TECHNOLOGY **UPDATE**

ELEMENTARY **STATISTICS**

MARIO F. TRIOLA

11TH EDITION

1-4 Beyond the Basics

29. Falsifying Data A researcher at the Sloan-Kettering Cancer Research Center was once criticized for falsifying data. Among his data were figures obtained from 6 groups of mice, with 20 individual mice in each group. These values were given for the percentage of successes in each group: 53%, 58%, 63%, 46%, 48%, 67%. What's wrong with those values?

30. What's Wrong with This Picture? The *Newport Chronicle* ran a survey by asking readers to call in their response to this question: "Do you support the development of atomic weapons that could kill millions of innocent people?" It was reported that 20 readers responded and 87% said "no" while 13% said "yes." Identify four major flaws in this survey.

1-5 Collecting Sample Data

Key Concept The methods we discuss in this section are important because the method used to collect sample data influences the quality of our statistical analysis. Of particular importance is the *simple random sample*. We use this sampling measure in this section and throughout the book. As you read this section, keep this concept in mind:

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

The first part of this section introduces the basics of data collection, and the second part of the section refines our understanding of two types of studies—observational studies and experiments.

Part 1: Basics of Collecting Data

Statistical methods are driven by the data that we collect. We typically obtain data from two distinct sources: *observational studies* and *experiments*.

DEFINITION

In an **observational study,** we observe and measure specific characteristics, but we don't attempt to *modify* the subjects being studied.

In an **experiment,** we apply some *treatment* and then proceed to observe its effects on the subjects. (Subjects in experiments are called **experimental units.**)

EXAMPLE 1 **Observational Study and Experiment**

Observational Study: A good example of an observational study is a poll in which subjects are surveyed, but they are not given any treatment. The *Literary Digest* poll in which respondents were asked who they would vote for in the presidential election is an observational study. The subjects were asked for their choices, but they were not given any type of treatment.

Experiment: In the largest public health experiment ever conducted, 200,745 children were given a treatment consisting of the Salk vaccine, while 201,229 other children were given a placebo. The Salk vaccine injections constitute a treatment that modified the subjects, so this is an example of an experiment.

Whether conducting an observational study or an experiment, it is important to select the sample of subjects in such a way that the sample is likely to be representative of the larger population. In Section 1-3 we saw that a voluntary response sample is one in which the subjects decide themselves whether to respond. Although voluntary response samples are very common, their results are generally useless for making valid inferences about larger populations.

DEFINITION

A **simple random sample** of n subjects is selected in such a way that every possible *sample of the same size n* has the same chance of being chosen.

Throughout this book, we will use various statistical procedures, and we often have a requirement that we have collected a *simple random sample*, as defined above.

The following definitions describe two other types of samples.

DEFINITION

In a **random sample** members from the population are selected in such a way that each *individual member* in the population has an equal chance of being selected.

A **probability sample** involves selecting members from a population in such a way that each member of the population has a known (but not necessarily the same) chance of being selected.

Note the difference between a random sample and a simple random sample. Exercises 21 to 26 will give you practice in distinguishing between a random sample and a simple random sample.

With random sampling we expect all components of the population to be (approximately) proportionately represented. Random samples are selected by many different methods, including the use of computers to generate random numbers. Unlike careless or haphazard sampling, random sampling usually requires very careful planning and execution.

EXAMPLE 2 **Sampling Senators** Each of the 50 states sends two senators to Congress, so there are exactly 100 senators. Suppose that we write the name of each *state* on a separate index card, then mix the 50 cards in a bowl, and then select one card. If we consider the two senators from the selected state to be a sample, is this result a random sample? Simple random sample? Probability sample?

SOLUTION The sample is a random sample because each individual senator has the same chance (one chance in 50) of being selected. The sample is *not* a simple random sample because not all samples of size 2 have the same chance of being chosen. (For example, this sampling design makes it impossible to select 2 senators from different states.) The sample is a probability sample because each senator has a known chance (one chance in 50) of being selected.

STATISTICS IN THE NEWS

Clinical Trials vs. Observational Studies

In a *New York Times* article about hormone therapy for women, reporter Denise Grady wrote about a report of treatments tested in randomized controlled trials. She stated that "Such trials, in which patients are assigned at random to either a treatment or a placebo, are considered the gold standard in medical research. By contrast, the observational studies, in which patients themselves decide whether to take a drug, are considered less reliable. . . . Researchers say the observational studies may have painted a falsely rosy picture of hormone replacement because women who opt for the treatments are healthier and have better habits to begin with than women who do not."

