>
<td>07</td>
<td>Gretchen*</td>
<td>12</td>
<td>Jayce</td>
<td>17</td>
</tr>
<tr>
<td>08</td>
<td>Abel</td>
<td>13</td>
<td>Ivan</td>
<td>18</td>
</tr>
<tr>
<td>09</td>
<td>Tracy*</td>
<td>14</td>
<td>Oscar</td>
<td>19</td>
</tr>
<tr>
<td>10</td>
<td>Kardell</td>
<td>15</td>
<td>Trey</td>
<td>20</td>
</tr>
</tbody>
</table>

1. The employer wants to select a simple random sample of 6 employees for a company photograph using the table of random digits. Which employees will be in the photograph if he starts on line 113?

2. The employer wants to select a simple random sample of 4 males for a company photograph. Which males will be in the photograph if he starts on line 111?

3. The employer wants to select a simple random sample of 3 females for a company photograph. Which females will be in the photograph if he starts on line 130?

4. Number the states consecutively, starting with 00, according to alphabetical order.

5. Which states will he visit if he starts on line 114?

6. Which states will he visit if he starts on line 134?
A drill sergeant is told to randomly inspect 12 lockers in Building 47. Building 47 has 114 lockers. The lockers are numbered consecutively, starting at 201. The sergeant uses the Table of Random Digits to determine which lockers to inspect.

7. Which lockers will be inspected if the sergeant starts on line 101?

8. Which lockers will be inspected if the sergeant starts on line 115?

There are 6418 runners in a marathon with bibs numbered 1 through 6418. Using the Table of Random Digits, the race organizer randomly selects 8 runners to receive free running gear.

9. If the organizer starts on line 120, which runners receive free gear?

10. If the organizer starts on line 130, which runners receive free gear?

The male animals in a park are numbered 001 through 080, and the female animals are numbered 081 through 200. Using the Table of Random Digits, a park ranger selects samples of animals that represent the males and females proportionally.

11. How many male animals and how many female animals should be in a sample of size 10? Starting on line 103, what are the numbers of the animals in the sample?

12. How many male animals and how many female animals should be in a sample of size 15? Starting on line 125, what are the numbers of the animals in the sample?

The owner of an Italian restaurant uses the Table of Random Digits to decide which menu items should have an accompanying photograph.

13. Number the items consecutively, from top to bottom, starting with 01 for minestrone soup.

14. Suppose the owner wants 2 starters, 2 entrees, and 2 desserts to be photographed. Which menu items will include a photograph if she starts on line 106?

15. Suppose the owner wants 2 starters, 4 entrees, and 2 desserts to be photographed. Which menu items will include a photograph if she starts on line 103?

16. Suppose the owner wants to photograph 6 menu items and wants the number of photographed items in each category to be proportional to the number of items in the menu. Which items will be photographed if she starts at line 101?
Statistics and Parameters

You can use data for one of two purposes: to summarize or to draw conclusions.

Distinguishing Between Descriptive and Inferential Statistics

Descriptive statistics is used to numerically summarize or represent a set of data. Here are some examples:

- A student’s grade point average is 3.27.
- The median home value in a city is $259,000.
- The ducks in a zoo have a mean weight of 1.2 kilograms and a standard deviation of 0.17 kilograms.

Inferential statistics is used to draw conclusions or make predictions. Notice in these examples that the purpose is to take the information gained from the sample and generalize it to the population it came from.

- A governor wants to know whether the residents in his state approve of his recent actions. In a poll, about 74% of those surveyed said they approved.
- Scientists caught 16 of the ducks in a lake, measured their lengths, and released them. They report, “Our findings indicate that the average length of the ducks in the lake is about 58 cm.”

Finding Parameters and Statistics

A parameter is a measurement that describes a population. A statistic is a measurement that describes a sample. Different notations make it easy to distinguish between parameters and statistics.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Population</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>$\mu$</td>
<td>$\bar{x}$</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>$\sigma$</td>
<td>$s$</td>
</tr>
<tr>
<td>Proportion</td>
<td>$p$</td>
<td>$\hat{p}$</td>
</tr>
</tbody>
</table>

THINK ABOUT IT

In descriptive statistics, the numbers used to describe the data set are certain. In inferential statistics, the numbers used to describe the population are “best estimates.”

NOTATION

The symbols $\mu$ and $\sigma$ are the lowercase Greek letters mu and sigma.

Read the symbol $\hat{p}$ as “p-hat.”
At a zoo, 55% of the penguins are male. A researcher selects a sample of five of the penguins and notes that three are male. What are $p$ and $\hat{p}$ for male penguins?

