Basic Statistics

For the Social and Behavioral Sciences

George M. Diekhoff

BASIC STATISTICS
FOR THE SOCIAL
AND BEHAVIORIAL
SCIENCES

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*For Beverly and Ben, two very good
reasons for putting my work aside
at the end of each day*

PREFACE

Basic Statistics provides a solid introduction to applied statistics for students in psychology, sociology, social work, and education. I have kept these students first in my mind as I have written.

After nearly 20 years of teaching statistics I can count on one hand the students who took the course as an elective! Indeed, the common denominator of students beginning their study of statistics is dread. I understand this. I haven't forgotten the confusion and frustration that I felt as I struggled through my own first course in statistics. I hope that these memories have helped me to write a friendlier book that gives a better fit to the needs of beginning statistics students.

Several helps are included in *Basic Statistics* to facilitate learning. Marginal definitions define key concepts the first time they are used in the text. Frequent comprehension checks ensure that each major idea is mastered before the next is presented. Answers and complete explanations for these comprehension checks are located at the end of each chapter. A set of review exercises, also at the end of each chapter, provides a second opportunity to strengthen understanding. Answers for review exercises appear in Appendix C at the end of the book. Examples and illustrations replace the usual proofs and derivations. Every statistical formula is followed by a step-by-step verbal description of computational mechanics. Every statistical procedure described in the book is accompanied by a complete, data-to-conclusions example. *Relevance* is the acid test applied in every decision to include or exclude material. And I have tried to sweeten the subject matter with a little humor sprinkled throughout.

The *Workbook and Computer Guide* that accompanies *Basic Statistics for the Social and Behavioral Sciences* provides even more help. This study guide provides lists of learning objectives, key concepts, important statistical formulas, more exercises, and self-tests that are useful whether or not you are working with a computer. If you are using the *SPSS/PC+ Studentware Plus*

statistical software package (optional from Prentice Hall) the *Workbook and Computer Guide* illustrates how to use this software effectively.

Many people have contributed importantly to this text and the accompanying materials. My thanks go first to Dr. Ludy T. Benjamin, who has been an inspiration to me throughout my student and professional years. Many thanks also are due Christine Cardone, formerly of Macmillan Publishing Company, who encouraged me to begin this project. Pete Janzow, Executive Editor with Prentice Hall, and Marilyn Coco, Pete's assistant, have been very helpful in guiding the development of the book and its ancillaries. Thanks also go to Lynne Lachenbach, who edited my often rough prose, and to Joan Stone, who translated the manuscript into printed text. I am grateful to Lauren Ward and Diane Guarine for their work in marketing the book. Thanks go too to the artists for their work. I am also thankful for the very useful insights of the reviewers whose comments shaped this book: Bernard C. Beins, Ithaca College; Stephen W. Brown, Rockhurst College; Jane A. Halpert, DePaul University; Susan Hoernbelt, Hillsborough Community College; Stan Kary, St. Louis Community College at Florissant Valley; Linda M. Noble, Kennesaw State College; and John Pittenger, University of Arkansas Little Rock (UALR).

Finally, I am grateful to the Longman Group UK Ltd., on behalf of the Literary Executor of the late Sir Ronald A. Fisher, F.R.S., and Dr. Frank Yates, F.R.S., for permission to reprint Tables III and VII from *Statistical Tables for Biological, Agricultural and Medical Research, 6/e* (1974).

George M. Diekhoff

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THE WHATS AND WHEREFORES OF STATISTICS

1

Chapter Outline

According to some recent publications in the social and behavioral sciences:

- Between 2% and 10% of students in the nation's colleges and universities register for classes late.
- The length of the average run reported by a sample of 68 joggers was 4.5 miles. On average, these joggers suffered about 1.2 running-related injuries each year.

Do these statements make sense to you? Yes? Good. Then you already understand some statistics, such as percentages and averages. Consider these excerpts:

- Late registrants who enrolled in classes in which the number of allowed absences was restricted were significantly more likely to drop the classes or be dropped than were timely registrants (χ^2 (1, $N = 122$) = 4.34, $p <$ .05).
- Among recreational joggers, the number of running-related injuries was significantly correlated with type A personality ($r = .29, N = 66, p < .01$).

These statements undoubtedly made some sense to you, but probably also left you with some questions. What exactly is the meaning of the word "significantly" here? What's all the gobbledygook enclosed in parentheses?