Hawthorne and Experimenter Effects

The well-known placebo effect occurs when an untreated subject incorrectly believes that he or she is receiving a real treatment and reports an improvement in symptoms. The Hawthorne effect occurs when treated subjects somehow respond differently, simply because they are part of an experiment. (This phenomenon was called the "Hawthorne effect" because it was first observed in a study of factory workers at Western Electric's Hawthorne plant.) An experimenter effect (sometimes called a Rosenthall effect) occurs when the researcher or experimenter unintentionally influences subjects through such factors as facial expression, tone of voice, or attitude.

Other Sampling Methods In addition to random samples and simple random samples, there are other sampling techniques. We describe the common ones here. Figure 1-2 compares the different sampling approaches.

DEFINITION

In **systematic sampling,** we select some starting point and then select every *k*th (such as every 50th) element in the population.

With **convenience sampling,** we simply use results that are very easy to get.

With **stratified sampling,** we subdivide the population into at least two different subgroups (or strata) so that subjects within the same subgroup share the same characteristics (such as gender or age bracket), then we draw a sample from each subgroup (or stratum).

In **cluster sampling,** we first divide the population area into sections (or clusters), then randomly select some of those clusters, and then choose *all* the members from those selected clusters.

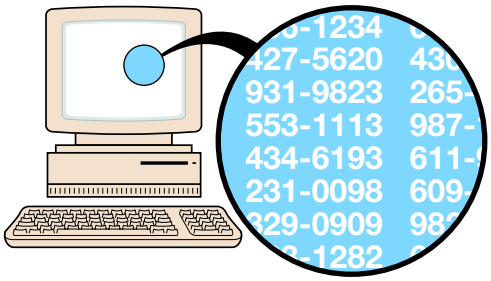
It is easy to confuse stratified sampling and cluster sampling, because they both use subgroups. But cluster sampling uses *all* members from a *sample* of clusters, whereas stratified sampling uses a *sample* of members from *all* strata. An example of cluster sampling is a preelection poll, in which pollsters randomly select 30 election precincts from a large number of precincts and then survey all the people from each of those precincts. This is much faster and much less expensive than selecting one person from each of the many precincts in the population area. Pollsters can adjust or weight the results of stratified or cluster sampling to correct for any disproportionate representations of groups.

For a fixed sample size, if you randomly select subjects from different strata, you are likely to get more consistent (and less variable) results than by simply selecting a random sample from the general population. For that reason, pollsters often use stratified sampling to reduce the variation in the results. Many of the methods discussed later in this book require that sample data be a *simple random sample,* and neither stratified sampling nor cluster sampling satisfies that requirement.

Multistage Sampling Professional pollsters and government researchers often collect data by using some combination of the basic sampling methods. In a **multistage sample design**, pollsters select a sample in different stages, and each stage might use different methods of sampling.

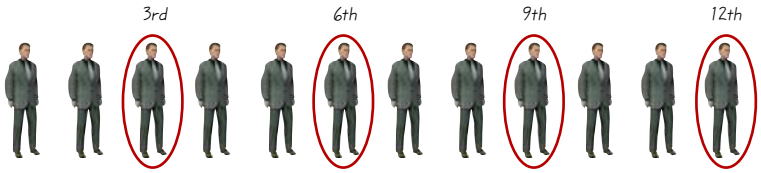
EXAMPLE 3 **Multistage Sample Design** The U.S. government's unemployment statistics are based on surveyed households. It is impractical to personally visit each member of a simple random sample, because individual households would be spread all over the country. Instead, the U.S. Census Bureau and the Bureau of Labor Statistics combine to conduct a survey called the Current Population Survey. This survey obtains data describing such factors as unemployment rates, college enrollments, and weekly earnings amounts. The survey incorporates a multistage sample design, roughly following these steps:

1. The surveyors partition the entire United States into 2007 different regions called *primary sampling units* (PSU). The primary sampling units are metropolitan areas, large counties, or groups of smaller counties.

