Surveys and Sampling

LEARNING OBJECTIVES

In this chapter we show you how to take samples that are representative of a larger population. After reading and studying this chapter, you should be able to:

1. Identify different ways of selecting a representative sample
2. Understand how to avoid bias
3. Explain terms such as population, sampling frame, and sample

Angus Reid Strategies

Angus Reid Strategies is a Canadian market research firm that monitors the values, attitudes, and preferences of consumers. They don’t just phone people and ask their opinions; instead, much of the company’s research is conducted over the Internet so that the respondents can be shown images, streaming video, and 3D virtual environments. In this way respondents become more engaged than they would be with traditional telephone interviews, which in turn leads to a higher-quality survey with more accurate results.

One of Angus Reid’s products is the Daily Omnibus, which allows business clients to pose questions online by noon one day and get a response from a representative sample of Canadians by 5 P.M. the next day. Angus Reid Strategies employs statisticians to ensure that the sample is representative of all regions of Canada and includes both English and French respondents. A representative sample is very important in ensuring that the results are valid nationwide. For instance, if we’re designing a national marketing campaign for a new product, we may conduct a survey to investigate the product features most in
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demand. The population sample we survey must be representative of the whole country so that we can be sure the results apply to our national marketing campaign.

Angus Reid’s statisticians also take other considerations into account when choosing the sample of respondents. Cost affects Angus Reid as it does all other market research companies, and the cost of conducting a survey is related to how many respondents participate in the survey. It’s easy to get a representative sample of Canadians if we have a budget that will allow us to interview a million people. But do you think it could be done by interviewing just a thousand people? Angus Reid would answer yes. Its statisticians use just 1000 adult Canadians in its Daily Omnibus.1

How do the researchers at Angus Reid know that the responses they get reflect the real attitudes of consumers? After all, they don’t poll entire populations, but they don’t want to limit their conclusions to just the people they surveyed. Generalizing from the data at hand to the world at large is something that market researchers, investors, and pollsters do every day. To do it wisely, they need to follow three fundamental principles.

LO 1

3.1 Three Features of Sampling

Feature 1: Examine a Part of the Whole

The first step is to draw a sample. We’d like to know about an entire population of individuals, but examining all of them is usually impractical, if not impossible. So we settle for examining a smaller group of individuals—a sample—selected from the population. For example, the whole of Canada is the population the Angus Reid researchers are interested in, but it’s not practical, cost-effective, or feasible to survey the entire population. So they examine a sample selected from that population.

You take samples of a larger population every day. For example, if you want to know how the vegetable soup you’re cooking for dinner tonight is going to taste, you try it. You certainly don’t consume the whole pot. You trust that the taste will represent the flavour of the entire pot. The idea of tasting is that a small sample, if selected properly, can represent the entire population.

The Angus Reid Daily Omnibus is an example of a sample survey, designed to ask questions of a small group of people in the hope of learning something about the entire population. Most likely, you’ve never been selected to be part of a national opinion poll. That’s true of most people. So how can the pollsters claim that a sample is representative of the entire population? Professional researchers like those who run the Angus Reid survey work hard to ensure that the “taste”—the sample they take—represents the population fairly.

Selecting a sample to represent the population fairly is more difficult than it sounds. Polls or surveys most often fail because the sample fails to represent part of the population. The way the sample is drawn may overlook subgroups that are hard to find. For example, a telephone survey may get no responses from people with caller ID and may favour other groups, such as the retired or the homebound, who would be more likely to be near their phones when the interviewer calls. Samples

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Three Features of Sampling

that over- or underemphasize some characteristics of the population are said to be biased. When a sample is biased, the summary characteristics of a sample differ from the corresponding characteristics of the population it is trying to represent. Conclusions based on biased samples are inherently flawed. There is usually no way to fix bias after the sample is drawn and no way to salvage useful information from it.

What are the basic techniques for making sure that a sample is representative? To make the sample as representative as possible, you might be tempted to hand-pick the individuals included in it. But the best strategy is to do something quite different: We should select individuals for the sample at random.

Feature 2: Randomize

Think back to our example of sampling vegetable soup. Suppose you add some salt to the pot. If you sample the soup from the top before stirring, you'll get the misleading idea that the whole pot is salty. If you sample from the bottom, you'll get the equally misleading idea that the whole pot is bland. But by stirring the soup, you randomize the amount of salt throughout the pot, making each spoonful more typical of the saltiness of the whole pot. Deliberate randomization is one of the great tools of statistics. (We'll discuss many aspects of randomness in Chapter 8.)

Randomization can protect against factors you aren’t aware of, as well as those you know are in the data. Suppose that while you aren’t looking a friend adds a handful of peas to the soup. The peas sink to the bottom of the pot, mixing with the other vegetables. If you don’t randomize the soup by stirring, your test spoonful from the top won’t include any peas. By stirring in the salt, you also randomize the peas throughout the pot, making your sample taste more typical of the overall pot even though you didn’t know the peas were there. So, randomizing protects us by giving us a representative sample even for effects we were unaware of.

How do we “stir” people in our survey? We select them at random. Randomizing protects us from the influences of all the features of our population by making sure that, on average, the sample looks like the rest of the population.

We all think we know what it means for something to be random. Rolling dice, spinning dials, and shuffling cards all produce random outcomes. What’s the most important aspect of the randomness in these games? It makes them fair.

Two things make randomization seem fair. First, nobody can guess the outcome before it happens. Second, when we want things to be fair, usually some underlying set of outcomes will be equally likely (although in many games, some combinations of outcomes are more likely than others). We’ll soon see how to use randomness to ensure that the sample we draw is representative of the population we want to study.

Truly random values are surprisingly hard to get. Computers are a popular way to generate random numbers. But even though they often do a much better job than humans, computers can’t generate truly random numbers either. Computers follow programs. Start a computer from the same place, and, all things being equal, it will follow the same path every time. So, numbers generated by a computer program are not truly random. Technically, “random” numbers generated by computer are pseudorandom. Fortunately, pseudorandom values are good enough for most purposes because they’re virtually indistinguishable from truly random numbers.

• Why not match the sample to the population? Rather than randomizing, we could try to design our sample to include every possible relevant characteristic: income level, age, political affiliation, marital status, number of children, place of
residence, etc. Clearly we couldn’t possibly think of all the things that might be important, however. Even if we could, we wouldn’t be able to match our sample to the population for all these characteristics. That’s why we randomize.

How well does a sample represent the population from which it was selected? Here’s an example using the database of a philanthropic organization with a donor list of about 3.5 million people. We’ve taken two samples, each of 8000 individuals at random from the population. Table 3.1 shows how the means and proportions match up on seven variables.

Notice that the two samples match closely in every category. This shows how well randomizing has “stirred” the population. We didn’t preselect the samples for these variables, but randomizing has matched the results closely. We can reasonably assume that since the two samples don’t differ too much from each other, they don’t differ much from the rest of the population either.

Even if a survey is given to multiple random samples, the samples will differ from each other, and, therefore, so will the responses. These sample-to-sample differences are referred to as **sampling variability**.

### Feature 3: The Sample Size Is What Matters

You probably weren’t surprised by the idea that a sample can represent the whole. And the idea of sampling randomly makes sense when you stop to think about it, too. But the third important feature of sampling often surprises people: The size of the sample determines what we can conclude from the data regardless of the size of the population. Many people think we need a large percentage, or fraction, of the population, but in fact all that matters is the sample size. The size of the population doesn’t matter at all. A random sample of 100 students in a university represents the student body just about as well as a random sample of 100 voters represents the entire electorate of Canada. This is perhaps the most surprising key feature behind survey design.

To understand how this works, let’s return one last time to our pot of soup. If you’re cooking for a banquet-sized group, rather than just for a few people, the amount of soup in your pot will increase, but you won’t need a bigger spoon to decide how the soup tastes. The same size spoonful is probably enough to make a decision about the entire pot, no matter how large the pot. What fraction of the population you sample doesn’t matter. It’s the sample size itself that’s important. This idea is of key importance to the design of any sample survey, because it determines the balance between how well the survey can measure the population and how much the survey costs.

How big a sample do you need? That depends on what you’re estimating, but drawing too small a sample won’t be representative of the population. To get an

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3Well, that’s not exactly true. If the sample is more than 10% of the whole population, it can matter. It doesn’t matter whenever, as usual, our sample is a very small fraction of the population.
idea of what’s really in the soup, you need a large enough taste to be a representative sample from the pot, including, say, a selection of the vegetables. For a survey that tries to find the proportion of the population falling into a category, you’ll usually need at least several hundred respondents.³

- **What do the professionals do?** How do professional polling and market research companies do their work? The most common polling method today is to contact respondents by telephone. Computers are used to generate random telephone numbers for telephone exchanges known to include residential customers; this method allows pollsters to contact people with unlisted phone numbers. The person who answers the phone will be invited to respond to the survey—if that person qualifies. (For example, only adults are usually surveyed, and the respondent usually must live at the residence phoned.) If the person answering doesn’t qualify, the caller will ask to speak with someone else. And when they actually conduct the interview, the pollsters often list possible responses (such as product names) in randomized order to avoid biases that might favour the first name on the list.

Do these methods work? The Pew Research Center for the People and the Press, reporting on one survey, says that

> Across five days of interviewing, surveys today are able to make some kind of contact with the vast majority of households (76%), and there has been no decline in this contact rate over the past seven years. But because of busy schedules, skepticism, and outright refusals, interviews were completed in just 38% of households that were reached using standard polling procedures.

Nevertheless, studies indicate that those actually sampled can give a good snapshot of larger populations from which the surveyed households were drawn.

