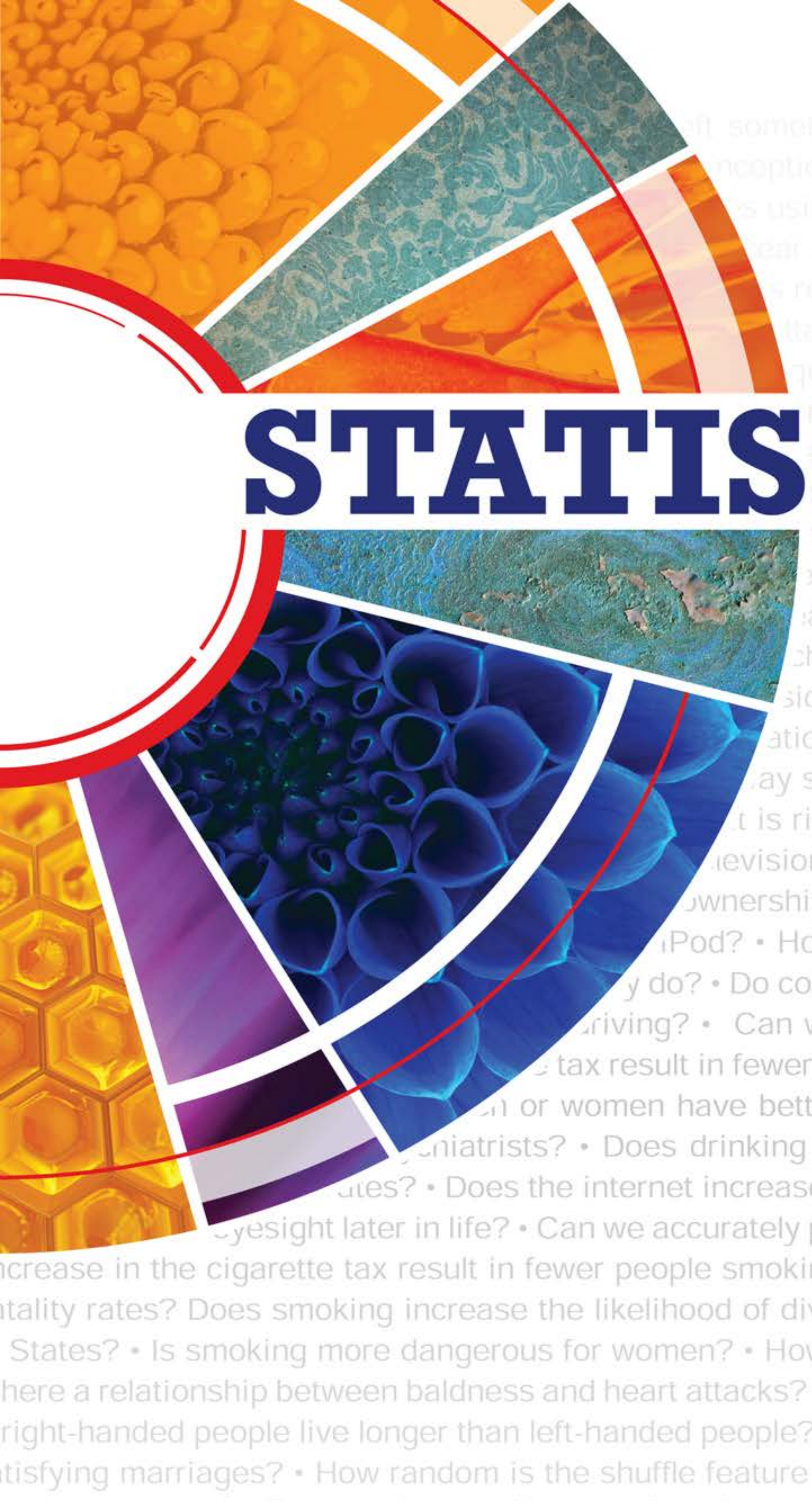

5TH EDITION

MIND ON STATISTICS

UTTS
HECKARD

Case Studies and Examples

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Chapter 2

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Mind on Statistics

Mind on Statistics

Fifth Edition

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CENGAGE Learning

Mind on Statistics, **Fifth Edition**
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To Bill Harkness—energetic, generous, and innovative educator, guide, and friend—who launched our careers in statistics and continues to share his vision.

and

To our students, from whom we continue to learn, and who teach us how to be better teachers.

Brief Contents

Contents

Instructors: the Supplemental Topics are available on the book companion website, or print copies may be custom published.

Preface

A Challenge

Before you continue, think about how you would answer the question in the first bullet, and read the statement in the second bullet. We will return to them a little later in this preface.

- What do you *really know* is true, and how do you know it?
- The diameter of the moon is about 2160 miles.

What Is Statistics, and Who Should Care?