$p = 0.55$ because 55% of the population is male.

$p = 0.6$ because $\frac{3}{5}$, or 60%, of the sample is male.

The mean weight of the penguins at the zoo is 9.9 pounds, with a standard deviation of 1.4 pounds. The penguins in the researcher’s sample weigh 9.7 pounds, 10.4 pounds, 11.5 pounds, 8.6 pounds, and 11.8 pounds. Find $\mu$, $\bar{x}$, $\sigma$, and $s$.

Because they describe the population, $\mu = 9.9$ and $\sigma = 1.4$.

Calculate to find the statistics.

$\bar{x} = \frac{52}{5} = 10.4$ and $s = \sqrt{\frac{6.9}{4}} \approx 1.3$

Using a Table for a Simulation

In the zoo ponds, 20% of the goldfish are white. Use the Table of Random Digits on pages A-3 and A-4, starting at line 118, to simulate randomly selecting a sample of 40 goldfish and recording their color.

Because $p$ is 20%, let 20% of the digits in the table represent selecting a white goldfish. For instance, let the digits 1 and 2 represent selecting a white goldfish and the digits 3, 4, 5, 6, 7, 8, 9, and 0 represent selecting a goldfish of another color.

The first five digits in line 118 are 0, 1, 1, 7, and 8, so the second and third fish selected were white. Continue reading across until you have selected 40 fish. You should have found that 10 of the 40 fish were white, so $\hat{p}$ is 25%.

Using a Table to Estimate a Probability

A dog successfully performs a trick 65% of the time. Use the Table of Random Digits on pages A-3 and A-4 to estimate the probability that it will successfully perform the trick on at least 7 out of its next 10 attempts. Start at line 116 and perform 6 trials.

Let the numbers 01 through 65 represent a success. The first 10 two-digit numbers in line 116 are 84, 30, 79, 12, 39, 50, 45, 56, 79, and 23, representing 5 successes in 10 attempts.

Continuing along line 116, the next 10 numbers represent 6 successes in 10 attempts. Confirm for yourself that in the next 4 groups of 10 there are 6, 6, 7, and 7 successes. Out of the 6 trials, only 2 had at least 7 successes. Based on this simulation, the probability that the dog successfully performs the trick on at least 7 out of its next 10 attempts is about 33%.
Problem Set

Determine whether the situation involves descriptive statistics or inferential statistics. Explain your answer.

1. A recent poll estimates that 15% of Americans have read a certain book.
2. Out of 25 students in the class, 40% are male.
3. The average weight of players on the team is 130 pounds.
4. A recent report estimates that 4 out of every 5 dentists recommend a brand of toothpaste.

Solve.

5. A sociologist studying the sleep habits of teenagers in the United States randomly surveyed 1873 teenagers. Of those, 297 teenagers had moderate to severe sleep disorders. Find $\hat{p}$.
6. A farmer randomly inspected 16 of his 93 peach trees for signs of a disease. Two of those trees showed signs of the disease. Find $\hat{p}$.
7. The songs in Li Ming’s MP3 folder have a mean size of 3760 KB. Her friend randomly downloaded 5 of Li Ming’s songs onto her cell phone. She calculated that the mean size of these songs is 4014 KB. Find $\mu$ and $\bar{x}$.
8. In a region where 48% of the population is male, there are 11 boys and 14 girls in a sample of children. Write $p$ and $\hat{p}$ for males, and $p$ and $\hat{p}$ for females.
9. People between the ages of 21 and 35 are surveyed. The mean of their credit card debt is $12,388. Suppose the actual mean credit card debt for this age group is $9301. Find $\mu$ and $\bar{x}$.

Forty percent of the seeds in a packet produce white flowers. The rest produce pink flowers. Use the Table of Random Digits on pp. A-3 and A-4 to simulate randomly planting 25 seeds.

10. The students in a typing class have a mean typing rate of 38.2 words per minute. Five randomly selected students have typing rates of 32, 28, 41, 38, and 45 words per minute. Find $\mu$ and $\bar{x}$.
11. The mean daily high temperature in January for a certain city is 39°F with a standard deviation of 6°F. High temperatures, recorded at randomly selected schools in the city on randomly selected days in a given January, are as follows: 27°F, 46°F, 47°F, 33°F, 51°F, 19°F, 23°F, 31°F, 44°F, and 30°F. Find $\sigma$, $s$, $\mu$, and $\bar{x}$.
12. The mean and standard deviation of scores on a national test is known to be 360 and 40, respectively. A group of 12 students had the following scores: 310, 415, 400, 375, 380, 445, 290, 315, 365, 365, 410, and 395. Find $\sigma$, $s$, $\mu$ and $\bar{x}$.

