1 Statistics and How They Are Used

CHAPTER OUTLINE

1.1 The Meaning of Statistics
Formally defines the term *statistics* and illustrates by describing what a statistician does

1.2 The Uses of Statistics
Shows how descriptive statistics are used to describe data and how inferential statistics are used to reach conclusions from the analysis of the data

1.3 Why Study Statistics?
Explains how the study of statistics is important for research, for writing publishable reports, for understanding scientific journals, and for discriminating between appropriate and inappropriate uses of statistics

1.4 Sources of Data
Discusses surveys and experiments, two main sources of data, and further classifies surveys as retrospective or prospective and as descriptive or analytical

1.5 Clinical Trials
Describes the use of a clinical trial to determine the value of a new drug or procedure

1.6 Planning of Surveys
Previews some hints on how to maximize the value of survey data

1.7 How to Succeed in Statistics
Offers some tips on getting the most out of class and other resources

✔ LEARNING OBJECTIVES

After studying this chapter, you should be able to

1. Define *statistics*
2. List several reasons for studying statistics
3. Distinguish clearly between
   a. descriptive and inferential statistics
   b. surveys and experiments
   c. retrospective and prospective studies
   d. descriptive and analytical surveys
4. Define *bias*
5. Describe the purpose and components of a clinical trial

1.1 THE MEANING OF STATISTICS

One way to understand statistics is to consider two basic questions: (1) What does the term *statistics* mean? and (2) What do statisticians do? Once we have the answers to these questions, we can delve into how statistics are used.

What Does *Statistics* Mean?

The word **statistics** has several meanings. It is frequently used to refer to recorded data such as the number of traffic accidents, the size of enrollment, or the number of patients visiting a clinic. Statistics is also used to denote characteristics calculated for a set of data—for example, mean, standard deviation, or correlation coefficient. In another context, statistics refers to statistical methodology and theory.

In short, statistics is a body of techniques and procedures dealing with the collection, organization, analysis, interpretation, and presentation of information that can be stated numerically.

What Do Statisticians Do?

A statistician is usually a member of a group that works on challenging scientific tasks. Frequently engaged in projects that explore the frontiers of human knowledge, the statistician is primarily concerned with developing and applying methods that can be used in collecting and analyzing data. He or she may select a well-established technique or develop a new one that provides a unique approach to a particular study, thus leading to valid conclusions. Specifically, the statistician's tasks are as follows:

1. *To guide the design of an experiment or survey.* A statistician should be consulted in the early planning stages so that an investigation can be carried

out efficiently, with a minimum of bias. Once data are collected, it is too late to plan ahead. By then, it is impossible to impose an appropriate statistical design or compensate for the lack of a randomly selected sample.

2. *To analyze data.* Data analysis may take many forms, such as examining the relationships among several variables, describing and analyzing the variation of certain characteristics (e.g., blood pressure, temperature, height, weight), or determining whether a difference in some response is significant.
3. *To present and interpret results.* Results are best evaluated in terms of probability statements that will facilitate the decision-making process. Mainland (1963:3) defines statistics as the "science and art of dealing with variation in such a way as to obtain reliable results." The art of statistics is especially pertinent to this task and involves skills usually acquired through experience.

The interpretation of statistics is both an art and a science. When results are said to be **significant,** the statistician is making a probability statement. He or she is saying that the differences are *most likely* real differences rather than chance or random differences. Because probability is often linked with sample size, large samples can yield seemingly impressive results. However, when the statistician scrutinizes the sample more closely, she or he may realize that, even though the results appear impressive, they have little or no practical value. An excellent example of the effects of a large sample is presented in Chapter 13 and involves the Pearson correlation technique.

Statisticians can also help with another key aspect of interpretation: Are the results applicable to other groups? Subject selection, especially the nonrandom selection of patients with specific study eligibility requirements, poses a particular problem. The statistician can help determine if the results from a published study are applicable to a somewhat different group of patients. For example, a clinical study on drug efficacy might find certain effects in the study group, but would those same effects be found in an elderly population? Are studies on cardiovascular disease, which have historically focused on men, applicable to women? Are bone density studies, in which women have been studied most extensively, applicable to men? Although statisticians may not be able to give definitive answers, they should be able to give objective advice to consider prior to making a judgment.