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**LO 3.2 A Census—Does It Make Sense?**

Why bother determining the right sample size? If you plan to open a store in a new community, why draw a sample of residents to understand their interests and needs? Wouldn’t it be better to just include everyone and make the “sample” be the entire population? Such a special sample is called a **census**. Although a census would appear to provide the best possible information about the population, there are a number of reasons why it might not.

First, it can be difficult to complete a census. Some individuals are hard to locate or hard to measure. Do you really need to contact the folks away on vacation when you collect your data? How about those with no telephone or mailing address? The cost of locating the last few cases may far exceed the budget. It can also be just plain impractical to take a census. The quality control manager for Hostess Twinkies doesn’t want to census all the Twinkies on the production line to determine their quality. Aside from the fact that nobody could eat that many Twinkies, it would defeat the purpose: There would be none left to sell.

Second, the population we’re studying may change. For example, in any human population, babies are born, people travel, and folks die during the time it takes to complete the census. News events and advertising campaigns can cause sudden shifts in opinions and preferences. A sample, surveyed in a shorter time frame, may actually generate more accurate information.

³Chapter 10 gives the details behind this statement and shows how to decide on a sample size for a survey.
Finally, taking a census can be cumbersome. A census usually requires a team of pollsters and/or the cooperation of the population. Some people might have more than one address. For example, students often have one address during the school year and another one during the summer. It takes a lot of effort to figure out which is the “main” or “primary” residence, so as to avoid double-counting.

For Example  Identifying sampling terms

A nonprofit organization has taken over a historic theatre and hopes to preserve it with a combination of attractive shows and fundraising. The organization has asked a team of students to help it design a survey to better understand the customer base likely to purchase tickets. Fortunately, the theatre’s computerized ticket system records contact and some demographic information for ticket purchasers, and that database of 7345 customers is available.

Questions: What is the population of interest?
What would a census involve in this case? Would it be practical?
What is the sampling frame?
Answers: The population is all potential ticket purchasers. A census would have to reach all potential purchasers. We don’t know who they are or have any way to contact them. The sampling frame is the list of previous ticket purchasers.

LO 3.3 Populations and Parameters

GfK Roper Reports Worldwide states that 60.5% of people over 50 worry about food safety, but only 43.7% of teens do. What does this claim mean? We can be sure the Roper researchers didn’t take a census to obtain the results. So they can’t possibly know exactly what percentage of teenagers worry about food safety. So what does “43.7%” mean?

To generalize from a sample to the world at large, we need a model of reality. Such a model doesn’t need to be complete or perfect. Just as a model of an airplane in a wind tunnel can tell engineers what they need to know about aerodynamics, even though it doesn’t include every rivet of the actual plane, models of data can give us summaries that we can learn from and use even though they don’t fit each data value exactly. It’s important to remember that they’re only models of reality and not reality itself. But without models, what we can learn about the world at large is limited to what we can say about the data we have at hand.

Models use mathematics to represent reality. We call the key numbers in those models parameters. All kinds of models have parameters, so sometimes a parameter used in a model for a population is called a population parameter.

But let’s not forget about samples. We use a sample to try to estimate values for the population parameters (see Figure 3.1). Anything calculated from a sample is a statistic. Those statistics that estimate population parameters are particularly interesting. Sometimes—and especially when we match statistics with the parameters they estimate—we use the term sample statistic.

We draw samples because we can’t work with the entire population. We hope that the statistics we compute from the sample will estimate the corresponding population parameters accurately. A sample that does this is said to be representative.
Simple Random Sampling (SRS)

How would you select a representative sample? It seems fair to say that every individual in the population should have an equal chance to be selected, but that’s not sufficient. There are many ways to give everyone an equal chance that still wouldn’t generate a representative sample. Consider, for example, a manufacturer that samples customers by drawing at random from product registration forms, half of which arrived by mail and half by online registration. They flip a coin to generate the samples. If it comes up heads, they draw 100 mail returns; tails, they draw 100 electronic returns. Each customer has an equal chance of being selected, but if tech-savvy customers are different, then the samples are hardly representative.

We need to do better. Suppose we insist that every possible sample of the size we plan to draw has an equal chance of being selected. This ensures that situations like the all tech-savvy (or not) samples are not likely to occur and still guarantees that each person has an equal chance of being selected. A sample drawn in this way is called a simple random sample (SRS). An SRS is the standard against which we measure other sampling methods, and the sampling method on which the theory of working with sampled data is based.

To select a sample at random, we first need to define a sampling frame, a list of individuals from which the sample will be drawn. For example, to draw a random sample of regular customers, a store might sample from its list of all “frequent buyers.” In defining the sampling frame, the store must deal with the details of defining the population. Are former frequent buyers who have moved away included?

Just Checking

1. Various claims are often made for surveys. Why is each of the following claims not correct?
   a) It is always better to take a census than to draw a sample.
   b) Stopping customers as they are leaving a restaurant is a good way to sample opinions about the quality of the food.
   c) We drew a sample of 100 from the 3000 students in a school. To get the same level of precision for a town of 30,000 residents, we’ll need a sample of 1000.
   d) A poll taken at a popular website (www.statsisfun.org) garnered 12,357 responses. The majority of respondents said they enjoy doing statistics. With a sample size that large, we can be sure that most people feel this way.
   e) The true percentage of all people who enjoy statistics is called a “population statistic.”

3.4 Simple Random Sampling (SRS)

A sample is used to calculate a statistic, which in turn is used to estimate a parameter of a population. For example, from surveying a sample of customers, we can calculate the percentage who prefer Brand X. The percentage from the sample can then be used to estimate the percentage of the whole population that prefers Brand X. The end result is that data from a sample is used to tell us something about a population.

Figure 3.1 A sample is used to calculate a statistic, which in turn is used to estimate a parameter of a population. For example, from surveying a sample of customers, we can calculate the percentage who prefer Brand X. The percentage from the sample can then be used to estimate the percentage of the whole population that prefers Brand X. The end result is that data from a sample is used to tell us something about a population.
How about those who still live in the area but haven’t shopped at the store in over a year? The answers to these questions may depend on the purpose of the survey.

Once we have a sampling frame, the easiest way to choose an SRS is with random numbers. We can assign a sequential number to each individual in the sampling frame. We then draw random numbers to identify those to be sampled. Let’s look at an example.

- We want to select five students from the 80 enrolled in a Business Statistics class. We start by numbering the students from 00 to 79. Now we get a sequence of random digits from a table (such as the table in the back of this book), technology (most statistics packages and spreadsheets can generate random numbers), or the Internet (e.g., a site like www.random.org). For example, we might get 051662930577482. Taking those random numbers two digits at a time gives us 05, 16, 62, 93, 05, 77, and 48. We ignore 93 because no one had a number that high. And to avoid picking the same person twice, we also skip the repeated number 05. Our simple random sample consists of students with the numbers 05, 16, 62, 77, and 48.

Often the sampling frame is so large that it would be awkward to search through the list to locate each randomly selected individual. An alternative method is to generate random numbers of several digits in length, assigning one to each member of the sampling frame. Then you could sort the random numbers, carrying along the identities of the individuals in the sampling frame. (Spreadsheets and statistics programs can typically do this kind of sort.) Now you can pick a random sample of any size you like off the top of the sorted list.

Samples drawn at random generally differ one from another. Each draw of random numbers selects different people for our sample. These differences lead to different values for the variables we measure. As was mentioned earlier, we call these sample-to-sample differences sampling variability. Surprisingly, sampling variability isn’t a problem; it’s an opportunity. If different samples from a population vary little from each other, then most likely the underlying population harbours little variation. If the samples show much sampling variability, the underlying population probably varies a lot. In the coming chapters, we’ll spend much time and attention working with sampling variability to better understand what we are trying to measure.

Questions:
What is the sampling frame?
If the customer database held 30,000 records instead of 7345, how much larger a sample would we need to get the same information?
If we then draw a different sample of 200 customers and obtain different answers to the questions on the survey, how do we refer to these differences?
Answers: The sampling frame is the customer database.
The size of the sample is all that matters, not the size of the population. We would need a sample of 200.
The differences in the responses are called sampling error, or sampling variability.
3.5 Other Random Sample Designs

Simple random sampling is not the only fair way to generate a sample. More complicated designs may save time or money or avert sampling problems. That said, all statistical sampling designs have in common the idea that chance, rather than human choice, is used to select the sample.

Stratified Sampling

Designs that are used to sample from large populations—especially populations residing across large areas—are often more complicated than simple random samples. Sometimes we slice the population into homogeneous groups, called strata, and then use simple random sampling within each stratum, combining the results at the end. This is called stratified random sampling.

Why would we want to stratify? Suppose we want to survey how shoppers feel about a potential new anchor store at a large suburban mall. The shopper population is 60% women and 40% men, and we suspect that men and women have different views on their choice of anchor stores. If we use simple random sampling to select 100 people for the survey, we could end up with 45 men and 55 women or 35 men and 65 women. Our resulting estimates of the attractiveness of a new anchor store could vary widely. To help reduce this sampling variability, we can force a representative balance, selecting 40 men at random and 60 women at random. This would guarantee that the proportions of men and women within our sample match the proportions in the population, and that should make such samples more accurate in representing the opinion of the population.

You can imagine that stratifying by race, income, age, and other characteristics can be helpful, depending on the purpose of the survey. When we use a sampling method based on strata, samples within each stratum are more like one another, so statistics calculated for the sampled values will vary less from one sample to another. This reduced sampling variability is the most important benefit of stratifying. It also means that we can obtain information about the strata themselves in addition to finding out about the whole population. For instance, a sample stratified by age group is used to estimate the unemployment rate of the Canadian workforce. This gives a more accurate estimate of the national unemployment rate than a simple random sample would. At the same time, it allows us to estimate the unemployment rate of each age group.