13. Let the digits 1, 2, 3, and 4 represent planting a seed for a white flower. Which digits represent planting a seed for a pink flower?
14. If you start at the beginning of line 136, how many seeds for white flowers are planted?
15. Write $p$ and $\hat{p}$ for this situation.
Twelve percent of the residents in a community have a master’s degree or higher. Use the Table of Random Digits on pp. A-3 and A-4 to simulate randomly selecting and asking 30 residents, “Do you have a master’s degree or higher?”

16. Let the digits 01 through 12 represent a response of Yes. Which digits represent a response of No?
17. Starting at the beginning of line 111, write the numbers as ordered pairs and circle those that indicate a response of Yes. How many residents in the sample have a master’s degree or higher?
18. Write \( p \) and \( \hat{p} \) for this situation.

A basketball player makes a foul shot 73% of the time. Use the Table of Random Digits on pp. A-3 and A-4 to solve.

19. Let the digits 01 through 73 represent a success. Write the numbers on line 105 as ordered pairs and circle those that represent a success. How many shots did he make?
20. Repeat the process to simulate 7 more trials by using lines 106 through 112.
21. In how many of the 8 trials did the player make at least 73% of the foul shots?
22. Based on the simulation, what is the average percent for the number of shots made?
Interval Estimates

In many practical situations, the population parameter is unknown.

Point and Interval Estimates

Point estimates are statistics, such as \( \hat{p} \) and \( \bar{x} \), that are used to estimate population parameters.

- The point estimate for \( p \) is \( \hat{p} \).
- The point estimate for \( \mu \) is \( \bar{x} \).

An interval estimate is a range of values that contain the point estimate and, therefore, is likely to contain the population parameter. It is determined by the margin of error, the greatest likely difference between the point estimate and parameter.

Find the lower limit by subtracting the margin of error from the point estimate. Find the upper limit by adding the margin of error to the point estimate. Look at the three ways you may see interval estimates described.

<table>
<thead>
<tr>
<th>General Form</th>
<th>Example</th>
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</thead>
<tbody>
<tr>
<td>point estimate ± margin of error</td>
<td>14% ± 2%</td>
</tr>
<tr>
<td>between lower limit and upper limit</td>
<td>between 12% and 16%</td>
</tr>
<tr>
<td>(lower limit, upper limit)</td>
<td>(12%, 16%)</td>
</tr>
</tbody>
</table>

Using Interval Estimates: Proportions

A survey determined that the proportion \( p \) of voters in a city who support a local wildlife refuge is likely to be in the interval (0.62, 0.67). Write the interval estimate in the form point estimate ± margin of error.

The margin of error is half the difference of the upper and lower limits: 
\[
\frac{0.67 - 0.62}{2} = 0.025.
\]
To find the point estimate \( \hat{p} \), add the margin of error to the lower limit: 0.62 + 0.025 = 0.645. The interval estimate is 0.645 ± 0.025.

Q & A

Q What is the interval for the number of voters who are likely to support the refuge?

A (465, 503)
If 750 voters are randomly sampled, what is the best estimate for the number of voters who support the wildlife refuge?

Because \( \hat{p} \) is the best estimate of \( p \), then 64.5% of the 750 voters, or about 484 of the voters, are likely to support the refuge.

Using Interval Estimates: Means

A study of a sample of two-toed sloths in a given area indicates that the mean weight of all the sloths in that area is between 16.8 pounds and 17.6 pounds. Write the interval estimate in the form point estimate ± margin of error.

Because \( \frac{17.6 - 16.8}{2} = 0.4 \), the margin of error is ± 0.4 pounds and the point estimate \( x \) is 16.8 pounds + 0.4 pounds, or 17.2 pounds.

The interval estimate is 17.2 pounds ± 0.4 pounds.

Using Point Estimates: Proportions

In a random sample of 63 homeowners in a city, 15 homeowners said that they would support a ban on all nonnatural lawn fertilizers in an effort to protect the fish in the local waterways. The sampling method had a margin of error of ± 3.5%. Write the interval estimate for the proportion that would support the ban in the form (lower limit, upper limit).

First determine the point estimate: \( \hat{p} = \frac{15}{63} \approx 0.238 \), or 23.8%.

Then subtract the margin of error from the point estimate to get the lower limit and add the margin of error to the point estimate to get the upper limit.

Lower limit: 23.8% − 3.5% = 20.3%
Upper limit: 23.8% + 3.5% = 27.3%

The interval estimate is (20.3%, 27.3%).