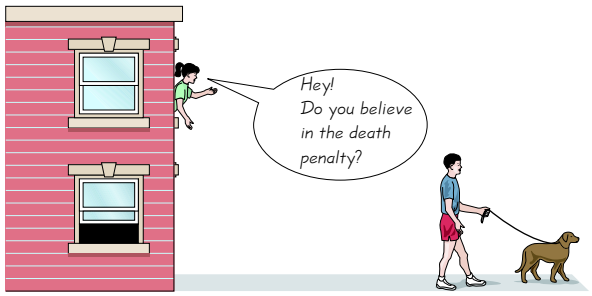


Random Sampling:
Each member of the population has an equal chance of being selected. Computers are often used to generate random telephone numbers.

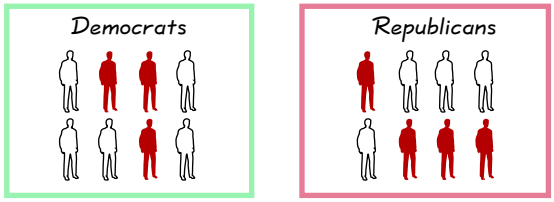
Simple Random Sampling:
A sample of n subjects is selected in such a way that every possible sample of the same size n has the same chance of being chosen.



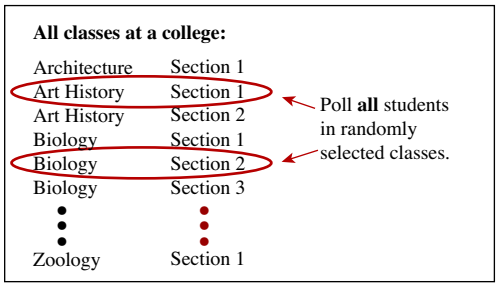
Systematic Sampling:
Select some starting point, then select every kth (such as every 50th) element in the population.



Convenience Sampling:
Use results that are easy to get.



Stratified Sampling:
Subdivide the population into at least two different subgroups (or strata) so that subjects within the same subgroup share the same characteristics (such as gender or age bracket), then draw a sample from each subgroup.



Cluster Sampling:
Divide the population into sections (or clusters), then randomly select some of those clusters, and then choose *all* members from those selected clusters.

Figure 1-2 Common Sampling Methods

Prospective National Children's Study

A good example of a prospective study is the National Children's Study begun in 2005. It is tracking 100,000 children from birth to age 21. The children are from 96 different geographic regions. The objective is to improve the health of children by identifying the effects of environmental factors, such as diet, chemical exposure, vaccinations, movies, and television. The study will address questions such as these: How do genes and the environment interact to promote or prevent violent behavior in teenagers? Are lack of exercise and poor diet the only reasons why many children are overweight? Do infections impact developmental progress, asthma, obesity, and heart disease? How do city and neighborhood planning and construction encourage or discourage injuries?

2. The surveyors select a sample of primary sampling units in each of the 50 states. For the Current Population Survey, 792 of the primary sampling units are used. (All of the 432 primary sampling units with the largest populations are used, and 360 primary sampling units are randomly selected from the other 1575.)
3. The surveyors partition each of the 792 selected primary sampling units into blocks, and they then use stratified sampling to select a sample of blocks.
4. In each selected block, surveyors identify clusters of households that are close to each other. They randomly select clusters, and they interview all households in the selected clusters.

This multistage sample design includes random, stratified, and cluster sampling at different stages. The end result is a complicated sampling design, but it is much more practical and less expensive than using a simpler design, such as using a simple random sample.

Part 2: Beyond the Basics of Collecting Data

In this part, we refine what we've learned about observational studies and experiments by discussing different types of observational studies and experiment design.

There are various types of observational studies in which investigators observe and measure characteristics of subjects. The definitions below, which are summarized in Figure 1-3, identify the standard terminology used in professional journals for different types of observational studies.

DEFINITION

In a **cross-sectional study,** data are observed, measured, and collected at one point in time.

In a **retrospective** (or **case-control**) **study,** data are collected from the past by going back in time (through examination of records, interviews, and so on).

In a **prospective** (or **longitudinal** or **cohort**) **study,** data are collected in the future from groups sharing common factors (called *cohorts*).

The sampling done in retrospective studies differs from that in prospective studies. In retrospective studies we go back in time to collect data about the characteristic that is of interest, such as a group of drivers who died in car crashes and another group of drivers who did not die in car crashes. In prospective studies we go forward in time by following groups with a potentially causative factor and those without it, such as a group of drivers who use cell phones and a group of drivers who do not use cell phones.