Do you get the sense that you have more to learn about statistics? Good. This "need to know" is one of the most important elements in successful learning. And the more you read and work in the social and behavioral sciences, the more you will feel it, because statistics are everywhere in psychology, sociology, social work, and related disciplines.

Statistics are the tools of trade in the social and behavioral sciences. With these statistical tools we can sift through thousands upon thousands of otherwise meaningless bits and pieces of data to tease out meaningful trends, patterns, and relationships. We can make sense out of what would otherwise be an incomprehensible mass of numerical facts and figures. With statistics we can answer questions that would be unanswerable without these tools. Statistics enable social and behavioral scientists to bring to bear on human problems the power of mathematics.

1.1 WHAT ARE STATISTICS?

statistics *Procedures used to organize, condense, and analyze data.*

We have used the word "statistics" several times now. Perhaps it is time to define this term. **Statistics** are procedures used to organize, condense, and analyze data so as to answer questions about the cases represented by those data.

This definition contains two additional terms—data and cases—that we need to examine more closely. Suppose we recorded the number of errors made by each of 20 laboratory rats as they made their way from the start box to the goal box of a maze. Numbers of errors would comprise the data, and each rat would constitute a case. Consider another example. Imagine that we have recorded the number of minutes each of several toddlers sucks their

thumb while viewing *Teenage Mutant Ninja Turtles* or *Barney the Friendly Dinosaur*. These numbers would now constitute the data, and each toddler would be considered a case. Finally, suppose one recorded the number of police officers per capita in each of 100 American cities. The data would now be numbers of police, and each city would be a case. Can you define the terms "data" and "case" from these examples?

Data are numerical facts and a **case** is the smallest unit of observation. You can see from these examples that social and behavioral scientists study all sorts of cases and collect all kinds of data. Statistics are the tools that we use to make sense of the data, and thus the cases that are represented by those data. Statistical analysis is not some abstract exercise in higher mathematics, divorced from the real world and pertinent only to multifunction-calculator-equipped eggheads. The numbers we work with represent living, breathing creatures, ranging from rats to toddlers to whole cities. Statistics enable us to answer potentially life-changing questions that would otherwise not be answerable.

> In each of the following examples, identify the "cases" and the "data." (a) A teacher has self-image test scores for each of her kindergarten pupils. (b) A school psychologist uses a 1–5 scale to rate the level of cooperation in each of several elementary school classrooms. (c) A researcher records the number of weapons violations reported during the last year in each of 30 school districts.
>   (Answer on p. 20.)

**COMPREHENSION CHECK
1.1**

1.2 WHY DO YOU NEED STATISTICS?

Do you need to learn statistics? This is a legitimate question that all students new to statistics ask. Let me answer this question with another question. Which carpenter would you hire to build new kitchen cabinets, one whose tool box contains a hammer and saw, or one whose tools fill the back of a van? Either carpenter could build your cabinets, but what would the finished product look like? The quality of the work is limited by the quality of the tools. This is true in the social and behavioral sciences just as surely as in carpentry. The only difference is in the nature of the tools.

> In your own words, why should *you* learn about statistics? What's in it for you?
>   (Answer on p. 20.)

**COMPREHENSION CHECK
1.2**

Equipped with tools for measuring, cutting, smoothing, and fastening, a carpenter can turn a pile of lumber into a cabinet, a table, or a dog house. Faced with a pile of data, the raw materials of the social and behavioral sciences, what can we do with our statistical tools? Let's sort through the statistical tool box.

1.3 KINDS OF STATISTICS

descriptive statistics *Sometimes used as a label for statistical procedures used in the analysis of sample data. Also used as a label for statistical procedures that describe some characteristic of either a sample or a population.*

sample *A group of cases that has been examined firsthand. Samples are often viewed as a subset of a larger population and are often studied as representative of that population.*

One way to classify statistical procedures is into two categories: descriptive statistics and inferential statistics. **Descriptive statistics** are procedures used to describe a given collection of data. If we collected the scores of students in your statistics class on the first exam and computed the class average, we would be using descriptive statistics. The purpose of descriptive statistics is to describe the **sample** at hand—the collection of cases that we have examined. Whereas the original data convey information about each individual case, descriptive statistics make it possible to describe the sample as a whole. The class average, for example, tells us about the class as a whole, not about any particular student. Descriptive statistics give us a way to see the forest and not just the individual trees. We will begin our study of descriptive statistics in Chapter 2.

