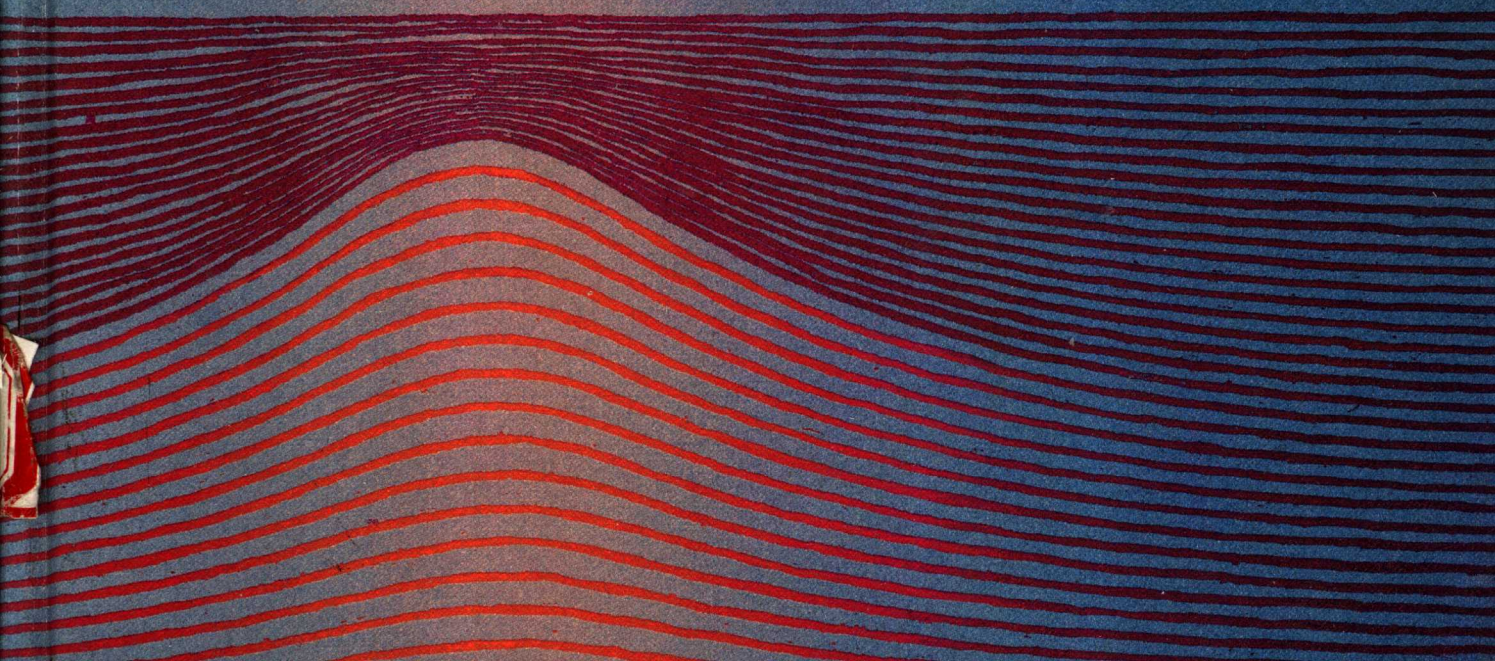
Elementary Statistics

4th Edition

Robert Johnson



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4th Edition

Robert Johnson
Monroe Community College

PWS-KENT Publishing Company
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Preface

The primary objective of this book is to present a truly readable introduction to statistics that will motivate students by presenting statistics in a context that relates to their personal experiences and that is organized to promote learning and understanding.

Statistics is a practical discipline that responds to the changing needs of our society. Today's student is a product of a particular cultural environment and as such is motivated differently from the student of a few years ago. Statistics is presented in this text as a very useful tool in learning about the world around us. While studying descriptive and inferential concepts, students will become aware of the practical application of these concepts to such fields as business, biology, engineering, industry, and the social sciences.

This book was written for use in an introductory course for non-mathematics students who need a working knowledge of statistics but do not have a strong mathematics background. Statistics requires the use of many formulas, so those students who have not had intermediate algebra should complete at least one semester of college mathematics before beginning this course. With students from such a mathematical background in mind, I have emphasized the readability, motivation, and promotion of learning as the primary goals for this book.