Sometimes we may simply not be able to get samples from our strata that are in the same proportions as in the whole population. For instance, suppose we conduct a survey of Canadians to ask whether they support increased use of nuclear power, and find that only 29% of our responses are from Ontario, whereas 38% of the Canadian population are Ontarians. If 54% of Ontarians in our sample support increased use of nuclear power, and 42% of non-Ontarians support it, then in our final results we would weight those figures according to the sizes of the populations, not the sizes of our samples. The percentage of Canadians supporting nuclear power would be estimated as: \( 54 \times 0.38 + 42 \times 0.62 = 46.56\% \). (It would not be correct to weight according to the number of responses to the survey: \( 54 \times 0.29 + 42 \times 0.71 = 45.48\% \).)

When stratifying a population, we are sometimes tempted to forget about some strata “because they are too small to bother with.” This can lead to strange results. When estimating imports and exports from a country, we survey companies, stratifying them by size: large, medium, small. However, it is tempting not
to bother with very small companies, since it takes extra time to survey them and they probably don’t export or import much anyway. A study by the International Monetary Fund (IMF) investigated the imbalance between world imports and exports. It is no surprise that each country’s volume of exports and imports differ. However, taking the world as a whole, each country’s exports become the imports of another country, so globally everything should balance out. Surprisingly, global exports were more than $300 billion higher than global imports were in 2010. Where did all those exports go? Are flying saucers taking exports from planet Earth into space? The IMF’s implicit response to that last question was no. Instead, it found that very small companies import more than they export, and the surveys used do not include a stratum for very small companies. The net result is that the surveys underestimate net imports. So the moral of the story is that it’s important to take samples from every stratum in our population, and not to discard strata because they’re inconvenient to survey or because we think they’ll have only a small impact on the overall results.

**Cluster Sampling**

Sometimes dividing the sample into homogeneous strata isn’t practical, and even simple random sampling may be difficult. For example, suppose we wanted to assess the reading level of a product instruction manual based on the length of the sentences. Simple random sampling could be awkward; we’d have to number each sentence and then find, for example, the 576th sentence or the 2482nd sentence, and so on. Doesn’t sound like much fun, does it?

We could make our task much easier by picking a few pages at random and then counting the lengths of the sentences on those pages. That’s easier than picking individual sentences and works if we believe that the pages are all reasonably similar to one another in terms of reading level. Splitting the population in this way into parts or **clusters** that each represent the population can make sampling more practical. We select one or a few clusters at random and perform a census within each of them. This type of sampling design is called **cluster sampling**. If each cluster fairly represents the population, cluster sampling will generate an unbiased sample.

What’s the difference between cluster sampling and stratified sampling? We stratify to ensure that our sample represents different groups in the population, and sample randomly within each stratum. This reduces the sample-to-sample variability. Strata are homogeneous, but differ from one another. By contrast, clusters are more or less alike, each heterogeneous and resembling the overall population. We cluster to save money or even to make the study practical (see Figure 3.2).

**Systematic Sampling**

Sometimes we draw a sample by selecting individuals systematically. For example, a **systematic sample** might select every 10th person on an alphabetical list of employees. To make sure our sample is random, we still must start the systematic selection with a randomly selected individual—not necessarily the first person on the list. When there is no reason to believe that the order of the list could be associated in any way with the responses measured, systematic sampling can give
Other Random Sample Designs

(a) Simple Random Sampling

(b) Systematic Random Sampling: every 6th item is selected

Figure 3.3  Simple and systematic random sampling.

(a) Strata are different from each other. Include all of them and then choose a random sample within each one.
(b) Clusters are similar to each other. Select some clusters at random and then choose a random sample within those that are selected.

Figure 3.2  Strata and clusters.

a representative sample. We compare systematic and simple random sampling in Figure 3.3. One of the virtues of systematic sampling is that it can be much less expensive than simple random sampling.

Let’s return to the reading-level example. Suppose we’ve chosen a section of the instruction manual at random, then three pages at random from that section, and now we want to select a sample of 10 sentences from the 73 sentences found on those pages. Instead of numbering each sentence so that we can pick a simple random sample, it would be easier to sample systematically. A quick calculation shows

Just Checking

2  We need to survey a random sample of the 300 passengers on a flight from Vancouver to Tokyo. Name each sampling method described below.
   a) Pick every 10th passenger as people board the plane.
   b) From the boarding list, randomly choose five people flying first-class and 25 of the other passengers.
   c) Randomly generate 30 seat numbers and survey the passengers who sit there.
   d) Randomly select a seat position (right window, right centre, right aisle, etc.) and survey all the passengers sitting in those seats.
that 73/10 = 7.3, so we can get our sample by picking every seventh sentence on the page. But where should we start? At random, of course. We’ve accounted for 10 × 7 = 70 of the sentences, so we’ll throw the extra three into the starting group and choose a sentence at random from the first 10. Then we should pick every seventh sentence after that and record its length.

When using systematic sampling, we must be careful that our sampling frequency is NOT related to something about the process we are sampling. For instance, suppose we’re sampling car tires coming off a production line for quality-control purposes, and we’ve decided to sample every 100th tire. If the production-line employees routinely adjust the settings on one of the machines every 100th tire, then our sample will not be random. Instead, we may be sampling tires that are all produced just after the machine is reset, thus biasing our results. Similar problems occur if we sample every 50th tire or every 200th tire. If something about the process being sampled changes regularly (in this case every 100th tire), we should sample at a frequency that is not related to 100. In this case we could, for instance, sample every 87th tire, or every 123rd tire.

Multistage Sampling

Sometimes we use a variety of sampling methods together. In trying to assess the reading level of our instruction manual, we might worry that the “quick start” instructions are easy to read, but that the “troubleshooting” chapter is more difficult. If so, we’d want to avoid samples that are selected heavily from any one chapter. To guarantee a fair mix of sections, we could randomly choose one section from each chapter of the manual. Then we would randomly select a few pages from each of those sections. If altogether that made too many sentences, we might select a few sentences at random from each of the chosen pages. So, what is our sampling strategy? First we stratify by the chapter of the manual and randomly choose a section to represent each stratum. Within each selected section, we choose pages as clusters. Finally, we consider an SRS of sentences within each cluster. The use of sampling schemes that combine several methods is called multistage sampling.

Most surveys conducted by professional polling organizations and market research firms use some combination of stratified and cluster sampling as well as simple random samples.

For Example  Identifying more complex designs

The theatre board wants to encourage people to come from out of town to attend theatre events. They know that, in general, about 40% of ticket buyers are from out of town. These customers often purchase dinner at a local restaurant or stay overnight in a local inn, generating business for the town. The board hopes this information will encourage local businesses to advertise in the theatre program, so they want to be sure out-of-town customers are represented in the samples. The database includes postal codes. The student consultants decide to sample 80 ticket buyers from postal codes outside the town and 120 from the town’s own postal code.

Questions: What kind of sampling scheme are the student consultants using to replace the simple random sample?
What are the advantages of selecting 80 out-of-town and 120 local customers?

Answers: A stratified sample, consisting of a sample of 80 out-of-town customers and a sample of 120 local customers.

By stratifying, the consultants can guarantee that 40% of the sample is from out of town, reflecting the overall proportions among ticket buyers. If out-of-town customers differ in important ways from local ticket buyers, a stratified sample will reduce the variation in the estimates for each group so that the combined estimates can be more precise.
In a course at a business school, the students form business teams, propose a new product, and use seed money to launch a business to sell the product on campus.

Before committing funds for the business, each team must complete the following assignment: “Conduct a survey to determine the potential market demand on campus for the product you’re proposing to sell.” Suppose your team’s product is a 500-piece jigsaw puzzle of the map of your university campus. Design a marketing survey and discuss the important issues to consider.

### Guided Example: Market Demand Survey

**PLAN**

**Setup** State the goals and objectives of the survey (the Why).

**Population and Parameters** Identify the population to be studied and the associated sampling frame. The What identifies the parameters of interest and the variables measured. The Who is the sample of people we draw.

**Sampling Plan** Specify the sampling method and the sample size, \( n \). Specify how the sample was actually drawn. What is the sampling frame?

The description should, if possible, be complete enough to allow someone to replicate the procedure, drawing another sample from the same population in the same manner. A good description of the procedure is essential, even if it could never practically be repeated. The question you ask is important, so state the wording of the question clearly. Make sure the question is useful in helping you with the overall goal of the survey.

**DO**

**Mechanics** Specify When, Where, and How the sampling will be performed. Specify any other details of your survey, such as how respondents were contacted, any incentives that were offered to encourage them to respond, how nonrespondents were treated, and so on.

Our team designed a study to find out how likely students at our school are to buy our proposed product—a 500-piece jigsaw puzzle of the map of our university campus. The population studied will be students at our school. We’ve obtained a list of all students currently enrolled to use as the sampling frame. The parameter of interest is the proportion of students likely to buy this product. We’ll also collect some demographic information about the respondents.

We will select a simple random sample of students. We decided against stratifying by sex or age because we thought that students were all more or less alike in their likely interest in our product.

We will ask the students we contact:

**Do you solve jigsaw puzzles for fun?**

Then we’ll show them a prototype puzzle and ask:

**If this puzzle sold for $10, would you purchase one?**

We will also record the respondents’ sex and age.