Design of Experiments

We now consider experiment design, starting with an example of an experiment having a good design. We use the experiment first mentioned in Example 1, in which researchers tested the Salk vaccine. After describing the experiment in more detail, we identify the characteristics of that experiment that typify a good design.

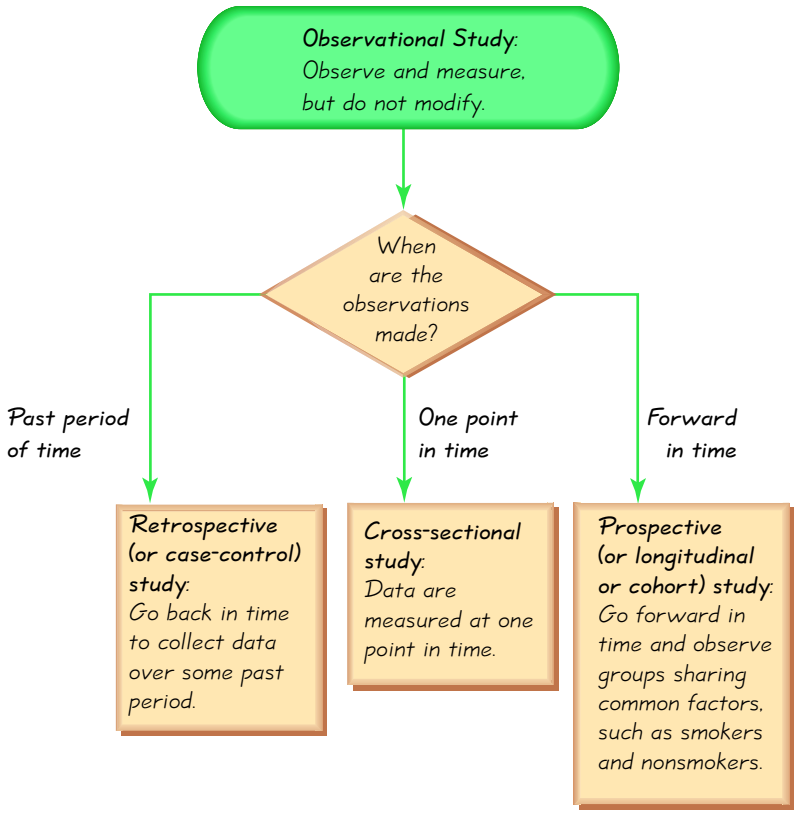


Figure 1-3
Types of Observational Studies

EXAMPLE 4 **The Salk Vaccine Experiment** In 1954, a large-scale experiment was designed to test the effectiveness of the Salk vaccine in preventing polio, which had killed or paralyzed thousands of children. In that experiment, 200,745 children were given a treatment consisting of Salk vaccine injections, while a second group of 201,229 children were injected with a placebo that contained no drug. The children being injected did not know whether they were getting the Salk vaccine or the placebo. Children were assigned to the treatment or placebo group through a process of random selection, equivalent to flipping a coin. Among the children given the Salk vaccine, 33 later developed paralytic polio, but among the children given a placebo, 115 later developed paralytic polio.

Randomization is used when subjects are assigned to different groups through a process of random selection. The 401,974 children in the Salk vaccine experiment were assigned to the Salk vaccine treatment group or the placebo group through a process of random selection, equivalent to flipping a coin. In this experiment, it would be extremely difficult to directly assign children to two groups having similar characteristics of age, health, sex, weight, height, diet, and so on. There could easily be important variables that we might not realize. The logic behind randomization is to use chance as a way to create two groups that are similar. Although it might seem that we should not leave anything to chance in experiments, randomization has been found to be an extremely effective method for assigning subjects to groups.

Replication is the repetition of an experiment on more than one subject. Samples should be large enough so that the erratic behavior that is characteristic of very small samples will not disguise the true effects of different treatments. Replication is used effectively when we have enough subjects to recognize differences from different treatments. (In another context, *replication* refers to the repetition or duplication of an experiment so that results can be confirmed or verified.) With replication, the large sample sizes increase the chance of recognizing different treatment effects. However, a large sample is not necessarily a good sample. Although it is important to have a sample that is sufficiently large, it is more important to have a sample in which subjects have been chosen in some appropriate way, such as random selection.