The Changes in the Fourth Edition

The teaching objectives of this edition are the same as those of the previous editions. The following significant changes made in this revision should be helpful in attaining these teaching objectives:

1. A discussion of data collection and the role of the computer in statistics has been added to chapter 2.
2. The descriptive statistics for single variable data have been reorganized and combined into one chapter with a "two-unit" approach. Unit 1 deals with graphical techniques; unit 2 deals with calculated techniques.
3. Chapter 4 on Probability has been reworked by merging the General and Specific Addition (and Multiplication) Rules under one heading. The exposition has also been divided into additional sections to clarify the discussion and increase the number of drill exercises.
4. *P*-values have been added to hypothesis testing.

5. Coverage of unequal replicates has been added to ANOVA.
6. Minitab Computer Output has been included for Descriptive statistics, Hypothesis-testing, Chi Square, ANOVA, and Regression Analysis.
7. Four "Working with Your Own Data" sections have been included for student exploration. These provide a more personalized learning experience by directing students to collect their own data and apply the techniques they have been studying by use of those data.
8. The exercise sets have been altered substantially. Many of the exercises are new, and others have been modified so that solutions are different from solutions in the third edition.

To the Instructor: The Text As a Teaching Tool

As stated earlier, one of my primary objectives in writing this book was to produce a truly readable presentation of elementary statistics. It is this specific intent that brought about the chapter format. Each chapter is designed to interest and involve students, and guide them step-by-step through the material in a logical manner. Each chapter includes:

A **Chapter Outline** that shows students what to look for in the following material.

A **News Article** that shows students how statistics are actually applied in the real world and demonstrates the type of statistic to be studied.

Chapter Objectives that tell students the specific information to be learned upon completion of the chapter.

Worked-out Examples with solutions to illustrate concepts as well as demonstrate the applications of statistics in real-world situations.

End-of-Section Exercises to facilitate practice in the use of concepts as they are presented.

In Retrospect, a section that provides a summary of the material just provided and relates the material to the chapter objectives.

Chapter Exercises that give students further opportunity to master conceptual and computational skills.

A **Vocabulary List** to help students review key terms.

A **Chapter Quiz** that helps students evaluate their mastery of the material.

The first three chapters are introductory in nature. Chapter 3 is a descriptive (first-look) presentation of bivariate data. I present this material at this point in the book for two reasons. First, students often ask about the relationship between two sets of data (such as heights and weights). Second, it affords me an opportunity to present a decision-making process (a hypothesis test with critical value) without confusion. This seems to reduce the resistance that always persists later when the formal hypothesis

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test procedure is introduced. (Of course, the instructor must make reference to this previous decision-making process.)

In the chapters on probability (4 and 5), I deliberately avoid the concepts of permutations and combinations. They are of no help in understanding statistics. Thus only the binomial coefficient is introduced in connection with the binomial probability distribution.

The instructor has several options in the selection of topics to be studied in a given course. I consider chapters 1 through 9 to be the basic core of a course (some sections of chapters 2, 3, and 6 may be omitted without affecting continuity). Following the completion of chapter 9, any combination of chapters 10 through 14 may be studied. There are two restrictions, however: chapter 3 must be studied prior to chapter 13, and chapter 10 must precede chapter 12.

The suggestions of instructors using the previous editions have been invaluable in helping me improve the text for the present revision. Should you, in teaching from this edition, have comments or suggestions, I would be most grateful to receive them. Please address such communications to me at Monroe Community College, Rochester, New York 14623.

To the Student: The Text As a Learning Tool

I believe that plain talk and a stress on common sense are this book's main merits as a learning tool. Such a treatment should allow you, provided that you have the necessary basic mathematics skills, to work your way through the course with relative ease. Examples of this procedure are (1) illustration 1–4 (p. 8), which is used to reemphasize the meanings of the eight basic definitions presented in chapter 1, and (2) the use of previously completed homework exercises to introduce a new concept (see the introduction of hypothesis testing on page 262).

It is my aim to motivate and involve you in the statistics that you are learning. The chapter format reflects these aims and can best promote learning if each part of each chapter is used as indicated.

1. Read the annotated outline to gain an initial familiarity with several of the basic terms and concepts to be presented.

2. Read the news article, which puts to practical use some of the concepts to be learned in the chapter.

3. Use the chapter objectives as a guide to map out the direction and scope of the chapter.

4. Learn and practice using the concepts of each section by doing the exercise set at the end of the respective section. Answers and partial solutions are provided at the back of the book to complement the study illustrations and to enable you to work independently. While working within a chapter, it will be helpful to save the results of the exercises, since some results will be used again in later exercise sets of the chapter. When this occurs, the later use has been cross-referenced.