1.2 THE USES OF STATISTICS

It is helpful to distinguish between the two major categories of statistics. **Descriptive statistics** deals with the enumeration, organization, and graphical representation of data. **Inferential statistics** is concerned with reaching conclusions from incomplete information—that is, generalizing from the specific.

Inferential statistics uses information obtained from a sample to say something about an entire population.

An example of *descriptive* statistics is the decennial **census** of the United States, in which all residents are requested to provide information such as age, sex, race, and marital status. The data obtained in such a census can then be compiled and arranged into tables and graphs that describe the characteristics of the population at a given time. An example of *inferential* statistics is an opinion poll such as the Gallup Poll, which attempts to draw inferences as to the outcome of an election. In such a poll, a sample of individuals (frequently fewer than 2000) is selected, their preferences are tabulated, and inferences are made as to how more than 80 million persons would vote if an election were held that day.

Statistical methods provide a logical basis for making decisions in a variety of areas when incomplete information is available. Here are some examples of scientific questions to which the application of statistical methodology has been useful:

1. How can researchers test the effectiveness of a new vaccine against the common cold?
2. How effective is a trial that seeks to reduce the risk of coronary heart disease?
3. How effective have several family planning programs been?
4. How much, if at all, does use of oral contraceptives increase a woman's chances of developing a thromboembolism?

The four specific studies described next further amplify the application of statistics.

Example: Smoking During Pregnancy

A pioneering study of the effects on the newborn infant of smoking during pregnancy was reported by Simpson (1957). She examined data on 7499 patients in three hospitals in and near Loma Linda (California) University and found from the records that prematurity rates increased with the number of cigarettes smoked per day. A more recent review of the various studies on this topic is given by the Surgeon General's Report on Smoking and Health (U.S. Department of Health, Education, and Welfare, 1979). The principal conclusion of that report is: "Maternal smoking during pregnancy has a significant adverse effect upon the well-being of the fetus and the health of the newborn baby."

Example: The Multiple Risk Factor Intervention Trial (MRFIT)

Paul (1976) reported on a national study of the primary prevention of coronary heart disease. The study's approach was to determine whether the risk of coro-

nary disease in middle-aged men can be significantly reduced through intervention. This intervention entailed simultaneously reducing their serum cholesterol levels, treating any high blood pressure, and encouraging the men to stop smoking. The 7-year trial involved 20 clinical centers and 12,866 subjects, all initially healthy but at high risk for coronary disease. At random, half the men were assigned to be followed through the intervention program, and the other half through their usual medical care, which included annual physicals and lab tests. The report of the results was prepared by the MRFIT research group and appeared in the *Journal of the American Medical Association* (1982; 248:1465–1477). Investigators observed that the risk factor levels declined in both groups. Furthermore, during the 7-year follow-up period, the mortality rates for coronary heart disease (CHD) were 17.9 deaths per 1000 for the intervention group and 19.3 deaths per 1000 for the untreated group. This was a nonsignificant difference, and the lack of a positive result has generated considerable discussion. There may be more plausible reasons for this outcome: (1) It is difficult to show a significant drop due to an intervention when the entire country is experiencing a multidecade decline in CHD rates; (2) the intervention strategy may not have been drastic enough to show a significant difference; and (3) because a report of the assessed risk factors was sent to the physicians of those in the untreated group, members of that group may have benefited from whatever "treatment" their physicians had prescribed for them.

Because skills, facilities, and funds are never unlimited, the problem arises as to how to extract the maximum amount of information in the most efficient manner. With the aid of statistics, it is usually possible to achieve greater precision at minimum cost by effectively using the resources available.

Example: The Framingham Study

Perhaps the most famous longitudinal study ever conducted was the Framingham Study. In 1948, the small city of Framingham, Massachusetts, was chosen for an ambitious project in health research. At that time, little was known about the general causes of heart disease and stroke, but the death rates from cardiovascular disease (CVD) had been increasing steadily and had reached epidemic proportions. The primary objective of the study was to identify the factors or characteristics that contribute to CVD. To this end, 5209 men and women, ages 30–62, who had not yet developed overt symptoms of CVD or suffered a heart attack or stroke underwent the first of many extensive physical examinations and lifestyle interviews.