Use a sample size that is large enough to let us see the true nature of any effects, and obtain the sample using an appropriate method, such as one based on *randomness.*

In the experiment designed to test the Salk vaccine, 200,745 children were given the actual Salk vaccine and 201,229 other children were given a placebo. Because the actual experiment used sufficiently large sample sizes, the researchers could observe the effectiveness of the vaccine. Nevertheless, though the treatment and placebo groups were very large, the experiment would have failed if subjects had not been assigned to the two groups in a way that made both groups similar in the ways that were important to the experiment.

Blinding is a technique in which the subject doesn't know whether he or she is receiving a treatment or a placebo. Blinding allows us to determine whether the treatment effect is significantly different from a **placebo effect,** which occurs when an untreated subject reports an improvement in symptoms. (The reported improvement in the placebo group may be real or imagined.) Blinding minimizes the placebo effect or allows investigators to account for it. The polio experiment was **double-blind,** meaning that blinding occurred at two levels: (1) The children being injected didn't know whether they were getting the Salk vaccine or a placebo, and (2) the doctors who gave the injections and evaluated the results did not know either.

Controlling Effects of Variables Results of experiments are sometimes ruined because of *confounding.*

DEFINITION

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

Try to plan the experiment so that confounding does not occur.

See Figure 1-4(a), where confounding can occur when the treatment group of women shows strong positive results. Because the treatment group consists of women and the placebo group consists of men, confounding has occurred because we can't determine whether the treatment or the sex of the subjects causes the positive results. It is important to design experiments to control and understand the effects of the variables (such as treatments). The Salk vaccine experiment in Example 4 illustrates one method for controlling the effect of the treatment variable: Use a *completely randomized experimental design,* whereby randomness is used to assign subjects to the treatment group and the placebo group. The objective of this experimental design is to control the effect of the treatment, so that we are able to clearly recognize the difference between the effect of the Salk vaccine and the effect of the placebo. Completely randomized experimental design is one of the following four methods used to control effects of variables.

Completely Randomized Experimental Design: Assign subjects to different treatment groups through a process of *random selection.* See Figure 1-4(b).

Randomized Block Design: A **block** is a group of subjects that are similar, but blocks differ in ways that might affect the outcome of the experiment. (In designing an experiment to test the effectiveness of aspirin treatments on heart disease, we might form a block of men and a block of women, because it is known that hearts of men and women can behave differently.) If testing one or more different treatments with different blocks, use this experimental design (see Figure 1-4(c)):

1. Form blocks (or groups) of subjects with similar characteristics.
2. Randomly assign treatments to the subjects within each block.

Rigorously Controlled Design: Carefully assign subjects to different treatment groups, so that those given each treatment are similar in the ways that are important to the experiment. In an experiment testing the effectiveness of aspirin on heart disease, if the placebo group includes a 27-year-old male smoker who drinks heavily and consumes an abundance of salt and fat, the treatment group should also include a person with similar characteristics (which, in this case, would be easy to find). This approach can be extremely difficult to implement, and we might not be sure that we have considered all of the relevant factors.

Matched Pairs Design: Compare exactly two treatment groups (such as treatment and placebo) by using subjects matched in pairs that are somehow related or have similar characteristics. A test of Crest toothpaste used matched pairs of twins, where one twin used Crest and the other used another toothpaste. The matched pairs might also consist of measurements from the same subject before and after some treatment.