Because people are curious about many things, chances are that your interests include topics to which statistics has made a useful contribution. As written in Chapter 17, "information developed through the use of statistics has enhanced our understanding of how life works, helped us learn about each other, allowed control over some societal issues, and helped individuals make informed decisions. There is almost no area of knowledge that has not been advanced by statistical studies."

Statistical methods have contributed to our understanding of health, psychology, ecology, politics, music, lifestyle choices, business, commerce, and dozens of other topics. A quick look through this book, especially Chapters 1 and 17, should convince you of this. Watch for the influences of statistics in your daily life as you learn this material.

How Is This Book Different? Two Basic Premises of Learning

We wrote this book because we were tired of being told that what statisticians do is boring and difficult. We think statistics is useful and not difficult to learn, and yet the majority of college graduates we've met seemed to have had a negative experience taking a statistics class in college. We hope this book will help to overcome these misguided stereotypes.

Let's return to the two bullets at the beginning of this preface. Without looking, do you remember the diameter of the moon? Unless you already had a pretty good idea or have an excellent memory for numbers, you probably don't remember. One premise of this book is that **new material is much easier to learn and remember if it is related to something interesting or previously known**. The diameter of the moon is about the same as the air distance between Atlanta and Los Angeles, San Francisco and Chicago, London and Cairo, or Moscow and Madrid. Picture the moon sitting between any of those pairs of cities, and you are not likely to forget the size of the moon again. Throughout this book, new material is presented in the context of interesting and useful examples. The first and last chapters (1 and 17) are exclusively devoted to examples and case studies, which illustrate the wisdom that can be generated through statistical studies.

Now answer the question asked in the first bullet: What do you *really know* is true, and how do you know it? If you are like most people, you know because it's something you have experienced or verified for yourself. It is not likely to be something you were told or heard in a lecture. The second premise of this book is that **new material is easier to learn if you actively ask questions and answer them for yourself**. *Mind on Statistics* is designed to help you learn statistical ideas by actively thinking about them. Throughout most of the chapters there are queries titled *Thought Questions.* Thinking about these questions will help you to discover and verify important ideas for yourself. Most chapters have a section called "Applets for Further Exploration" that will guide you through hands-on activities and present you with a "Challenge Question." Working through the applets in those sections will help you actively engage with the material. We encourage you to think and question, rather than simply read and listen.

New to This Edition

- New Case Studies and Examples were written for the new edition. Data in examples, case studies, and exercises also have been updated to the latest information available.
- Many new figures that help illustrate concepts have been added.
- Most chapters have a new section called "Applets for Further Exploration" that accompany applets on the course website. Students are guided through a process of hands-on exploration, and then presented with a "Challenge Question" to solidify their understanding of the concepts.
- Chapter 7 (Probability) has been reorganized to focus on the use of simple tools for understanding probability and solving probability problems.
- The number of In Summary boxes has been increased, and the boxes are placed more consistently throughout the chapters.
- The language has been tightened and simplified whenever possible.

Text Features

Chapters 9 to 13, which contain the core material on sampling distributions and statistical inference, are organized in a modular, flexible format. There are six modules for each of the topics: sampling distributions, confidence intervals, and hypothesis testing. The first module presents an introduction and the remaining five modules each deal with a specific parameter, such as one mean, one proportion, or the difference in two means. Chapter 9 covers sampling distributions, Chapters 10 and 11 cover confidence intervals, and Chapters 12 and 13 cover hypothesis testing.

This structure emphasizes the similarity among the inference procedures for the five parameters discussed. It allows instructors to illustrate that each procedure covered is a specific instance of the same process. We recognize that instructors have different preferences for the order in which to cover inference topics. For instance, some prefer to first cover all topics about proportions and then cover all topics about means. Others prefer to first cover everything about confidence intervals and then cover everything about hypothesis testing. **With the modular format, instructors can cover these topics in the order they prefer**.

To aid in the navigation through these modular chapters, the book contains **color-coded, labeled tabs that correspond to the introductory and parameter modules**. The table below, also found in Chapter 9, lays out the color-coding system as well as the flexibility of these new chapters. In addition, the table is a useful course planning tool.