The results of this study and subsequent analysis have directly contributed to our knowledge about the major risk factors for CVD—high blood pressure, high blood cholesterol levels, smoking, obesity, diabetes, and physical inactivity—as well as providing a great deal of valuable information on the effects of related factors such as blood triglyceride and HDL cholesterol levels, age, gender, and psychosocial issues. This knowledge of CVD risk factors has influenced clinical practice and treatment, and prevention programs aimed at reducing the

incidence of CVD. This study is continuing with second- and third-generation groups, or **cohorts.** As of the summer of 2003, 879 scientific articles had been published using data obtained from the Framingham Study and listed at the following Web site: www.nhlbi.gov/aboutframingham/.

Example: The STAR Trial

The STAR (study of tamoxifen and raloxifene) Trial is an example of a **longitudinal study** that is just getting started. According to their Web site the STAR Trial is "one of the largest breast cancer prevention studies ever" (www.nci.nih.gov/clinicaltrials/digestpage/STAR). The trial will involve 22,000 postmenopausal women at increased risk of breast cancer, from 500 centers in the United States, Puerto Rico, and Canada. The primary purpose of the study is to determine whether the osteoporosis prevention drug raloxifene (Evista®) is as effective in reducing the chances of developing breast cancer as tamoxifen (Nolvadex®). Statisticians will play a key role by analyzing the data and determining which drug has an effect, how great the effect is, and whether widespread use of one or more of these drugs is warranted.

1.3 WHY STUDY STATISTICS?

Many students ask, "Why should I study statistics?" or "How useful will statistics be in my future career?" or, especially if this is a required class, "Why do I have to take this class?" The answers to these questions depend on their career objectives.

A knowledge of statistics is essential for both understanding and conducting research in any of the health professions. Those of you using this text are probably taking your first statistics class, and for many of you, it may be your only statistics class. Whatever health profession you ultimately enter, there is likely to be a strong emphasis on science and the scientific method for advancing the profession. Whenever a new method, drug, device, or intervention is developed, a key question is, "Does it work?" Statistics are used to analyze the data and help you decide if the new idea is worthy of being incorporated into your professional lives.

For example, consider these research questions: "Is the drug raloxifene (Evista®) as effective in reducing the chances of developing breast cancer as tamoxifen (Nolvadex®)?" "Does the Atkins Diet lead to weight loss?" and "Can touch therapists detect a human energy field?" Such questions require researchers to gather data, statistically analyze the data, and then interpret the results within the context of their profession. To keep abreast of these and other current developments in their field, they need to review and understand the writings in scientific journals. And full understanding of these writings often requires a working knowledge of statistical terminology and methodology. For persons

active in research, a basic understanding of statistics is useful not only in the conduct of their investigations but also in the effective presentation of their findings in papers and reports for publication, and at professional meetings. Some proficiency in statistics is also helpful for individuals who are preparing or may be called upon to evaluate research proposals. Furthermore, people with an understanding of statistics are better able to decide whether their professional colleagues use statistics to objectively view the issue or merely to support their personal biases; that is, it helps them decide whether the claims are valid.

A knowledge of statistics can help anyone discriminate between fact and fiction in everyday life. This is especially true in relation to the multitude of health claims in newspapers and magazines, on television and radio, on the Internet, and even in ads for pharmacies and grocery stores. A working knowledge of statistics is one more tool to use in making these daily comparisons and evaluations.

Finally, a course in statistics should help you know when, and for what purpose, a statistician should be consulted.

1.4 SOURCES OF DATA

In observing various phenomena, we are usually interested in obtaining information on specific characteristics—for instance, age, weight, height, marital status, or smoking habits. These characteristics are referred to as **variables;** the values of the observations recorded for them are referred to as **data.** Data are the raw materials of statistics. They are derived from incredibly diverse sources. Knowing our sources provides clues to our data—their reliability, their validity, and the inferences we might draw.