The survey will be administered in the middle of the fall semester during October. We have a master list of registered students, which we will randomize by matching it with random numbers from www.random.org and sorting on the random numbers, carrying the names. We will contact selected students by phone or email and arrange to meet with them. If students are unwilling to participate, we’ll try to persuade them. If they still refuse, the next name from the randomized list will be substituted until a sample of 200 participants is found.

We will meet with students in an office set aside for this purpose so that each will see the puzzle under similar conditions.
MEMO

Re: Survey Plans

Our team’s plans for the puzzle market survey call for a simple random sample of students. Because subjects need to be shown the prototype puzzle, we must arrange to meet with selected participants. We have set aside an office for that purpose.

We will also collect demographic information so that we can determine whether there is in fact a difference in interest level across age groups or between men and women.

REPORT

Conclusion

This report should include a discussion of all the elements needed to design the study. It’s good practice to discuss any special circumstances or other issues that may need attention.

3.6 Practicalities

The Who of a survey can refer to different groups, and the resulting ambiguity can tell you a lot about the success of a study. First, you should think about the population of interest. Often, this is not a well-defined group. For example, who, exactly, is a mall “shopper”—only the hurrying couples already carrying a purchase, or should we include people eating at the food court? How about teenagers outside the mall’s video store, who may be carrying purchases or just hanging out, or both? Even when the population is clear, it may not be a practical group to study. For example, election polls want to sample from all those who will vote in the next election—a population that is particularly tricky to identify before election day.

Second, you must specify the sampling frame. Usually, the sampling frame is not the group you really want to know about, and sometimes it’s actually much smaller. The sampling frame limits what your survey can find out.

Then there’s your target sample. These are the individuals for whom you intend to measure responses. You’re not likely to get responses from all of them. (“I know it’s dinner time, but I’m sure you wouldn’t mind answering a few questions. It’ll only take 20 minutes or so. Oh, you’re busy?”) Nonresponse is a problem in many surveys.

Finally, there is your sample—the actual respondents. These are the individuals about whom you do get data and can draw conclusions. Unfortunately, they might not be representative of either the sampling frame or the population. For instance, the sample likely does not include people who were too busy to answer your questions, a common problem with most samples!

At each step, the group you can study may be constrained further. The Who keeps changing, and each constraint can introduce biases. A careful study should address the question of how well each group matches the population of interest. One of the main benefits of simple random sampling is that it never loses its sense of who’s Who. The Who in an SRS is the population of interest from which you’ve drawn a representative sample. That’s not always true for other kinds of samples.

When people (or committees!) decide on a survey, they often fail to think through the important questions about who are the Who of the study and whether they’re the individuals about whom the answers would be interesting or have meaningful business consequences. This is a key step in performing a survey and should not be overlooked.
3.7 The Valid Survey

It isn’t sufficient to draw a sample and start asking questions. You want to feel confident that your survey can yield the information you need about the population you’re interested in. In other words, you need a **valid survey**.

To help ensure that you create a valid survey, you need to ask four questions:

- What do I want to know?
- Who are the appropriate respondents?
- What are the best questions?
- What will be done with the results?

These questions may seem obvious, but there are a number of specific pitfalls to avoid:

**Know what you want to know.** Far too often, decision makers decide to perform a survey without any clear idea of what they hope to learn from it. Before considering a survey, you must be clear about what you hope to learn and from whom you hope to learn it. If you can’t identify those two factors, then you can’t judge whether you have a valid survey. In other words, the survey instrument—the questionnaire itself—can be a source of errors. Perhaps the most common error is to ask unnecessary questions. The longer the survey, the fewer people will complete it, leading to greater nonresponse bias. For each question on your survey, you should ask yourself whether you really want to know the response and what you would do with the responses if you had them. If you don’t have a good use for the answer to a question, don’t ask it.

**Use the right sampling frame.** A valid survey obtains responses from appropriate respondents. Be sure you have a suitable sampling frame. Have you identified the population of interest and sampled from it appropriately? A company looking to expand its base might survey customers who returned warrantee registration cards—after all, that’s a readily available sampling frame—but if the company wants to know how to make its product more attractive, it needs to survey customers who rejected its product in favour of a competitor’s product. This is the population that can tell the company what it needs to change about its product to capture a larger market share.

It is equally important to be sure that your respondents actually know the information you hope to discover. Your customers may not know much about the competing products, so asking them to compare your product with others may not yield useful information.

**Ask specific rather than general questions.** It’s better to be specific. “Do you usually recall TV commercials?” won’t be as useful as “How many TV commercials can you recall from last night?” or, better yet, “Please describe for me all the TV commercials you can recall from your viewing last night.”

**Watch for biases.** Even with the appropriate sampling frame, you must beware of response bias in your sample. If customers who purchase more expensive items are less likely to respond to your survey, this can lead to nonresponse bias. Although you can’t expect all mailed surveys to be returned, if those individuals who don’t respond have common characteristics, your sample will no longer represent the population you hope to learn about. Surveys in which respondents volunteer to participate, such as online surveys, suffer from voluntary response bias. Individuals with the strongest feelings on either side of an issue are more likely to respond; those who don’t care may not bother.
**It’s important not to confuse accuracy and bias.** You’re taking a sample in order to estimate something that applies to the whole population, i.e., you’re trying to get the right answer, or hit the target, as shown in Figure 3.4. Bias means that you’ve designed a survey that will be systematically off, no matter how many people you interview. To reduce bias, you’ll need to design a better survey. That’s sometimes tough to do, though. Nonresponse bias is particularly difficult to deal with, unless the market research budget is enticing enough to pay respondents fairly for their feedback. Accuracy can be improved by generating a larger sample; however, again the research budget needs to be large enough to pay for all those extra interviews and for the time required to analyze the extra results.

**Be careful with question phrasing.** Questions must be carefully worded. A respondent may not understand the question—or may not understand the question the way the researcher intended it. For example, “Does anyone in your family own a Ford truck?” leaves the term “family” unclear. Does it include only spouses and children or parents and siblings, or do in-laws and second cousins count, too? Similarly, a question like “Was your Twinkie fresh?” might be interpreted quite differently by different people.

**Be careful with answer phrasing.** Respondents and survey-takers may provide inaccurate responses, especially when questions are politically or sociologically sensitive. This also applies when the question doesn’t take into account all possible answers, such as a true–false or multiple-choice question to which there may be other answers. Or the respondent may not know the correct answer to the survey question. We refer to inaccurate responses (intentional or unintentional) as measurement errors. One way to cut down on measurement errors is to provide a range of possible responses. But be sure to phrase them in neutral terms.

The best way to protect a survey from measurement errors is to perform a pilot test. In a pilot test, a small sample is drawn from the sampling frame, and a draft version of the survey instrument is administered. A pilot test can point out flaws in the instrument. For example, during a staff cutback at one of our schools, a researcher surveyed faculty members to ask how they felt about the reduction in staff support. The scale ran from “It’s a good idea” to “I’m very unhappy.” Fortunately, the pilot study showed that everyone was very unhappy or worse. The scale was retuned to cover responses from “unhappy” to “ready to quit.”

**Be sure you really want a representative sample.** Up to now we’ve discussed how statisticians choose a sample so as to obtain results that are valid for a population; in other words, a representative sample. But sometimes our objective is different, and we don’t want a representative sample. In this case, although we’re not doing statistics, we may well be doing something else useful. Table 3.2 contrasts these situations in the case of corporate social responsibility.
A nonprofit organization has enlisted some student consultants to help design a fundraising survey for the theatre. The student consultants suggest to the board of directors that they may want to rethink their survey plans. The consultants point out that there are differences between the population, the sampling frame, the target sample contacted by telephone, and the actual sample.

**Question:** How do the population sampling frame, target sample, and sample differ?

**Answer:**
- **Population:** All potential ticket buyers.
- **Sampling Frame:** Only those who have previously purchased tickets. Anyone who wasn’t attracted to previous productions wouldn’t be surveyed. That could keep the board from learning of ways to make the theatre’s offering more attractive to those who hadn’t purchased tickets before.
- **Target Sample:** Those selected from the database who can be contacted by telephone. Those with unlisted numbers or who had declined to give their phone number can’t be contacted. It may be more difficult to contact those with caller ID.
- **Actual Sample:** Those previous customers selected at random from the database who can be reached by telephone and who agree to complete the survey.

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**Statistical Application of a Representative Sample**

A topic many companies are interested in is corporate social responsibility, or CSR. They want to know how important their CSR efforts are to their customers. We could estimate this by asking Canadians whether they agree with the statement “I always try to buy from companies that are good corporate citizens.” A representative sample of the entire Canadian population would be needed to come to a valid conclusion.

**Nonstatistical Application of a Nonrepresentative Sample**

The nonprofit organization Canadian Business for Social Responsibility wanted to encourage small businesses to engage in CSR by showing how other small businesses had done it successfully. To document the tricks of the trade, they interviewed only those small businesses that were interested and engaged in CSR. A representative sample of all small businesses, most of which are not involved in CSR, would not have been useful for this particular purpose.

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**Table 3.2** Applications of representative and nonrepresentative samples. Only the representative sample is used by statisticians.

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**For Example** Survey design

A nonprofit organization has enlisted some student consultants to help design a fundraising survey for the theatre. The student consultants suggest to the board of directors that they may want to rethink their survey plans. The consultants point out that there are differences between the population, the sampling frame, the target sample contacted by telephone, and the actual sample.

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**What Can Go Wrong? or, How to Sample Badly**

Bad sample designs yield worthless data. Many of the most convenient forms of sampling can be seriously biased. And there is no way to correct for the bias from a bad sample. So it’s wise to pay attention to sample design—and to beware of reports based on poor samples.