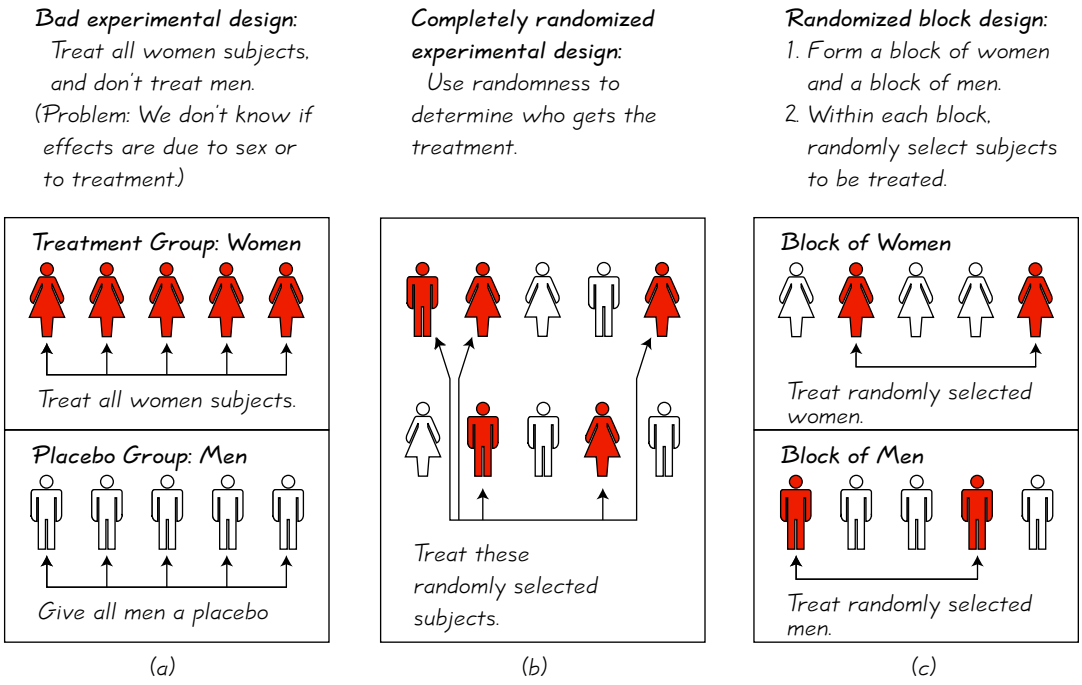


Figure 1-4 Controlling Effects of a Treatment Variable

Summary Three very important considerations in the design of experiments are the following:

1. Use *randomization* to assign subjects to different groups.
2. Use *replication* by repeating the experiment on enough subjects so that effects of treatments or other factors can be clearly seen.
3. *Control the effects of variables* by using such techniques as blinding and a completely randomized experimental design.

Sampling Errors No matter how well you plan and execute the sample collection process, there is likely to be some error in the results. For example, randomly select 1000 adults, ask them if they graduated from high school, and record the sample percentage of "yes" responses. If you randomly select another sample of 1000 adults, it is likely that you will obtain a *different* sample percentage.

DEFINITION

A **sampling error** is the difference between a sample result and the true population result; such an error results from chance sample fluctuations.

A **nonsampling error** occurs when the sample data are incorrectly collected, recorded, or analyzed (such as by selecting a biased sample, using a defective measurement instrument, or copying the data incorrectly).

If we carefully collect a sample so that it is representative of the population, we can use methods in this book to analyze the sampling error, but we must exercise extreme care to minimize nonsampling error.

Experimental design requires much more thought and care than we can describe in one relatively brief section. Taking a complete course in the design of experiments is a good way to learn much more about this important topic.

1-5 Basic Skills and Concepts

Statistical Literacy and Critical Thinking

1. Random Sample and Simple Random Sample What is the difference between a random sample and a simple random sample?

2. Observational Study and Experiment What is the difference between an observational study and an experiment?

3. Simple Random Convenience Sample A student of the author listed his adult friends, then he surveyed a simple random sample of them. Although this is a simple random sample, are the results likely to be representative of the general population of adults in the United States? Why or why not?

4. Convenience Sample The author conducted a survey of the students in his classes. He asked the students to indicate whether they are left-handed or right-handed. Is this convenience sample likely to provide results that are typical of the population? Are the results likely to be good or bad? Does the quality of the results in this survey reflect the quality of convenience samples in general?

***In Exercises 5–8, determine whether the given description corresponds to an* observational study *or an* experiment.**

5. Touch Therapy Nine-year-old Emily Rosa was an author of an article in the *Journal of the American Medical Association* after she tested professional touch therapists. Using a cardboard

partition, she held her hand above the therapist's hand, and the therapist was asked to identify the hand that Emily chose.

6. Smoking Survey A Gallup poll surveyed 1018 adults by telephone, and 22% of them reported that they smoked cigarettes within the past week.

7. Treating Syphilis In a morally and criminally wrong study, 399 black men with syphilis were *not* given a treatment that could have cured them. The intent was to learn about the effects of syphilis on black men. The subjects were initially treated with small amounts of bismuth, neoarsphenamine, and mercury, but those treatments were replaced with aspirin.