Organization of Chapters 9 to 13

Parameter	Chapter 9: Sampling Distributions (SD)	Chapter 10: Confidence Intervals (CI)	Chapter 11: Confidence Intervals (CI)	Chapter 12: Hypothesis Tests (HT)	Chapter 13: Hypothesis Tests (HT)
0. Introductory	**SD Module 0** Overview of sampling distributions	**CI Module 0** Overview of confidence intervals		**HT Module 0** Overview of hypothesis testing	
1. Population Proportion (p)	**SD Module 1** SD for one sample proportion	**CI Module 1** CI for one population proportion		**HT Module 1** HT for one population proportion	
2. Difference in two population proportions ($p_1 - p_2$)	**SD Module 2** SD for difference in two sample proportions	**CI Module 2** CI for difference in two population proportions		**HT Module 2** HT for difference in two population proportions	
3. Population mean (μ)	**SD Module 3** SD for one sample mean		**CI Module 3** CI for one population mean		**HT Module 3** HT for one population mean
4. Population mean of paired differences (μ_d)	**SD Module 4** SD for sample mean of paired differences		**CI Module 4** CI for population mean of paired differences		**HT Module 4** HT for population mean of paired differences
5. Difference in two population means ($\mu_1 - \mu_2$)	**SD Module 5** SD for difference in two sample means		**CI Module 5** CI for difference in two population means		**HT Module 5** HT for difference in two population means

To add to the flexibility of topic coverage, Supplemental Topics 1 to 5 on discrete random variables, nonparametric tests, multiple regression, two-way ANOVA, and ethics are now available for use in both print and electronic formats. Instructors, please contact your sales representative to find out how these chapters can be custom published for your course.

Student Resources: Tools for Learning

There are a number of tools provided in this book and beyond to enhance your learning of statistics.

Tools for Conceptual Understanding

Thought Questions appear throughout each chapter to encourage active thinking and questioning about statistical ideas. *Hints* are provided at the bottom of the page to help you develop this skill.

THOUGHT QUESTION 2.4 Redo the bar graph in Figure 2.4 using counts instead of percentages. The necessary data are given in Table 2.3. Would the comparison of frequency of myopia across the categories of lighting be as easy to make using the bar graph with counts? Generalize your conclusion to provide guidance about what should be done in similar situations.*

***HINT:** Which graph makes it easier to compare the percentage with myopia for the three groups? What could be learned from the graph of counts that isn't apparent from the graph of percentages?

NEW! Applets for Further Exploration sections provide opportunities for in-class or independent hands-on exploration of key statistical concepts. The applets that accompany this feature can be found on the book's companion website.

APPLETS FOR FURTHER EXPLORATION

For each of the applets, follow the instructions for what to do and what to notice, then try to answer the Challenge question. Additional instructions and questions are given at the applet website, http://www.cengage.com/statistics/Utts5e.

Applet 5.1: Simple Random Sampling in Action

What to Do: Press the "Sample" button and watch as a random sample of 10 stick figures is chosen from the picture. The results will include the mean height and the percent female in the sample. Take multiple samples without pressing the "Start Over" button. Press the "Show Results" button.

What to Notice: The blue stick figures represent women and the red stick figures represent men. The heights of the stick figures vary, and when you choose a sample you are shown the percent female and the mean height for the 10 individuals selected. For the population, the mean height is 68 inches and the percent female is 55%. Notice that the percent female in the sample can only be multiples of 10% and so can never equal the population value of 55%. Notice that the mean heights for the samples vary considerably, but they should be close to 68 inches fairly often.

Challenge Question: Explain whether you would you expect the relationship between the mean height and the percent of females in the samples to be a positive association or a negative association. Is that what you observed when you took multiple samples and examined the results?

Supplemental Notes boxes provide additional technical discussion of key concepts.

SUPPLEMENTAL NOTE

A Philosophical Issue about Probability

There is some debate about how to represent probability when an outcome has been determined but is unknown, such as if you have flipped a coin but not looked at it. Technically, any particular outcome has either happened or not. If it has happened, its probability of happening is 1; if it hasn't, its probability of happening is 0. In statistics, an example of this type of situation is the construction of a 95% confidence interval, which was introduced in Chapter 5 and which we will study in detail in Chapters 10 and 11. Before the sample is chosen, a probability statement makes sense. The probability is .95 that a sample will be selected for which the computed 95% confidence interval covers the truth. After the sample has been chosen, "the die is cast." Either the computed confidence interval covers the truth or it doesn't, although we may never know which is the case. That's why we say that we have *95% confidence* that a computed interval is correct, rather than saying that *the probability* that it is correct is .95.

Investigating Real-Life Questions

UPDATED! Relevant **Examples** form the basis for discussion in each chapter and walk you through real-life uses of statistical concepts.

EXAMPLE 3.5 **Describing Height and Handspan with a Regression Line** In Figure 3.1 (p. 70), we saw that the relationship between handspan and height has a straight-line pattern. Figure 3.6 displays the same scatterplot as Figure 3.1, but now a regression line is shown that describes the average relationship between the two variables. We used statistical software (Minitab) to find the "best" line for this set of measurements. We will discuss the criterion for "best" later. For now, let's focus on what the line tells us about the data.