Surveys and Experiments

Data may come from anywhere: observational surveys, planned surveys, or experiments. The two fundamental kinds of investigations are **surveys** and **experiments.** Data from a survey may represent observations of events or phenomena over which few, if any, controls are imposed. The study of the effects of the explosion of the atomic bomb on the inhabitants of Hiroshima and Nagasaki is an example of a survey. In this case, the radiation to which the survivors were exposed (referred to as "treatment" in statistics) was in no way controlled or assigned. By contrast, in an experiment, we design a research plan purposely to impose controls over the amount of exposure (treatment) to a phenomenon such as radiation. The distinction between them is that an experiment imposes controls on the methods, treatment, or conditions under which it is performed, whereas in a survey, such controls are seldom possible.

A classic example of an experiment is the Veterans Administration Cooperative Study. It began in 1963 and involved 523 hypertensive men who were patients in 16 Veterans Administration hospitals (Veterans Administration, 1970,

1972). The study demonstrated that oral hypertensive medications, judiciously administered, could significantly reduce blood pressure levels, whereas **placebos** (substances or treatments that have no therapeutic value) had no effect on blood pressure.

Although experimental investigations are preferable to surveys, in some cases there are reasons for not conducting them—for instance, ethical reasons, as when a beneficial treatment may be withheld from one of the groups; or administrative reasons, as when an experiment may seriously disrupt the established routine of patients' care.

Health researchers conduct surveys on human populations all the time. These surveys may be categorized as retrospective or prospective.

Retrospective Studies

Retrospective studies (commonly referred to as **case-control studies**) gather past data from selected cases and controls to determine differences, if any, in the exposure to a suspected factor. In retrospective studies, the researcher identifies individuals with a specific disease or condition (cases) and also identifies a comparable sample without that disease or condition (controls). The purpose of the comparison is to determine if the two groups differ as to their exposure to some specific factor. An example is a study that compares the smoking habits of women who bore premature babies with those of women who carried their pregnancies to term. Given the comparative data, the researcher then seeks to determine whether there is a statistical relation between the possible **stimulus variable,** or causative factor (smoking), and the **outcome variable** (prematurity).

A disadvantage of retrospective studies is that the data were usually collected for other purposes and may be incomplete. Surveys frequently fail to include relevant variables that may be essential to determining whether the two groups studied are comparable. This absence of demonstrated comparability between cases and controls may envelop the results in a cloud of doubt. In addition, because of the historical nature of such records or the necessity of relying on memory, serious difficulties may attend the selection of appropriate controls. Unknown biases frequently hinder such studies.

The major advantages of retrospective studies are that they are economical and are particularly applicable to the study of rare diseases. Such studies also make it possible to obtain answers relatively quickly because the cases are usually easily identified.

In retrospective studies, sample selection begins with the outcome variable (disease). The researcher looks back in time to identify the stimulus variable (factor). In prospective studies (discussed next), the stimulus variable is known in advance, and the study population is followed over time, while occurrences of the outcome are noted. A generalized **2 × 2 table** may be used to illustrate the study design; Table 1.1 shows an example. This table is applicable to both retrospective and prospective studies, and is called a fourfold table because it consists of four elements—*a*, *b*, *c*, and *d:*

Table 1.1 Generalized 2 × 2 Table

	Outcome Variable		
Stimulus Variable	With Disease	Without Disease	Total
Present	a	b	$a + b$
Absent	c	d	$c + d$
Total	$a + c$	$b + d$	

1. Element a represents persons with the stimulus variable who developed the disease.
2. Element b represents persons with the stimulus variable who did not develop the disease.
3. Element c represents persons without the stimulus variable who developed the disease.
4. Element d represents persons without the stimulus variable who did not develop the disease.

Prospective Studies

Prospective studies are usually **cohort studies,** in which the researchers enroll a group of healthy persons (a cohort) and follow them over a certain period to determine the frequency with which a disease develops. An example that was briefly described in section 1.2 is the Framingham Study. Framingham subjects were analyzed statistically based on the presence or absence of one or more variables (e.g., smoking, diabetes, high blood pressure, obesity) that at the beginning of the study were only suspected of being related to CVD or stroke. In a prospective study, we must first look at the key variables of interest simply because the disease or diseases being studied have not yet occurred. In the Framingham Study, as subjects either developed CVD or had a stroke, the key variables were compared for the individuals who acquired the disease and those who did not. Based on the data analysis, the researchers could then begin to determine the degree of importance of each variable in relation to CVD or stroke.