8. Testing Echinacea A study of the effectiveness of echinacea involved 707 cases of upper respiratory tract infections. Children with 337 of the infections were given echinacea, and children with 370 of the infections were given placebos (based on data from "Efficacy and Safety of Echinacea in Treating Upper Respiratory Tract Infections in Children," by Taylor et al., *Journal of the American Medical Association,* Vol. 290, No. 21).

***In Exercises 9–20, identify which of these types of sampling is used:* random, systematic, convenience, stratified, *or* cluster.**

9. Ergonomics A student of the author collected measurements of arm lengths from her family members.

10. Testing Echinacea A study of the effectiveness of echinacea involved upper respiratory tract infections. One group of infections was treated with echinacea and another group was treated with placebos. The echinacea and placebo groups were determined through a process of random assignment (based on data from "Efficacy and Safety of Echinacea in Treating Upper Respiratory Tract Infections in Children" by Taylor et al., *Journal of the American Medical Association,* Vol. 290, No. 21).

11. Exit Polls On the day of the last presidential election, ABC News organized an exit poll in which specific polling stations were randomly selected and all voters were surveyed as they left the premises.

12. Sobriety Checkpoint The author was an observer at a Town of Poughkeepsie Police sobriety checkpoint at which every fifth driver was stopped and interviewed. (He witnessed the arrest of a former student.)

13. Wine Tasting The author once observed professional wine tasters working at the Consumer's Union testing facility in Yonkers, New York. Assume that a taste test involves three different wines randomly selected from each of five different wineries.

14. Recidivism The U.S. Department of Corrections collects data about returning prisoners by randomly selecting five federal prisons and surveying all of the prisoners in each of the prisons.

15. Quality Control in Manufacturing The Federal-Mogul Company manufactures Champion brand spark plugs. The procedure for quality control is to test every 100th spark plug from the assembly line.

16. Credit Card Data The author surveyed all of his students to obtain sample data consisting of the number of credit cards students possess.

17. Tax Audits The author once experienced a tax audit by a representative from the New York State Department of Taxation and Finance, which claimed that the author was randomly selected as part of a "statistical" audit. (Isn't that ironic?) The representative was a very nice person and a credit to humankind.

18. Curriculum Planning In a study of college programs, 820 students are randomly selected from those majoring in communications, 1463 students are randomly selected from those majoring in business, and 760 students are randomly selected from those majoring in history.

19. Study of Health Plans Six different health plans were randomly selected, and all of their members were surveyed about their satisfaction (based on a project sponsored by RAND and the Center for Health Care Policy and Evaluation).

20. Gallup Poll In a Gallup poll, 1003 adults were called after their telephone numbers were randomly generated by a computer, and 20% of them said that they get news on the Internet every day.

Random Samples and Simple Random Samples. ***Exercises 21–26 relate to random samples and simple random samples.***

21. Sampling Prescription Pills Pharmacists typically fill prescriptions by scooping a sample of pills from a larger batch that is in stock. A pharmacist thoroughly mixes a large batch of Lipitor pills, then selects 30 of them. Does this sampling plan result in a random sample? Simple random sample? Explain.

22. Systematic Sample A quality control engineer selects every 10,000th M&M plain candy that is produced. Does this sampling plan result in a random sample? Simple random sample? Explain.

23. Cluster Sample ABC News conducts an election day poll by randomly selecting voting precincts in New York, then interviewing all voters as they leave those precincts. Does this sampling plan result in a random sample? Simple random sample? Explain.

24. Stratified Sample In order to test for a gender gap in the way that citizens view the current President, the Tomkins Company polls exactly 500 men and 500 women randomly selected from adults in the United States. Assume that the numbers of adult men and women are the same. Does this sampling plan result in a random sample? Simple random sample? Explain.

25. Convenience Sample NBC News polled reactions to the last presidential election by surveying adults who were approached by a reporter at a location in New York City. Does this sampling plan result in a random sample? Simple random sample? Explain.

26. Sampling Students A classroom consists of 36 students seated in six different rows, with six students in each row. The instructor rolls a die to determine a row, then rolls the die again to select a particular student in the row. This process is repeated until a sample of 6 students is obtained. Does this sampling plan result in a random sample? Simple random sample? Explain.