In a random sample of 120 homeowners in the city, how many homeowners would you expect to say they would support the ban? Give the answer as an interval.

Because 20.3% of 120 is about 24, and 27.3% is about 33, you would expect between 24 and 33 of the homeowners to say they would support the ban.

Using Point Estimates: Means

In a two-toed sloth study, the sloths in the sample had a mean body length of 63 centimeters. The study had a margin of error of ± 0.7 centimeters. Write the interval estimate for the mean body length in the form (lower limit, upper limit).

Lower limit: 63 centimeters − 0.7 centimeters = 62.3 centimeters
Upper limit: 63 centimeters + 0.7 centimeters = 63.7 centimeters

The interval estimate is (62.3 centimeters, 63.7 centimeters).
Problem Set

Write the interval in the form (lower limit, upper limit).

1. 33.5% ± 4%
2. 81 centimeters ± 1.6 centimeters
3. 142.75 grams ± 2.25 grams
4. 0.66 ± 0.025

The results of a poll indicate that between 46% and 52% of consumers prefer Drink A to Drink B.

5. Give a point estimate for the proportion of consumers that prefer Drink A to Drink B.
6. Give the margin of error for the poll.
7. For 1500 randomly selected consumers, give the interval for the number of consumers who are likely to prefer Drink A to Drink B.

From a phone survey, a researcher determined that the true estimate for the proportion of voters who will reelect the mayor is likely in the interval (0.39, 0.47).

8. What is the point estimate of the proportion of voters who will vote to reelect the mayor?
9. What is the survey’s margin of error?
10. If 23,000 voters cast a vote in the election, what is the best estimate for the number of voters likely to reelect the mayor?

The mean weight of a sample of bottles in a factory indicates that the mean weight of all bottles produced that day is between 0.9 kilograms and 1.25 kilograms.

11. If 23,000 voters cast a vote in the election, give the interval for the number of voters who are likely to vote to reelect the mayor.

12. Give a point estimate for the mean weight of bottles produced that day.
13. Write the interval estimate in the form point estimate ± margin of error.
14. Could the bottles produced that day have a mean weight of 0.88 kilograms? Explain.

In a town’s study of its stray cats, a sample of stray cats had a mean weight of 7.3 pounds. The study had a margin of error of 1.1 pounds.

15. Write the interval estimate for the mean weight of the town’s stray cats in the form (lower limit, upper limit). Then describe the interval estimate in words.
16. In a second study, performed shortly after the first, the mean weight of a sample of stray cats was 6.8 pounds. This study had a margin of error of 0.8 pounds. Write the interval estimate for the mean weight of the town’s stray cats based on this study.
In a random sample of the 2877 cars on a used car lot, 5 of the 43 chosen cars failed a safety inspection. The sampling method had a margin of error of ± 0.02.

17. Give the point estimate of the proportion of cars on the lot that would fail the inspection.

18. Write the interval estimate for the proportion that would fail in the form (lower limit, upper limit).

In a random sample of 1300 adults, the participants were asked if they exercised daily for at least 30 minutes, and 312 of the participants said Yes. The poll had a margin of error of ± 3%.

20. Find \( \hat{p} \).

21. Write the interval estimate for the percent of all adults who exercise daily in the form (lower limit, upper limit). Then describe the interval estimate in words.

22. If another 1300 adults were randomly selected, how many would you expect to say Yes to the same question? Write your answer as an interval of numbers of people.

A toy-car model producer randomly selects and measures a sample of axles from a recently produced batch. The results indicate that for this batch the mean difference of the toy axle lengths and their proposed lengths is in the interval (−0.8 centimeters, 0.2 centimeters), where a negative difference is too short and a positive difference is too long.

25. Find the point estimate for this interval.

26. What is the margin of error for the interval estimate?

27. Are the axles in this batch likely to be shorter or likely to be longer than the proposed length?

28. Would the point estimate change if the interval were (−0.2 centimeters, 0.8 centimeters)? Would the margin of error change? Explain.
Chapter 5 Wrap-Up

Unrepresentative Samples

The president of a new animal shelter plans to survey a sample of townspeople, asking how much they are likely to donate to the shelter. The following methods are likely to lead to an unrepresentative sample.

<table>
<thead>
<tr>
<th>Sampling Method</th>
<th>Description of Probable Bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>She surveys her friends and family.</td>
<td>This sample is unrepresentative because friends and family are likely to donate more than other townspeople.</td>
</tr>
<tr>
<td>She surveys a group of high school students who live in the town.</td>
<td>This sample is unrepresentative because many high school students are not employed and are likely to donate less than other townspeople.</td>
</tr>
</tbody>
</table>

Random Samples

A random sample is likely to lead to a representative sample.