The primary advantage of prospective studies is that they permit the accurate estimation of disease incidence in a population. They make it possible to include potentially relevant variables (e.g., age, gender, ethnicity, occupation) that may be related to the outcome variable. Furthermore, data are collected under uniform conditions and for specified reasons, and there are better opportunities to draw appropriate conclusions or make appropriate comparisons

while limiting or controlling the amount of **bias,** which may be considered systematic error. For example, in the Framingham Study, researchers were able to collect data *before* subjects developed CVD or stroke. The net result is that our current understanding of CVD and stroke is better than if they had waited for subjects to develop the disease and then tried to understand why. The primary disadvantage of prospective studies is that they take considerable time (Framingham started in 1948) and are expensive, especially if the disease studied has a low incidence rate.

Although prospective studies provide useful data, they typically are not used to establish or "prove" a causal relationship, because the variables cannot be randomly assigned or manipulated. We simply cannot randomly assign subjects to either a smoking group or a nonsmoking group and then see if the CVD or stroke rates differ over time. Typically, subjects are identified as either smokers or nonsmokers and studied over time. Then a statistical analysis is performed to determine if and how much the CVD and stroke rates differ from those of nonsmokers. Although this may yield strong evidence for a relationship between smoking, CVD, and stroke, we would still have to make sure that smoking was the real cause. Some risk factors from the Framingham Study are also emerging. The data suggest that these factors are related to CVD and stroke, but as of yet, a causal relationship has not been established. Three factors identified are homocysteine, Lp(a) (a lipoprotein that may prevent the breakup of clots), and various infectious agents (www.framingham.com/heart/4stor_02.htm). With these emerging risk factors, there may be "a point in the accumulation of evidence when it is more prudent to act on the basis that the association is causal rather than to await further evidence" (McMahon and Pugh, 1970:22).

Comparison of Ratios

For each type of study, it is instructive to note the different ratios that can be constructed and the questions that can be answered. For *retrospective* studies, the ratios to be compared (using the notation of Table 1.1) are

$$\frac{a}{a+c} \quad \text{and} \quad \frac{b}{b+d}$$

By comparing them, we can answer the question, "Were mothers of premature infants more likely to have been smokers than mothers of full-term infants?"

For *prospective* studies, the ratios to be compared are

$$\frac{a}{a+b} \quad \text{and} \quad \frac{c}{c+d}$$

This comparison answers the question, "Which group has the higher frequency of premature infants—mothers who smoke or mothers who do not smoke?"

Descriptive and Analytical Surveys

Retrospective surveys are usually **descriptive surveys** that provide estimates of a population's characteristics, such as the proportion of individuals who had a physical examination during the past 12 months. Prospective surveys may be descriptive or analytical. **Analytical surveys** seek to determine the degree of association between a variable and a factor in the population. An example is the relationship between having (or not having) regular physical examinations and some measure of health status.

1.5 CLINICAL TRIALS

A **clinical trial** is a carefully designed experiment that is generally considered to be the best method for evaluating the effectiveness of a new drug or treatment method. Clinical trials are used extensively to test the efficacy of new drugs and treatments. The federal Food and Drug Administration (FDA) requires clinical trials before drugs and other medical products under their purview receive approval.

Prior to starting a clinical trial, it is essential for the investigator(s) to write "a prospectively written **protocol** that describes in detail the design of the proposed research" (Schechtman, 2000:117). Included in the protocol are clearly defined hypotheses, detailed delineation of inclusion and exclusion criteria for study subjects, descriptions of the proposed interventions and the randomization process, a detailed explanation of how bias may be minimized, a description of the procedures to minimize errors in the collection and analysis of data, a justification of the sample size, and an a priori explanation of the statistical techniques used for data analysis (Schechtman, 2000). What this means is that all facets of a clinical trial must be carefully considered *before* the trial is begun and *before* data are collected. The protocol should also be considered a contract between the investigator(s) and whoever is sponsoring the research (Chew, 2000).