1-5 Beyond the Basics

In Exercises 27–30, identify the type of observational study **(cross-sectional, retrospective, prospective).**

27. Victims of Terrorism Physicians at the Mount Sinai Medical Center studied New York City residents with and without respiratory problems. They went back in time to determine how those residents were involved in the terrorist attacks in New York City on September 11, 2001.

28. Victims of Terrorism Physicians at the Mount Sinai Medical Center plan to study emergency personnel who worked at the site of the terrorist attacks in New York City on September 11, 2001. They plan to study these workers from now until several years into the future.

29. TV Ratings The Nielsen Media Research Company uses people meters to record the viewing habits of about 5000 households, and today those meters will be used to determine the proportion of households tuned to *CBS Evening News*.

30. Cell Phone Research University of Toronto researchers studied 699 traffic crashes involving drivers with cell phones (based on data from "Association Between Cellular-Telephone Calls and Motor Vehicle Collisions," by Redelmeier and Tibshirani, *New England Journal of Medicine,* Vol. 336, No. 7). They found that cell phone use quadruples the risk of a collision.

31. Blinding A study funded by the National Center for Complementary and Alternative Medicine found that echinacea was not an effective treatment for colds in children. The experiment involved echinacea treatments and placebos, and blinding was used. What is blinding, and why was it important in this experiment?

32. Sampling Design You have been commissioned to conduct a job survey of graduates from your college. Describe procedures for obtaining a sample of each type: random, systematic, convenience, stratified, cluster.

33. Confounding Give an example (different from the one in the text) illustrating how confounding occurs.

34. Sample Design In "Cardiovascular Effects of Intravenous Triiodothyronine in Patients Underdoing Coronary Artery Bypass Graft Surgery" (*Journal of the American Medical Association,* Vol. 275, No. 9), the authors explain that patients were assigned to one of three groups: (1) a group treated with triidothyronine, (2) a group treated with normal saline bolus and dopamine, and (3) a placebo group given normal saline. The authors summarize the sample design as a "prospective, randomized, double-blind, placebo-controlled trial." Describe the meaning of each of those terms in the context of this study.

Review

Instead of presenting formal statistics procedures, this chapter emphasizes a general understanding of some important issues related to uses of statistics. Definitions of the following terms were presented in this chapter, and they should be known and clearly understood: *sample, population, statistic, parameter, quantitative data, categorical data, voluntary response sample, observational study, experiment,* and *simple random sample*. Section 1-2 introduced statistical thinking, and addressed issues involving the context of data, source of data, sampling method, conclusions, and practical implications. Section 1-3 discussed different types of data, and the distinction between categorical data and quantitative data should be well understood. Section 1-4 dealt with the use of critical thinking in analyzing and evaluating statistical results. In particular, we should know that for statistical purposes, some samples (such as voluntary response samples) are very poor. Section 1-5 introduced important items to consider when collecting sample data. On completing this chapter, you should be able to do the following:

- Distinguish between a population and a sample and distinguish between a parameter and a statistic
- Recognize the importance of good sampling methods in general, and recognize the importance of a *simple random sample* in particular. Understand that if sample data are not collected in an appropriate way, the data may be so completely useless that no amount of statistical torturing can salvage them.

Statistical Literacy and Critical Thinking

1. Election Survey *Literary Digest* magazine mailed 10 million sample ballots to potential voters, and 2.3 million responses were received. Given that the sample is so large, was it reasonable to expect that the sample would be representative of the population of all voters? Why or why not?

2. Movie Data Data Set 9 in Appendix B includes a sample of movie titles and their lengths (in minutes).

a. Are the lengths categorical or quantitative data?

b. Are the lengths discrete or continuous?

c. Are the data from an observational study or an experiment?

d. What is the level of measurement of the titles (nominal, ordinal, interval, ratio)?

e. What is the level of measurement of the lengths (nominal, ordinal, interval, ratio)?

3. Gallup Poll The typical Gallup poll involves interviews with about 1000 subjects. How must the survey subjects be selected so that the resulting sample is a simple random sample?

4. Sampling The U.S. Census Bureau provided the average (mean) travel time to work (in minutes) for each state and the District of Columbia for a recent year. If we find the average (mean) of those 51 values, we get a result of 22.4 minutes. Is this result the average (mean) travel time to work for the United States? Why or why not?