5. Use the In Retrospect section to reflect on the concepts you have just learned and the relationship of the material in this chapter to the material of previous chapters. At this point it would be meaningful to reread the news article.
6. The Chapter Exercises at the end of the chapter offer additional learning experiences, since in these exercises you must now identify the technique to be used and must be able to apply it. The exercises are graded; everyone will be able to complete the first exercises with reasonable ease, but succeeding exercises become more challenging. Occasionally the results of an exercise should be saved for use in later exercises.
7. The Vocabulary List and Quiz are provided as self-testing devices. You are encouraged to use them. The correct responses for the Quiz may be found in the back of the book.
8. The "Working with Your Own Data" sections direct you to collect a set of data, often of your own interest, and to apply the techniques you have studied. This opportunity should (i) reinforce the concepts studied and (ii) result in an interesting and informative statistical experience with real data.

Supplements

The complete instructional package that accompanies this book includes the following:

1. The **Study Guide with Self-Correcting Exercises** offers students an alternative approach to mastering difficult concepts. For each chapter in the text, the study guide provides alternative explanations of difficult, numerous worked-out examples, and self-correcting exercises. There is a review of elementary algebra.
2. A **Test Item Card File** for testing each chapter. These are printed on cards to make them easy to reproduce.
3. The **Solutions Manual** shows at least one complete solution to each exercise in the textbook. Occasionally I have added some parenthetical comments to aid the teacher in such areas as when to assign specific problems and how some problems can be of greatest use.
4. The **Minitab Student Supplement** by James Scott and Kenneth Bond of Creighton University. For those interested in teaching or learning the course interactively with the computer, this supplement is a text-specific introduction to the MINITAB Statistical Software Package and is keyed to text discussion and examples.

Acknowledgments

I owe a debt to many other books. Many of the ideas, principles, examples, and developments that appear in this text stem from thoughts provoked by these sources.

It is a pleasure to acknowledge the aid and encouragement I have received throughout the development of this text from my students and colleagues at Monroe Community College. Special thanks go also to those who read and offered suggestions about the previous editions. I also want to acknowledge and thank the reviewers for this edition: Paul Alper, College of St. Thomas; Nancy Adcox, Mt. San Antonio College; Joan Garfield, University of Minnesota General College; Carroll Hall, New Mexico State University; Hank Harmeling, North Shore Community College; Michael Karelius, American River College; Raymond Knodel, Bemidji State University; Larry Ringer, Texas A & M University; Thomas Sturm, College of St. Thomas; William Tomhave, University of Minnesota; and Jean Vincenzi, Saddleback College. In addition, Dr. Susan Reiland did a very thorough check of the entire manuscript.

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Robert R. Johnson

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PART I

Descriptive Statistics

When one embarks on a statistical solution to a problem, a sequence of events must develop. The order in which these events occur should be: (1) the situation investigated is carefully and fully defined, (2) a sample of data is collected from the appropriate population following an established and appropriate procedure, (3) the sample data are converted into usable information (this usable information, either numerical or pictorial, is called the descriptive statistics*), and (4) the theories of statistical inference are applied to the sample information in order to draw conclusions about the sampled population (these conclusions or answers are called* inferences*).*

The first part of this textbook, chapters one through four, will concentrate on the first three of the four events identified above. The second part of the textbook will deal with probability theory, the theory on which statistical inferences rely. The third and fourth parts of the text will survey the various types of inferences that can be made from sample information.

1 Statistics

Chapter Outline

1–1 What is Statistics?

1–2 Uses and Misuses of Statistics

Statistical analysis, like nuclear fission and firearms, can be ***applied*** *either* ***responsibly or irresponsibly****. The way it is done is up to you.*

1–3 Introduction to Basic Terms

Population, sample, variable, data, experiment, parameter, statistic, attribute data, and variable data.

1–4 Measurability and Variability

Statistics is a study of the variability *that takes place in the response variable. It should not be a function of the ability to measure.*

1–5 Comparison of Probability and Statistics

*Probability is related to statistics as the phrase "****likelihood*** *of rain today" is related to the phrase "****actual amount*** *of rain that falls".*

1–6 Data Collection

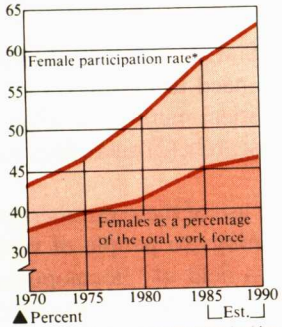
The problem of selecting a ***representative sample*** *from a defined population can be solved using the* ***random*** *method.*

1–7 Statistics and the Computer

Today's state of the art.