Two key features of a clinical trial are randomization and blinding, each of which helps minimize bias. **Blinding** means that the study subjects and/or the investigators do not know who is in the control group and who is in the experimental group. As Schechtman (2000:118) aptly puts it, "The purpose of blinding is to reduce the likelihood that study assessments will be biased because subject or investigator behavior has been influenced by knowledge of treatment group assignment." In a **single-blind study,** the subject does not know if she or he is in the treatment or the control group. An even better approach is to design a trial known as a **double-blind study.** In this case, neither the subject nor the investigator knows to which group the subject is assigned. A neutral party keeps track of who is in which group and typically discloses it only at the conclusion of the trial.

The second key feature in a clinical trial is **randomization.** True randomization, while not guaranteeing equivalent groups, is the method most likely to consistently reduce bias by producing equivalent treatment and control groups.

(The **treatment group,** which receives a potentially therapeutic agent, is compared with a **control group,** which receives a placebo or the standard therapeutic agent.) In the most basic randomization procedure, each subject in the trial is randomly assigned to either the experimental or the control group; this assignment is fully independent of all preceding assignments. Because the use of controls doubles the size of the sample, some investigators have tried alternatives such as historical controls—subjects selected from a set of records after a study has been completed. Historical controls present problems, however, because of changes in the population over time and because there is no way to eliminate selection bias. Volunteer groups have also been used as controls. Because such a group is self-selected, it is usually atypical of the rest of the population, thus limiting the inferences that may be drawn. Some investigators have chosen controls from patients in certain hospital wards. But this method presents problems of selection for a particular kind of disease or condition and may overrepresent patients hospitalized for a long time or those recently admitted. It is important to remember this: "The consistent message is that trials that use nonrandom assignments tend to produce biased overestimates of true therapeutic efficacy" (Schechtman, 2000:117).

As mentioned previously, an a priori explanation of the statistical procedures is an important component of a protocol. Before collecting data in any type of study, it is important to know how you will analyze the data. Consulting a statistician will help you not only with the analysis but also with the procedures and data collection. We have seen situations in which the data had already been collected when the statistician was consulted. Sometimes we look at what has been done and realize that, if relatively minor adjustments in the data collection process had been made at the beginning, the data might have been much easier to analyze, and the results would have been more meaningful. Regardless of whether we are discussing a clinical trial or any other type of study, we cannot overemphasize the importance of a well-written protocol *prior* to beginning the study.

Example: The Salk Vaccine Clinical Trial

The 1954 clinical trial of the Salk poliomyelitis vaccine is a good example of how a clinical trial can be used to solve an important public health problem. At that time, outbreaks of polio were unpredictable. Because the disease caused paralysis and frequently death, such outbreaks were of great concern to both parents and children. Enter Dr. Jonas Salk. Salk developed a vaccine that proved safe and effective in a laboratory setting in producing antibodies against polio. The question to be answered, then, was whether this promising vaccine could prevent polio in exposed individuals.

To find the answer, a clinical trial was set up. Statisticians recommended that at least 400,000 children be included in the study: 200,000 children in the treatment group and 200,000 children in the control group. The large numbers were needed to provide an adequate number of cases in order to get valid

results. An adequate number could be obtained only with these large sample sizes because the incidence rate of polio cases was estimated to be 35 per 100,000 children. The 400,000 children in the study were randomly assigned either to a treatment group (the group receiving the active Salk vaccine) or to a control group (the group receiving a placebo, which consisted of an injection of salt dissolved in water). Because of this precaution—the addition of the double-blind feature—neither the children nor the administrators of the treatment knew which children received the vaccine and which received the placebo. Furthermore, those who examined the children to determine whether they had contracted polio were also unaware of their patients' group status.

It was important that the study group be randomly allocated so that the two groups would be comparable. If this procedure had not been followed, it is likely that the treatment group would have been biased because children from higher socioeconomic levels, whose parents were aware that they were at greater risk, would have been more likely to participate. Such children were at greater risk because their environment was more hygienic than that of children from lower socioeconomic strata, and they were less likely to have developed an immunity to the disease.

The tabulation of the collected data indicated that the incidence rate of cases in the treatment group was 28 per 100,000 versus 71 per 100,000 in the control group. Statistical analysis of these rates showed that the Salk polio vaccine was indeed effective and that the clinical trial (one of the largest ever) and its cost ($5 million) were justified.