**Voluntary Response Sample**

One of the most common dangerous sampling methods is the voluntary response sample. In a voluntary response sample, a large group of individuals is invited to respond, and all who do respond are counted. This method is used by call-in shows, 900 numbers, Internet polls, and questionnaires sent by mail. Voluntary response samples are almost always biased, and so conclusions drawn from them are almost always wrong.

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It’s often hard to define the sampling frame of a voluntary response study. Practically, the frames are groups such as Internet users who frequent a particular website or viewers of a particular TV show. But those sampling frames don’t correspond to the population you’re likely to be interested in.

Even if the sampling frame is of interest, voluntary response samples are often biased toward those with strong opinions or those who are strongly motivated—and especially toward those with strong negative opinions. A request that travellers who have used the local airport visit a survey site to report on their experiences is much more likely to hear from those who had long waits, cancelled flights, and lost luggage than from those whose flights arrived on time and were free of luggage and scheduling-related hassles. The resulting voluntary response bias invalidates the survey.

**Convenience Sampling**

Another sampling method that doesn’t work is convenience sampling. As the name suggests, in *convenience sampling* we simply include the individuals who are convenient. Unfortunately, this group may not be representative of the population. Suppose we read a newspaper article reporting a survey that found 99% of people have an Internet connection. Later in the article, we learn that the survey was conducted via the Internet. That was a convenient way to collect data and surely easier than drawing a simple random sample, but perhaps it overestimated the percentage of people in the general population with an Internet connection.

Many surveys conducted at shopping malls suffer from the same problem. People in shopping malls are not necessarily representative of the population of interest. Mall shoppers tend to be more affluent and include a larger percentage of teenagers and retirees than the population at large. To make matters worse, survey interviewers tend to select individuals who look “safe,” or easy to interview.

Convenience sampling is a widespread problem in the business world. When a company wants to find out what people think about its products or services, it may turn to the easiest people to sample: its own customers. But the company will never learn how those who don’t buy its product feel about it.

**Bad Sampling Frame?**

An SRS from an incomplete sampling frame introduces bias because the individuals included may differ from the ones not in the frame. It may be easier to sample workers from a single site, but if a company has many sites and they differ in worker satisfaction, training, or job descriptions, the resulting sample can be biased. For example, there is serious concern among professional pollsters that the increasing numbers of people who can be reached only by cell phone may bias telephone-based market research and polling.

**Undercoverage**

Many survey designs suffer from *undercoverage*, in which some portion of the population isn’t sampled at all or has a smaller representation in the sample than it has in the population. Undercoverage can arise for a number of reasons, but it’s always a potential source of bias. Are people who use answering machines to screen callers (and are thus less available to blind calls from market researchers) different from other customers in their purchasing preferences?
The Valid Survey

• **Nonrespondents.** No survey succeeds in getting responses from everyone. The problem is that those who don’t respond may differ from those who do. And if they differ on just the variables we care about, the lack of response will bias the results. Rather than sending out a large number of surveys for which the response rate will be low, it’s often better to design a smaller, randomized survey for which you have the resources to ensure a high response rate.

• **Long, dull surveys.** Surveys that are too long are more likely to be refused, reducing the response rate and biasing all the results. Keep it short.

• **Response bias.** Response bias includes the tendency of respondents to tailor their responses to please the interviewer and the consequences of slanted question wording.

Push polls, which masquerade as surveys, present one side of an issue before asking a question. For example, a question like

> Would the fact that the new store that just opened in the mall sells mostly goods made overseas by workers in sweatshop conditions influence your decision to shop there rather than in the downtown store that features domestically produced products?

is designed not to gather information, but to spread ill will toward the new store.

### How to Think About Biases

• **Look for biases in any survey.** If you design a survey of your own, ask someone else to help look for biases that may not be obvious to you. Do this before you collect your data. There’s no way to recover from a biased sample or a survey that asks biased questions.

  A bigger sample size for a biased study just gives you a bigger useless study. A really big sample gives you a really big useless study.

• **Spend your time and resources reducing biases.** No other use of resources is as worthwhile as those designed to reduce biases.

• **If you possibly can, pretest or pilot your survey.** Administer the survey in the exact form you intend to use it to a small sample drawn from the population you intend to sample. Look for misunderstandings, misinterpretation, confusion, or other possible biases. Then redesign your survey instrument.

• **Always report your sampling methods in detail.** Others may be able to detect biases where you did not expect to find them.

### For Example

**Common mistakes in survey design**

A board member proposes that rather than telephoning past customers, the pollsters should simply post someone at the door to ask theatre goers their opinions. Another suggests that it would be even easier to post a questionnaire on the theatre website and invite responses there. A third member suggests that rather than working with random numbers, the pollsters should simply phone every 200th person on the list of past customers.

(continued)
Question: Identify the three methods proposed and explain what strengths and weaknesses they have.

Answer: Questioning customers at the door would generate a convenience sample. It would be cheap and fast, but is likely to be biased by the quality of the particular performance where the survey takes place.

Inviting responses on the website would generate a voluntary response sample. Only customers who frequented the website and decided to respond would be surveyed. This might, for example, underrepresent older customers or those without home Internet access.

Sampling every 200th name from the customer list would lead to a systematic sample. It is slightly easier than randomizing. If the order of names on the list is unrelated to any questions asked, then this might be an acceptable method. But if, for example, the list is kept in the order of first purchases (when a customer’s name and information were added to the database), then there might be a relationship between opinions and location on the list.

Ethics In Action

The Petitcodiac River Group is interested in applying for funds from the New Brunswick provincial government in order to continue its restoration and conservation of the Petitcodiac River. While the group has managed to gain significant support for its cause through education and community involvement, the executive committee is now interested in presenting the province with more compelling evidence. The Petitcodiac Group decided to survey local residents regarding their attitudes toward the proposed expansion of the river restoration and conservation project. With limited time and money (the deadline for the grant application was fast approaching), the executive committee was delighted when one of its members, Harry Greentree, volunteered to undertake the project. Harry owned a local organic food store and agreed to allow a sample of his shoppers to be interviewed during the next one-week period. The only concern that the committee had was that the shoppers be selected in a systematic fashion—for instance, by interviewing every fifth person who entered the store. Harry had no problem with this request and was eager to help the Petitcodiac River Group.

**ETHICAL ISSUE** Introducing bias into the results (even if not intentional). One might expect consumers of organic food to be more concerned about the environment than the general population (related to Item C, ASA Ethical Guidelines; see Appendix C, the American Statistical Association’s Ethical Guidelines for Statistical Practice, also available online at www.amstat.org/about/ethicalguidelines.cfm).

**ETHICAL SOLUTION** Harry is using a convenience sample from which results cannot be generalized. If the Petitcodiac River Group cannot improve its sampling scheme and survey design (e.g., for lack of expertise or time), the group should openly discuss the weaknesses of its sampling method when it discloses details of the study. When reporting the results, the group should note that findings are from a convenience sample and should include an appropriate disclaimer.

What Have We Learned?

**Learning Objectives** We’ve learned that a representative sample can offer important insights about populations. It’s the size of the sample—and not the fraction it represents of the larger population—that determines the precision of the statistics it yields.
What Have We Learned?

We’ve learned several ways to draw samples, all based on the power of randomness to make them representative of the population of interest:

• A simple random sample (SRS) is our standard. Every possible group of individuals has an equal chance of being in our sample. That’s what makes it simple.

• Stratified samples can reduce sampling variability by identifying homogeneous subgroups and then randomly sampling within each.

• Cluster samples randomly select among heterogeneous subgroups that each resemble the population at large, making our sampling tasks more manageable.

• Systematic samples can work in some situations and are often the least expensive method of sampling. But we still want to start them randomly.

• Multistage samples combine several random sampling methods.

We’ve learned that bias can destroy our ability to gain insights from our sample:

• Nonresponse bias can arise when sampled individuals will not or cannot respond.

• Response bias arises when respondents’ answers might be affected by external influences, such as question wording or interviewer behaviour.

We’ve learned that bias can also arise from poor sampling methods:

• Voluntary response samples are almost always biased and should be avoided and distrusted.

• Convenience samples are likely to be flawed for similar reasons.

We’ve learned to look for biases in any survey we find and to be sure to report our methods whenever we perform a survey, so that others can evaluate the fairness and accuracy of our results.

We’ve learned to choose samples from sampling frames that are representative of the population.

• Even with a reasonable design, sample frames may not be representative.

• Undercoverage occurs when individuals from a subgroup of the population are selected less often than they should be.

Terms

Biased Any systematic failure of a sampling method to represent its population.

Census An attempt to collect data on the entire population of interest.

Cluster A representative subset of a population chosen for reasons of convenience, cost, or practicality.

Cluster sampling A sampling design in which groups, or clusters, representative of the population are chosen at random and a census is then taken of each.

Convenience sampling A sampling technique that selects individuals who are conveniently available.

Measurement error Intentional or unintentional inaccurate response to a survey question.

Multistage sampling Sampling schemes that combine several sampling methods.

Nonresponse bias Bias introduced to a sample when a large fraction of those sampled fails to respond.

Parameter, population parameter A numerically valued attribute of a model for a population. We rarely expect to know the value of a parameter, but we do hope to estimate it from sampled data.

Pilot test A small trial run of a study to check that the methods of the study are sound.

Population The entire group of individuals or instances about whom we hope to learn.

Randomization A defence against bias in the sample selection process, in which each individual is given a fair, random chance of selection.

Representative sample A sample from which the statistics computed accurately reflect the corresponding population parameters.

Response bias Anything in a survey design that influences responses.