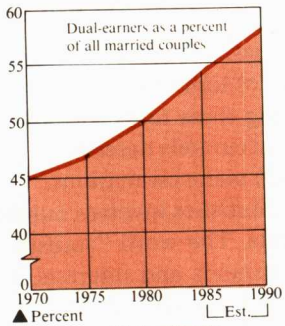
The Lasting Changes Brought by Women Workers

More women will be entering the labor force than ever before...



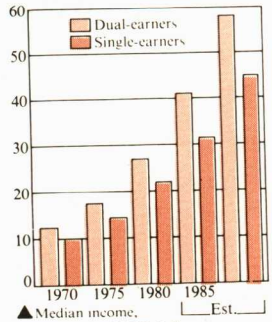
*Number of women employed or looking for work as a percentage of all women of working age

...which will translate into more two-earner families



Data: Bureau of Labor Statistics, Data Resources Inc.

...widening the income gap between dual- and single-earner families



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McDonald's Restaurant Chain Has Sold Over 43,000,000,000 Hamburgers!

4 out of 5 doctors recommend

Average Gain on Today's Stockmarket Was 4.14

"Oh, I was just an average guy....."

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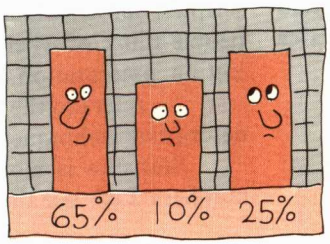

It's Your Life

Statistics about the American teen

What's your biggest problem? If it's school, you're not alone. Dr. Myron Harris and Jane Norman have discovered that school weighs heaviest on the minds of young people. They surveyed over 160,000 teen-agers and published the results in *The Private Life of the American Teenager* (Rawson, Wade). Here's a list of some of their findings:

- More than eight out of ten teens with a working mother feel happy and proud of her.
- Eighty percent of the girls want a career.
- Ninety percent of the teens surveyed believe in marriage.
- Seventy-four percent say they would live with someone before marrying him or her.
- Seven out of ten high school students have tried marijuana.
- Sixty percent study only to pass tests, not to learn. Fifty-five percent admit that they cheat.
- Eighty-three percent say they can usually tell one or both parents how they feel about an issue.
- Almost sixty percent fear their parents' death—even more than they fear their own.
- Seventy-five percent of the teens believe that divorce is justified if parents argue often, if physical violence is involved, or if one or both parents are unfaithful.

Erdice Court

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Chapter Objectives

The purpose of this introductory chapter is to present (1) an initial image of the field of statistics, (2) several of the basic vocabulary words used in studying statistics, and (3) the basic ideas and concerns about the processes used to obtain sample data.

Section 1–1 What is Statistics?

Statistics is the universal language of the sciences. Statistics is more than just a "kit of tools." As potential users of statistics we need to master the "art" of using these tools correctly. Careful use of statistical methods enables us to (1) accurately describe the findings of scientific research, (2) make decisions, and (3) make estimations.

Statistics involves numbers, subjects, and the use of these numbers and subjects. The word "statistics" has different meanings to people of varied backgrounds and interests. To some people it is a field of "hocus-pocus," whereby a person in the know overwhelms the layperson. To other people it is a way of collecting and displaying large amounts of numerical information. And to still another group it is a way of "making decisions in the face of uncertainty." In the proper perspective each of these points of view is correct.

descriptive and inferential statistics

The field of statistics can be roughly subdivided into two areas: descriptive statistics and inferential statistics. **Descriptive statistics** is what most people think of when they hear the word "statistics." It includes the collection, presentation, and description of numerical data. The term **inferential statistics** refers to the technique of interpreting the values resulting from the descriptive techniques and then using them to make decisions.

Statistics is more than just numbers—it is what is done to or with numbers. Let's use the following definition:

statistics

Statistics

The science of collecting, classifying, presenting, and interpreting numerical data.

Before we begin our detailed study, let's look at a few examples of how and when statistics can be and is applied.

Illustration 1–1

State University is planning an expansion program of its physical facilities. To draw up an effective course of action, the board of trustees decides that it needs the answer to this question: How many college students will we need to accommodate over the next ten years? This question can immediately be broken down into a number of smaller questions: How many college students will there be? How many will want to attend State U? And so on. To answer these questions the researcher will need to obtain data that will

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