If descriptive statistics enable us to look past the individual trees to the forest as a whole, inferential statistics enable us to look beyond a particular forest to draw conclusions about forests in general, even those that we haven't examined firsthand. **Inferential statistics** are procedures that let us generalize our findings beyond the particular sample at hand to the larger **population** represented by that sample. A developmental psychologist who assesses the impact of a children's television program on the moral development of a sample of 20 toddlers certainly cares about those 20 toddlers, but is probably even more interested in generalizing to the population of all toddlers. The family therapist who studies social interaction patterns in a sample of 20 couples in marriage counseling is interested in those couples, but probably also wants to generalize the findings to the population of all such couples. We will begin our study of inferential statistics in Chapter 5.

inferential statistics *A category of statistical procedures that enable generalizing from sample data to the larger population.*

population *The complete set of cases represented by the sample subset.*

COMPREHENSION CHECK 1.3

What do we learn from : (a) the data; (b) descriptive statistics; and (c) inferential statistics?
(Answer on p. 20.)

We have seen that descriptive statistics tell us about the sample at hand. Inferential statistics tell us about populations beyond the sample at hand. Thus the distinction between descriptive and inferential statistics is based on the target of our description: the sample or the population beyond the sample.

Another way of categorizing our statistical tools is according to *what* they tell us about that target—what the statistics *do*. A carpenter has tools that measure (measuring tape, T-square), tools that cut (saws, chisels), tools that join pieces together (hammer, clamps, screwdrivers), and tools that smooth surfaces (planes, sandpaper). So, too, statistical procedures can be grouped according to what they do, that is, what they tell us. Considered in this way, statistics can be divided into four classes: (1) descriptive statistics; (2) significant difference tests; (3) correlational statistics; and (4) regression. Let's consider each of these functions of statistics in turn.

Descriptive Statistics

One purpose of statistics is simple description. Sometimes statistics are used to describe individual cases. Percentile ranks, described in Chapter 2, de-

scribe individuals by indicating how low or high their scores are, relative to the others. The standard score or "*z* score," discussed in Chapter 4, is another statistic that is used in describing individual cases.

Other times we use statistics to describe the characteristics and attributes of a sample consisting of many individual cases. Averages, percentages, and measures of the variability of data are described in Chapters 2 and 3 and are all examples of these descriptive statistics.

Populations also need to be described, and we can use inferential statistics to describe populations on the basis of samples drawn from them. These procedures are inferential statistics in that they let us go beyond the sample at hand to the larger population. They are descriptive statistics in the sense that their purpose is to describe the population.

Let's consider an example. Suppose that a poll of 100 Rocky Bottom State University students revealed that 64% favored a four-day school week during the summer. This percentage describes the sentiment of the sample of 100 students who were polled. But what about the many other students who were not included in this sample? Can we describe the entire population of Rocky Bottom students on the basis of just this sample? The answer is yes, and the statistical procedure involved, called interval estimation, is discussed in Chapter 5. Interval estimation is considered an inferential statistic because it is used to go beyond the sample data at hand to make generalizations about some larger population. In terms of the purpose accomplished, though, interval estimation is a descriptive statistical procedure because it is used to describe the characteristics of a population.

COMPREHENSION CHECK 1.4

Significant Difference Tests

Other statistical procedures are used to evaluate differences—differences between a sample and a larger population, differences between two samples, before-vs.-after differences, and so on. **Significant difference tests,** discussed in Chapters 6–9, all answer this question: How large must a difference be in order for one to conclude that the difference is replicable and due to more than just chance fluctuations in the particular data at hand?

Suppose that 8 toddlers viewing 30 minutes of *Teenage Mutant Ninja Turtles* cartoons sucked their thumbs an average of 6.5 minutes, compared to an average thumb-sucking time of 5.9 minutes for *Barney the Friendly Dinosaur.* Is this difference large enough that you would bet the farm on seeing it again if the study were replicated, that is, repeated with a completely new sample of toddlers? How about a difference of 8 minutes for *Turtles* and 4 minutes for *Barney*? Eighteen minutes for *Turtles* and 1 minute for *Barney*? Clearly, we need some way of determining how big a difference needs to be before we consider it reliable. This is the purpose of significant difference tests. A difference is called *significant* if it is extremely unlikely to be the product of chance fluctuations in the data. Put another way, a significant difference is a reliable difference. A significant difference is a difference seen

significant difference tests *A group of inferential statistical procedures that determine the likelihood that a difference seen in sample data is the result of chance fluctuations in the data. These statistics determine how big a difference must be to be considered reliable.*