Sample A subset of a population, examined in the hope of learning about the population.
### Sample size
The number of individuals in a sample, usually denoted by \( n \).

### Sample survey
A study that asks questions of a sample drawn from some population in hopes of learning something about the entire population.

### Sampling frame
A list of individuals from which the sample is drawn. Individuals in the population of interest but who are not in the sampling frame cannot be included in any sample.

### Sampling variability
The natural tendency of randomly drawn samples to differ from one another.

### Simple random sample (SRS)
A sample in which each set of \( n \) individuals in the population has an equal chance of selection.

### Statistic, sample statistic
A value calculated for sampled data, particularly one that corresponds to, and thus estimates, a population parameter. The term “sample statistic” is sometimes used, usually to parallel the corresponding term “population parameter.”

### Stratified random sample
A sampling design in which the population is divided into several homogeneous subpopulations, or strata, and random samples are then drawn from each stratum.

### Systematic sampling
A sample drawn by selecting individuals systematically from a sampling frame.

### Voluntary response bias
Bias introduced to a sample when individuals can choose on their own whether to participate in the sample.

### Voluntary response sample
A sample in which a large group of individuals are invited to respond and decide individually whether to participate. Voluntary response samples are generally worthless.

### Undercoverage
A sampling scheme that biases the sample in a way that gives a part of the population less representation than it has in the population.

### Skills
- Know the basic concepts and terminology of sampling.
- Be able to recognize population parameters in descriptions of populations and samples.
- Understand the value of randomization as a defence against bias.
- Understand the value of sampling to estimate population parameters from statistics calculated on representative samples drawn from the population.

### Plan
- Understand that the size of the sample (not the fraction of the population) determines the precision of estimates.
- Know how to draw a simple random sample from a master list of a population, using a computer or a table of random numbers.

### Do
- Know what to report about a sample as part of your account of a statistical analysis.
- Be sure to report possible sources of bias in sampling methods. Recognize voluntary response and nonresponse as sources of bias in a sample survey.

### Technology Help: Random Sampling
Computer-generated pseudorandom numbers are usually quite good enough for drawing random samples, but there is little reason not to use the truly random values available on the Internet. Here’s a convenient way to draw an SRS of a specified size using a computer-based sampling frame. The sampling frame can be a list of names or of identification numbers arrayed, for example, as a column in a spreadsheet, statistics program, or database.
Market Survey Research

You are part of a marketing team that needs to research the potential of a new product. Your team decides to email an interactive survey to a random sample of consumers. Write a short questionnaire that will generate the information you need about the new product. Select a sample of 200 using an SRS from your sampling frame. Discuss how you will collect the data and how the responses will help your market research.

Canadian Labour Force Survey

Most people have heard of the unemployment rate, but not so many know where it comes from. Does the rate simply represent the number of people claiming Employment Insurance (EI)? It turns out that that would be an underestimation of the number of people unemployed, since many people are unemployed but ineligible for EI. Instead, Statistics Canada conducts the Labour Force Survey, interviewing people to find out their employment status and then estimating the unemployment rate for the whole country. During the second half of every month Statistics Canada analysts survey about 50,000 households, analyze the responses, and report the results. The most widely publicized number from this survey is the unemployment rate, but the survey covers much other information; for example, shifts of employees from one industry to another, hours worked, and demographic information about employees including age, sex, marital status, education level, and province or territory of residence. How would you design the Canadian Labour Force Survey?

• What is the population of interest?
• Why might it be difficult to select a simple random sample from this sampling frame?
• What sampling technique would you use to ensure that we have a representative sample of people from each province and territory and from the demographic groups described above?

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### MINI Case Studies

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Generate random numbers of enough digits so that each exceeds the size of the sampling frame list by several digits. This makes duplication unlikely.</td>
</tr>
<tr>
<td>2.</td>
<td>Assign the random numbers arbitrarily to individuals in the sampling frame list. For example, put them in an adjacent column.</td>
</tr>
<tr>
<td>3.</td>
<td>Sort the list of random numbers, carrying along the sampling frame list.</td>
</tr>
<tr>
<td>4.</td>
<td>Now the first $n$ values in the sorted sampling frame column are an SRS of $n$ values from the entire sampling frame.</td>
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### MyStatLab

Students! Save time, improve your Grades with MyStatLab. You can practise many of this chapter’s exercises as often as you want, and most feature step-by-step guided solutions to help you find the right answer. You’ll find a personalized study plan available to you too!
CHAPTER 3 • Surveys and Sampling

Exercises

SECTIONS 3.1 AND 3.2
1. Indicate whether each statement below is true or false. If false, explain why.
   a) We can eliminate sampling error by selecting an unbiased sample.
   b) Randomization helps to ensure that our sample is representative.
   c) Sampling error refers to sample-to-sample differences and is also known as sampling variability.
   d) It’s better to try to match the characteristics of the sample to the population rather than to rely on randomization.

2. Indicate whether each statement below is true or false. If false, explain why.
   a) To get a representative sample, you must sample a large fraction of the population.
   b) Using modern methods, it is best to select a representative subset of a population systematically.
   c) A census is the only true representative sample.
   d) A random sample of 100 students from a school with 2000 students has the same precision as a random sample of 100 from a school with 20,000 students.

SECTIONS 3.3 AND 3.4
3. A consumer advocacy group is interested in gauging perceptions about food safety among professionals in the food industry. Specifically, the analysts in the advocacy group wish to determine the percentage of professional food preparers in Canada who believe food safety has improved. The analysts use an alphabetized list of members of the Chef’s Collaborative organization and use Excel to generate a randomly shuffled list of the members. The analysts then select members to contact from this list until they have succeeded in contacting 150 members.
   a) What is the population?
   b) What is the sampling frame?
   c) What is the population parameter of interest?
   d) What sampling method is used?

4. An airline company is interested in the opinions of its frequent flyer customers about its proposed new routes. Specifically, pollsters want to know what proportion of flyers plan to use one of the airline’s new hubs in the next six months. The pollsters take a random sample of 10,000 from the database of all frequent flyers and send them an email message with a request to fill out a survey in exchange for 1500 air miles.
   a) What is the population?
   b) What is the sampling frame?
   c) What is the population parameter of interest?
   d) What sampling method is used?

SECTION 3.5
5. GfK Roper Consulting conducts a global consumer survey to help multinational companies understand different consumer attitudes throughout the world. In India, the researchers interviewed 1000 people aged 13 to 65 (www.gfkamerica.com). Their sample is designed so that they attract 500 males and 500 females.
   a) Are they using a simple random sample? How do you know?
   b) What kind of design do you think they’re using?

6. For their class project, a group of Business students decide to survey the student body to assess opinions about a proposed new student coffee shop to judge how successful it might be. Their sample of 200 contained 50 first-year students, 50 second years, 50 third years, and 50 fourth years.
   a) Do you think the group was using an SRS? Why?
   b) What kind of sampling design do you think they used?

7. The consumer advocacy group from Exercise 3 that was interested in gauging perceptions about food safety among professionals in the food industry has decided to use a different method to generate a sample. Instead of randomly selecting members from a shuffled list, a representative listed the members in alphabetical order and took every 10th member until they succeeded in contacting 150 members.
   What kind of sampling method did the group use?

8. The airline company from Exercise 4, which is interested in the opinions of its frequent flyer customers about its proposed new routes, has decided that different types of customers might have different opinions. Of their customers, 50% are silver level, 30% are blue, and 20% are red. The researchers first compile separate lists of silver, blue, and red members and then randomly select 5000 silver members, 3000 blue members, and 2000 red members to email. What kind of sampling method have they used?

SECTIONS 3.6 AND 3.7
For Exercises 9 and 10, identify the following, if possible. (If not, say why.)
   a) The population
   b) The population parameter of interest
c) The sampling frame

d) The sample

e) The sampling method, including whether or not randomization was employed

f) Any potential sources of bias you can detect and any problems you see in generalizing to the population of interest.

9. A business magazine mailed a questionnaire to the human resources directors of all Fortune 500 companies, and received responses from 23% of them. Those responding reported that they did not find that such surveys intruded significantly into their workday. **LO 2, 3**

10. A question posted on the Lycos website asked visitors to the site to say whether they thought businesses should be required to pay for their employees’ health insurance. **LO 2, 3**

11. An intern for the consumer advocacy group in Exercise 3 has decided to make the survey process simpler by calling 150 of the members who attended the symposium on “Food Safety in the 21st Century” recently held in Toronto. The intern has the phone numbers of each attendee, so it will be easy to contact them. He’ll start calling members from the top of the list, which was generated as the members enrolled for the symposium. He has written the following script to read to them:

“As we learned in Toronto, food safety is of utmost importance in the restaurant business today. Given the enormous effort of the Food Safety Institute in developing proper guidelines and educational tools for food professionals, do you agree that food safety has improved in Canada?”

a) What is the population of interest?

b) What is the sampling frame?

c) Point out any problem you see with the sampling procedure and/or the survey itself. What are potential impacts of these problems? **LO 2, 3**

12. The airline company in Exercise 4 has realized that some of its customers either don’t have email or don’t check it regularly. It decides to restrict the mailing to customers who have recently registered for a “Win a Trip to Miami” contest, figuring that those with Internet access are more likely to read and to respond to its email. The company sends an email to recent registrants with the following message:

“Did you know that National Airlines has just spent over $3 million refurbishing our brand-new hub in Miami? By answering the following question, you may be eligible to win $1000 worth of coupons that can be spent in any of the fabulous restaurants or shops in the Miami airport. Might you possibly think of travelling to Miami in the next six months on your way to one of your destinations?”

a) What is the population?

b) What is the sampling frame?

c) Point out any problems you see with the sampling procedure and/or the survey itself. What are potential impacts of these problems? **LO 2, 3**

13. An intern is working for Pacific TV (PTV), a small cable and Internet provider, and has proposed some questions that might be used in a survey to assess whether customers are willing to pay $50 for a new service. **Question 1:** If PTV offered state-of-the-art high-speed Internet service for $50 per month, would you subscribe to that service? **Question 2:** Would you find $50 per month—less than the cost of a daily cappuccino—an appropriate price for high-speed Internet service?

a) Do you think these are appropriately worded questions? Why or why not?

b) Suggest questions with better wording. **LO 2, 3**

14. Here are more proposed survey questions for the survey mentioned in Exercise 13:

**Question 3:** Do you find that the slow speed of dial-up Internet access reduces your enjoyment of web services?

**Question 4:** Given the growing importance of high-speed Internet access for your children’s education, would you subscribe to such a service if it were offered?

a) Do you think these are appropriately worded questions? Why or why not?

b) Which one has more neutral wording? Explain “what can go wrong.” **LO 2, 3**

“WHAT CAN GO WRONG?”