There are 237 animals in an animal shelter. To create a simple random sample of 15 animals, the president assigns each animal a number from 001 to 237.

If she starts at line 111, she will choose the animals assigned to numbers 071, 197, 103, 174, 185, 043, 194, 017, 179, 031, 143, 137, 058, 055, and 214.
In Summary

Measures taken from samples are called statistics, and measures taken from populations are called parameters. If the sample is not biased, the sample statistic estimates the population parameter. The margin of error shows the likely accuracy of the estimate.
Practice Problems

Sampling

A college student studying health education wants to know the mean number of calories in the snacks that are sold in the vending machines around campus. When he sees students buying snacks from a vending machine, he records the type of snack purchased and the number of calories listed on the wrapper. He does this for 2 weeks and records the number of calories in 17 different snacks. He calculates the mean number of calories in these snacks to be 335.

1. Describe the population and the sample as thoroughly as possible.
2. Identify the type of sampling used as volunteer, convenience, or systematic.
3. Tell how the sample of snacks could be biased.
4. Is the number 335 a statistic or a parameter?
5. Tell if the situation involves descriptive statistics or inferential statistics.

A homeowner wants to know if people in her neighborhood would be interested in starting a book club. She prints flyers with ideas for the club and requests that people text Yes or No to her cell phone in response to the following question:

Although joining a book club could mean losing approximately an hour a day of free time to read the required book for each month, would you like to participate in a book club with your neighbors?

The homeowner tapes a flyer to 200 doors. She receives 46 text responses, and 15 of those responses are Yes.

6. Describe the population and the sample as thoroughly as possible.
7. Identify the type of sampling used as volunteer, convenience, or systematic.
8. Toward which group of people is the sampling technique biased? Explain.
9. What proportion of the responses were Yes responses?
10. Explain how the wording of the question could be responsible for the low proportion of Yes responses.

Solve.

11. A chain of grocery markets employs 412 part-time workers and 198 full-time workers. In a sample of 55 employees at those markets, 32 said they worked part time. Write \( p \) and \( \hat{p} \) for part-time workers, and \( p \) and \( \hat{p} \) for full-time workers.

12. The average amount of money customers spend trying to win a scooter in a carnival game is $11.50 with a standard deviation of $0.75. The amounts spent by a sample of customers chosen over one weekend are as follows:

$5.50, $16, $13.25, $10, $14.25, $15.75, $9.25, $10, $13.25, $7.50

Find \( \mu \), \( \sigma \), \( \bar{x} \), and \( s \).
The executive assistant at a company is selecting a sample of company employees and asking how many miles they commute, one way, to work. To form the sample, he prints an alphabetical list of all employee names and chooses every 15th name. The mean number of one-way commute miles from the sample is 19.6. The survey has a margin of error of ± 2.4 miles.

13. Describe the population and the sample as thoroughly as possible.

14. Identify the type of sampling used as volunteer, convenience, or systematic.

15. Which is equal to 19.6: \( \mu \) or \( \bar{x} \)?

16. Write the interval estimate for the mean number of one-way commute miles in the form (lower interval limit, upper interval limit). Then describe the interval in words.

The results of a poll indicate that between 61% and 64% of a city’s residents are in favor of tougher water restrictions in the face of the upcoming drought.

17. Give a point estimate for the percent of residents in favor of tougher water restrictions.

18. Give the margin of error for the poll.

19. If there are 83,972 residents, what is the best estimate for the number of residents who are in favor of the tougher restrictions?

20. In a random sample, 800 residents are asked whether they are in favor of the tougher water restrictions. What is the interval for the number of residents who are likely to say Yes?

The counties of the state of New Jersey are listed below. Use the Table of Random Digits on pp. A-3 and A-4 to solve. Note: Counties with an asterisk (*) represent counties that border the Atlantic Ocean.

Atlantic* Gloucester Ocean*
Bergen* Hudson* Passaic
Burlington Hunterdon Salem
Camden Mercer Somerset
Cape May* Middlesex* Sussex
Cumberland Monmouth* Union*
Essex* Morris Warren

21. Number the counties consecutively, starting with 00, according to alphabetical order.

22. Create an SRS of 5 counties by starting at line 106.

23. If an SRS of 7 counties represents ocean-bordering and non-ocean-bordering counties proportionally, how many of each type of county are in the sample?

24. Write the names of the counties chosen if the SRS of 7 counties are chosen proportionally by starting at line 110.