Some students may be concerned about the ethical problem of withholding treatment from half of the study group. However, before the clinical trial, there was no definite proof of the effectiveness of the Salk polio vaccine, and without a control group, there was no available scientific, rigorous procedure by which to provide definitive answers. A clinical trial had to be carried out. Once it was—and the evidence was convincing—the public health authorities had the ammunition necessary to mount a national campaign to virtually eradicate polio. Their efforts were successful; polio is no longer considered a public health threat.

1.6 PLANNING OF SURVEYS

The previous sections discussed several types of medical surveys that may give rise to data. Before starting a survey, it is essential to formulate a clear plan of action. An outline of such a plan, including the major steps that should be followed in pursuing the investigation, is given in Chapter 17.

1.7 HOW TO SUCCEED IN STATISTICS

Studying statistics is somewhat analogous to studying a foreign language because a considerable number of new terms and concepts need to be learned. We have found that students who do this successfully scan the chapter outline,

read the conclusion and the vocabulary list, and review the learning objectives before coming to class. Also, as soon as possible after the class, they study and learn the relevant terms, concepts, principles, and formulas in the textbook. After doing the assigned exercises, they try to reformulate the objectives as questions and then answer them. We suggest that you do the same. The questions you form from the objectives also serve as excellent review questions you can use to help prepare for tests and exams. If you are not sure of some of these objectives, you may need to go back and reread the chapter or do additional exercises. Doing as many exercises as possible is one of the best ways to learn statistics. If anything is still not clear, make up questions you can ask at the tutorial session or in class.

In addition, read essays dealing with the application of statistics to a variety of fields. Also, because many of the exercises involve a large number of measurements, you may find a calculator helpful. Finally, keep in mind that students who are successful in mastering statistics do not allow themselves to get behind.

◆ CONCLUSION

A statistician designs efficient and unbiased investigations that provide data that he or she then analyzes, interprets, and presents to others so that decisions can be made. To do this work, the statistician uses techniques that are collectively called "statistics." Students of statistics learn these techniques and how they may relate to their work and to everyday life. In particular, they learn how to make correct inferences about a target population of interest based on sample data. Students need to know not only how to understand the scientific literature of their field but also how to select from various kinds of investigations the one that best fits their research purpose.

◆ VOCABULARY LIST

analytical survey
bias
blinding
case-control study
census
clinical trial
cohort
cohort study
control group
data
descriptive statistics
descriptive survey
double-blind study
experiment
inferential statistics
longitudinal study
outcome variable
placebo
prospective study
protocol
randomization
retrospective study
significant
single-blind study
statistics
stimulus variable
survey
treatment group
2×2 table
variable

◆ EXERCISES

1.1 Suggest and describe briefly a survey and its objectives.
a. Is it a descriptive or an analytical survey?
b. What are some potential sources of bias?

1.2 Suggest and describe an experiment.
a. What research question are you testing?
b. What is the "treatment" in this experiment?
c. What are some potential sources of bias?

1.3 Suggest a clinical trial for some phenomenon of interest to you, such as drug use or exercise.
a. How would you select and allocate cases?
b. What would be the treatment?
c. What would be the outcome variable for determining the effectiveness of the treatment?
d. What double-blind feature would you include, if any?

1.4 Find a newspaper or magazine article that uses data or statistics.
a. Were the data obtained from a survey or an experiment?
b. Is the study descriptive or inferential?
c. What research question was the author trying to answer?
d. How did she or he select the cases? What population do the cases represent?
e. Was there a control group? How were the control subjects selected?
f. Are possible sources of bias mentioned?
g. If conclusions are stated, are they warranted?
h. Make a copy of the article to turn in with your answers to these questions.

1.5 Define: *bias, clinical trial, experiment, survey,* and *statistics.*

1.6 Explain what is meant by
a. descriptive statistics
b. inferential statistics

1.7 Answer the following questions regarding the Salk vaccine trial:
a. Why was such a large trial necessary?
b. Why was a control group needed?
c. Why was it important to include a double-blind feature?
d. If volunteers had been used in this trial rather than a random sample of individuals, of what value would the results have been?

1.8 U.S. census statistics show that college graduates make more than $254,000 more in their lifetime than non-college graduates. If you were to question the validity of this observation, what would be your basis for doing so?