15. Indicate whether each statement below is true or false. If false, explain why.

a) A local television news program that asks viewers to call in and give their opinion on an issue typically results in a biased voluntary response sample.

b) Convenience samples are generally not representative of the population.

c) Measurement error is the same as sampling error.

d) A pilot test can be useful for identifying poorly worded questions on a survey. **LO 1, 2, 3**

16. Indicate whether each statement below is true or false. If false, explain why.

a) Asking viewers to call into a 900 number (for which a toll charge will be applicable) is a good way to produce a representative sample.

b) When writing a survey, it’s a good idea to include as many questions as possible to ensure efficiency and to lower costs.

c) A recent poll on a website was valid because the sample size was over 1,000,000 respondents.

d) Malls are not necessarily a good place to conduct surveys because people who frequent malls may not be representative of the population at large. **LO 1, 2, 3**
17. For your marketing class, you’d like to take a survey from a sample of all the Catholic Church members in your city to assess the market for a DVD about the Vatican. A list of churches shows 17 Catholic churches within the city limits. Rather than try to obtain a list of all members of all these churches, you decide to pick three churches at random. For those churches, you’ll ask to get a list of all current members and contact 100 members at random.
   a) What kind of design have you used?
   b) What could go wrong with the design you have proposed? \( \text{LO} \, 1, \, 2, \, 3 \)

18. The Ontario Ministry of Natural Resources plans to study the fishing industry around Port Dover on Lake Erie. To do that, researchers decide to randomly select five fishing boats at the end of a randomly chosen fishing day and to count the numbers and types of all the fish on those boats.
   a) What kind of design have they used?
   b) What could go wrong with the design they have proposed? \( \text{LO} \, 1, \, 2, \, 3 \)

**CHAPTER EXERCISES**

19. **Software licences.** The website www.gamefaqs.com asked, as its question of the day to which visitors to the site were invited to respond, “Do you ever read the end-user licence agreements when installing software or games?” Of the 98,574 respondents, 63.47% said they never read those agreements—a fact that software manufacturers might find important.
   a) What kind of sample was this?
   b) How much confidence would you place in using 63.47% as an estimate of the fraction of people who don’t read software licences? \( \text{LO} \, 1 \)

20. **Drugs in baseball.** Major League Baseball, responding to concerns about its “brand,” tests players to see whether they’re using performance-enhancing drugs. Officials select a team at random, and a drug-testing crew shows up unannounced to test all 40 players on the team. Each testing day can be considered a study of drug use in Major League Baseball.
   a) What kind of sample is this?
   b) Is that choice appropriate? \( \text{LO} \, 1 \)

21. **Gallup.** At its website (www.galluppoll.com), the Gallup Poll publishes results of a new survey each day. Scroll down to the end, and you’ll find a statement that includes an explanation such as this: Results are based on telephone interviews with 1008 national adults, aged 18 and older, conducted April 2–5, 2010. . . . Question wording and practical difficulties in conducting surveys can introduce error or bias into the findings of public opinion polls.
   a) For this survey, identify the population of interest.
   b) Gallup performs its surveys by phoning numbers generated at random by a computer program. What is the sampling frame?
   c) What problems, if any, would you be concerned about in matching the sampling frame with the population? \( \text{LO} \, 3 \)

22. **Defining the survey.** At its website (www.gallupworldpoll.com), the Gallup World Poll reports results of surveys conducted in various places around the world. At the end of one of these reports, researchers describe their methods, including explanations such as the following:

   Results are based on face-to-face interviews with randomly selected national samples of approximately 1000 adults, aged 15 and older, who live permanently in each of the 21 sub-Saharan African nations surveyed. Those countries include Angola (areas where land mines might be expected were excluded), Benin, Botswana, Burkina Faso, Cameroon, Ethiopia, Ghana, Kenya, Madagascar (areas where interviewers had to walk more than 20 kilometres from a road were excluded), Mali, Mozambique, Niger, Nigeria, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Uganda (the area of activity of the Lord’s Resistance Army was excluded from the survey), Zambia, and Zimbabwe. . . . In all countries except Angola, Madagascar, and Uganda, the sample is representative of the entire population.
   a) Gallup is interested in sub-Saharan Africa. What kind of survey design are they using?
   b) Some of the countries surveyed have large populations. (Nigeria is estimated to have about 130 million people.) Some are quite small. (Togo’s population is estimated at 5.4 million.) Nonetheless, Gallup sampled 1000 adults in each country. How does this affect the precision of its estimates for these countries? \( \text{LO} \, 1 \)

23–31. **Survey details.** For the following reports about statistical studies, identify the following items (if possible). If you can’t tell, then say so—this often happens when we read about a survey.
   a) The population
   b) The population parameter of interest
   c) The sampling frame
   d) The sample
   e) The sampling method, including whether or not randomization was employed
   f) Any potential sources of bias you can detect and any problems you see in generalizing to the population of interest

23. **Technology forecasting.** To estimate the impact of new technologies on fuel efficiency for motor vehicles, a consulting company requests the opinions of established researchers in the automobile industry, the clean-tech industry, government research labs, and universities. \( \text{LO} \, 2 \)

24. **Alternative medicine.** Consumers Union asked all subscribers whether they had used alternative medical treatments and, if so, whether they had benefited from...
them. For almost all the treatments, approximately 20% of those responding reported cures or substantial improvement in their condition. LO 3

25. **Global warming.** The Gallup Poll interviewed 1007 randomly selected adults aged 18 and older, between March 23 and 25, 2007. Gallup reports that when asked when (if ever) they think the effects of global warming will begin to happen, 60% of respondents said the effects had already begun. Only 11% thought they would never happen. LO 3

26. **At the bar.** Researchers waited outside a bar they had randomly selected from a list of such establishments. They stopped every 10th person who came out of the bar and asked whether he or she thought drinking and driving was a serious problem. LO 3

27. **Election poll.** Hoping to learn what issues may resonate with voters in the coming election, the campaign director for a mayoral candidate selects one block from each of the city’s election districts. Staff members go there and interview all the residents they can find. LO 3

28. **Toxic waste.** The Canadian Environmental Assessment Agency took soil samples at 16 locations near a former industrial waste dump and checked each for evidence of toxic chemicals. The researchers found no elevated levels of any harmful substances. LO 3

29. **Housing discrimination.** Inspectors send trained “renters” of various races and ethnic backgrounds, and of both sexes, to inquire about renting randomly assigned advertised apartments. They look for evidence that landlords deny access illegally based on race, sex, or ethnic background. LO 3

30. **Quality control.** A company packaging snack foods maintains quality control by randomly selecting 10 cases from each day’s production and weighing the bags. Then the quality control staff open one bag from each case and inspect the contents. LO 3

31. **Contaminated milk.** Dairy inspectors visit farms unannounced and take samples of the milk to test for contamination. If the milk is found to contain dirt, antibiotics, or other foreign matter, the milk will be destroyed and the farm is considered to be contaminated pending further testing. LO 3

32. **Pulse poll.** A local TV station conducted a “Pulse Poll” to predict the winner in the upcoming mayoral election. Evening news viewers were invited to phone in their votes, with the results to be announced on the late-night news. Based on the phone calls, the station predicted that Amabo would win the election with 52% of the vote. It was wrong: Amabo lost, getting only 46% of the vote. Do you think the station’s faulty prediction is more likely to be a result of bias or sampling error? Explain. LO 2

33. **Paper poll.** Prior to the mayoral election discussed in Exercise 32, the local newspaper conducted a poll. The paper surveyed a random sample of registered voters stratified by political party, age, sex, and area of residence. This poll predicted that Amabo would win the election with 52% of the vote. The newspaper was wrong: Amabo lost, getting only 46% of the vote. Do you think the newspaper’s faulty prediction is more likely to be a result of bias or sampling error? Explain. LO 2

34. **Cable company market research.** A cable TV company is considering offering optical fibre to residences to improve the speed of its HDTV download service. Before launching the new service, however, the company wants to find out whether customers would pay the $50 per month that the company wants to charge. An intern has prepared several alternative plans for assessing customer demand. For each, indicate what kind of sampling strategy is involved and what (if any) biases might result.

   a) Put a big ad in the newspaper asking people to log their opinions on the company’s website.
   b) Randomly select one of the towns and contact every cable subscriber by phone.
   c) Send a survey to each customer and ask each of them to fill it out and return it.
   d) Randomly select 20 customers from each town. Send them a survey, and follow up with a phone call if they do not return the survey within a week. LO 1, 2

35. **Cable company market research, part II.** Four new sampling strategies have been proposed to help a cable TV company determine whether enough cable subscribers are likely to purchase the new HDTV download service. For each, indicate what kind of sampling strategy is involved and what (if any) biases might result.

   a) Run a poll on the local TV news, asking people to call one of two phone numbers to indicate whether they would be interested in the new service.
   b) Hold a meeting in each of the 15 towns, and tally the opinions expressed by those who attend the meetings.
   c) Randomly select one street in each town and contact a random section of the households on that street.
   d) Go through the company’s customer records, selecting every 40th subscriber. Send employees to those homes to interview the people chosen. LO 1, 2

36. **Canadian research in the Great Lakes.** Fisheries and Oceans Canada operates a laboratory in Sault Ste. Marie, Ontario, to study the abundance of species of fish that have invaded the Great Lakes from other ecosystems. Researchers have found 145 such “exotic” species, and wish to get more details on each species present. Suppose they take a sample every third day at dawn during June and July from each of the Great Lakes.
37. Amusement park riders. An amusement park has opened a new roller coaster. It is so popular that people line up and wait for up to three hours for a two-minute ride. Concerned about how patrons (who paid a large amount to enter the park and ride on the rides) feel about this, researchers survey every 10th person who is waiting in line for the roller coaster, starting from a randomly selected individual.

a) What kind of sample is this?
b) Is it likely to be representative?
c) What is the sampling frame? LO 1, 3

38. Playground. Some people have been complaining that the children’s playground at a municipal park is too small and in need of repair. Managers of the park decide to survey city residents to see if they believe the playground should be rebuilt. Park managers hand out questionnaires to parents who bring children to the park. Describe possible biases in this sample. LO 2

39. Survey wording. The intern designing the study of a new Internet service for the companies mentioned in Exercises 34 and 35 has proposed some questions that might be used in the surveys.

Question 1: If the cable company offered the new service for $50 per month, would you subscribe to it?
Question 2: Would you find $50 per month—less than the cost of a daily cappuccino—an appropriate price for the new service?

a) Do you think these are appropriately worded questions? Why or why not?
b) Which one has more neutral wording? Explain. LO 2

40. More words. Here are more proposed survey questions.

Question 3: Many people in Japan have optical fibre connected to their homes. Should it be made available to you?
Question 4: Since HDTV movies can be watched without downloading them, would you pay $50 a month for an HDTV download service?

a) Do you think these are appropriately worded questions? Why or why not?
b) Propose a question with more neutral wording. LO 2

41. Another ride. The survey of patrons waiting in line for the roller coaster mentioned in Exercise 37 asks whether it is worthwhile to wait a long time for the ride and whether the amusement park should install still more roller coasters. What biases might cause a problem for this survey? LO 2

42. Playground bias. The survey described in Exercise 38 asked,

Many people believe this playground is too small and in need of repair. Do you think the playground should be repaired and expanded even if that means raising the entrance fee to the park?

Describe two ways this question may lead to response bias. LO 2

43. (Possibly) biased questions. Examine each of the following questions for possible bias. If you think the question is biased, indicate how and propose a better question.

a) Should companies that pollute the environment be compelled to pay the costs of cleanup?
b) Should a company enforce a strict dress code? LO 2

44. More possibly biased questions. Examine each of the following questions for possible bias. If you think the question is biased, indicate how and propose a better question.

a) Do you think price or quality is more important in selecting an MP3 player?
b) Given humanity’s great tradition of exploration, do you favour continued funding for space flights? LO 2

45. Phone surveys. Any time we conduct a survey, we must take care to avoid undercoverage. Suppose we plan to select 500 names from the city phone book, call those homes between noon and 4 p.m., and interview whoever answers.

a) Why is it difficult to use a simple random sample here?
b) Describe a more convenient, but still random, sampling strategy.
c) What kinds of households are likely to be included in the eventual sample of opinion? Who will be excluded?
d) Suppose instead that we continue calling each number, perhaps in the morning or evening, until an adult is contacted and interviewed. How does this improve the sampling design?
e) Random-digit dialling machines can generate the phone calls for us. How would this improve our design? Is anyone still excluded? LO 1, 2, 6

46. Cell phone survey. What about drawing a random sample only from cell phone exchanges? Discuss the advantages and disadvantages of such a sampling method compared with surveying randomly generated telephone numbers from non–cell phone exchanges. Do you think these advantages and disadvantages have changed over time? How do you expect they’ll change in the future? LO 2

47. Change. How much pocket change do you have on you right now? Go ahead, count it.

a) How much change do you have?
b) Suppose you check on your change every day for a week as you head for lunch and average the results. What parameter would this average estimate?
c) Suppose you ask 10 friends to average their change every day for a week, and you average those 10 measurements. What is the population now? What parameter would this average estimate?
d) Do you think these 10 average change amounts are likely to be representative of the population of change amounts in your class? In your university? In the country? Why or why not? LO 1, 2, 3

48. **Fuel economy.** Occasionally, when I fill my car with gas, I figure out how many litres it consumes per 100 kilometres. I wrote down those results after six gas fill-ups in the past few months. Overall, it appears my car gets 8.1 litres per 100 kilometres.

a) What statistic have I calculated?
b) What is the parameter I’m trying to estimate?
c) How might my results be biased?
d) When *Consumer Reports* checks a car like mine to predict its fuel economy, what parameter is it trying to estimate? LO 2

49. **Accounting.** Between quarterly audits, a company likes to check on its accounting procedures to address any problems before they become serious. The accounting staff makes both wholesale and retail sales, requiring different bookkeeping procedures. LO 1

b) How would you modify that strategy if the company makes both wholesale and retail sales, requiring different bookkeeping procedures? LO 1

50. **Happy workers?** A manufacturing company employs 14 project managers, 48 forepersons, and 377 labourers. In an effort to keep informed about any possible sources of employee discontent, management wants to conduct job satisfaction interviews with a simple random sample of employees every month.

a) Do you see any danger of bias in the company’s plan? Explain.
b) How might you modify that strategy if the company makes both wholesale and retail sales, requiring different bookkeeping procedures? LO 1

c) Why do you think a simple random sample might not provide the representative opinion the company seeks?
d) What ethical issue would be involved if the company statistician conducted the survey this way? (See Appendix C.)
e) Propose a better sampling strategy.
f) Listed below are the last names of the project managers. Use random numbers to select two people to be interviewed. Be sure to explain your method carefully. LO 1, 2

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<th>Ahmed</th>
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<th>Chen</th>
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51. **Quality control.** Sammy’s Salsa, a small local company, produces 20 cases of salsa a day. Each case contains 12 jars and is imprinted with a code indicating the date on which it was bottled and the batch number. To help maintain consistency, at the end of each day, Sammy selects three bottles of salsa, weighs the contents, and tastes the product. Help Sammy select the sample jars. Today’s cases are coded 07N61 through 07N80.

a) Carefully explain your sampling strategy.
b) Show how to use random numbers to pick the three jars for testing.
c) Did you use a simple random sample? Explain. LO 1

52. **Fish quality.** Concerned about reports of discoloured scales on fish caught downstream from a newly sited chemical plant, scientists set up a field station in a shoreline public park. For one week they asked people fishing there to bring any fish they caught to the field station for a brief inspection. At the end of the week, the scientists said that 18% of the 234 fish that were submitted for inspection displayed the discolouration. From this information, can the researchers estimate what proportion of fish in the river have discoloured scales? Explain. LO 2

53. **More sampling methods.** Consider each of these situations. Do you think the proposed sampling method is appropriate? Explain.

a) We want to know if business leaders in the community support the development of an “incubator” site at a vacant lot on the edge of town. We spend a day phoning local businesses listed in the phone book to ask whether they’d sign a petition.
b) We want to know if travellers at the local airport are satisfied with the food available there. We go to the airport on a busy day and interview every 10th person waiting in line in the food court. LO 1

54. **Canadian Census.** The Canadian Census collects demographic data for specific groups such as lone-parent families, seniors, and those from specific language groups via what is commonly referred to as the “Short Form.” The Short Form questionnaire is issued to each household in Canada, and all Canadian residents are legally required to complete the form. In addition to the “Short Form,” a more detailed (long) form, sent for completion to certain households only, used to be mandatory, but became voluntary instead at the time of the 2011 census. What are the impacts of the change from mandatory to voluntary participation in the longer census? LO 2

55. **Harris Interactive.** Harris Interactive conducts surveys online with panels of people who have volunteered to participate. One of these is the “Body Mass Index” panel consisting of people classified into four groups according to their Body Mass Index, BMI:

- 15,000 underweight adults: BMI < 18.5
- 38,000 normal weight adults: BMI between 18.5 and 24.9
- 51,000 overweight adults: BMI between 25 and 29.5
- 59,000 obese adults: BMI > 29.5
They fill out questionnaires online, which Harris Interactive analyzes to provide information to the food industry on food and drink preferences, how these preferences are affected by attitudes to health, and interest in specialty food products and supplements. Comment on this survey using the concepts discussed in this chapter. (Source: www.harrisinteractive.com) LO 1, 2, 3

Just Checking Answers

1. a) It can be hard to reach all members of a population, and it can take so long that circumstances change, affecting the responses. A well-designed sample is often a better choice.
b) This sample is probably biased—people who didn’t like the food at the restaurant might not choose to eat there.
c) No, only the sample size matters, not the fraction of the overall population.
d) Students who frequent this website might be more enthusiastic about statistics than the overall population. A large sample cannot compensate for bias.
e) It’s the population “parameter.” “Statistics” describe samples.

2. a) Systematic
   b) Stratified
   c) Simple
   d) Cluster