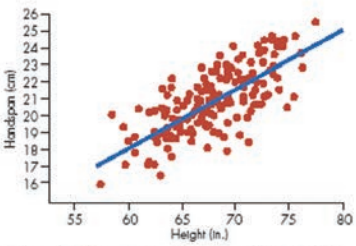

Figure 3.6 Regression line describing height and handspan

UPDATED! Case Studies apply statistical ideas to intriguing news stories. As the Case Studies are developed, they model the statistical reasoning process.

CASE STUDY 5.2 No Opinion of Your Own? Let Politics Decide

This is an excellent example of how people will respond to survey questions when they do not know about the issues, and how the wording of questions can influence responses. In 1995, the *Washington Post* decided to expand on a 1978 poll taken in Cincinnati, Ohio, in which people were asked whether they "favored or opposed repealing the 1975 Public Affairs Act" (Morin, 1995, p. 36). There was no such act, but about one-third of the respondents expressed an opinion about it.

In February 1995, the *Washington Post* added this fictitious question to its weekly poll of 1000 randomly selected respondents: "Some people say the 1975 Public Affairs Act should be repealed. Do you agree or disagree that it should be repealed?" Almost half (43%) of the sample expressed an opinion, with 24% agreeing that it should be repealed and 19% disagreeing!

The *Post* then tried another trick that produced even more disturbing results. This time, they polled two separate groups of 500 randomly selected adults. The first group was asked: "President Clinton [a Democrat] said that the 1975 Public Affairs Act should be repealed. Do you agree or disagree?" The second group was asked: "The Republicans in Congress said that the 1975 Public Affairs Act should be repealed. Do you agree or disagree?" Respondents were also asked about their party affiliation.

Overall, 53% of the respondents expressed an opinion about repealing this fictional act! The results by party affiliation were striking: For the Clinton version, 36% of the Democrats but only 16% of the Republicans agreed that the act should be repealed. For the "Republicans in Congress" version, 36% of the Republicans but only 19% of the Democrats agreed that the act should be repealed. In April 2013, the Huffington Post repeated this poll, replacing "Clinton" with "Obama." The results were similar. (Sources: http://www.huffingtonpost.com/2013/04/11/survey-questions-fiction_n_2994363.html and http://big.assets.huffingtonpost.com/toplines_full.pdf)

Original **Journal Articles** for many of the Examples and Case Studies can be found on the companion website on CourseMate, http://www.cengage.com/statistics/Utts5e. By reading the original, you are given the opportunity to learn much more about how the research was conducted, what statistical methods were used, and what conclusions the original researchers drew.

EXAMPLE 2.2 **Lighting the Way to Nearsightedness** A survey of 479 children found that those who had slept with a nightlight or in a fully lit room before the age of 2 had a higher incidence of nearsightedness (myopia) later in childhood (*Sacramento Bee*, May 13, 1999, pp. A1, A18). The raw data for each child consisted of two categorical variables, each with three categories. Table 2.3 gives the categories and the number of children falling into each combination of them. The table also gives percentages (relative frequencies) falling into each eyesight category, where percentages are computed within each nighttime lighting category. For example, among the 172 children who slept in darkness, about 90% (155/172 = .90) had no myopia.

Read the original source on the companion website, http://www.cengage.com/statistics/Utts5e.

Getting Practice

Basic Exercises, comprising 25% of all exercises found in the text, focus on practice and review. These exercises, found under the header *Skillbuilder Exercises* and appearing at the beginning of each exercise section, complement the conceptual and data-analysis exercises. Basic exercises give you ample practice for these key concepts.

Exercises

Bold exercises have answers in the back of the text.

Note: Many of these exercises will be repeated in later chapters in which the relevant material is covered in more detail.

Skillbuilder Exercises

1.1 Refer to the data and five-number summaries given in Case Study 1.1. Give a numerical value for each of the following.
- **a.** The fastest speed driven by anyone in the class.
- **b.** The slowest of the "fastest speeds" driven by a male.
- **c.** The speed for which one-fourth of the women had driven at that speed or faster.
- **d.** The proportion of females who had driven 89 mph or faster.
- **e.** The number of females who had driven 89 mph or faster.

1.2 A five-number summary for the heights in inches of the women who participated in the survey in Case Study 1.1 is as shown:

	Female Heights (Inches)	
Median	65	
Quartiles	63.5	67.5
Extremes	59	71

a. What is the median height for these women?

b. What is the range of heights—that is, the difference in heights between the shortest woman and the tallest woman?

c. What is the interval of heights containing the shortest one-fourth of the women?

d. What is the interval of heights containing the middle one-half of the women?

1.3 In recent years, Vietnamese American women have had the highest rate of cervical cancer in the country. Suppose that among 200,000 Vietnamese American women, 86 developed cervical cancer in the past year.
- **a.** Calculate the rate of cervical cancer for these women.
- **b.** What is the estimated risk of developing cervical cancer for Vietnamese American women in the next year?
- **c.** Explain the conceptual difference between the rate and the risk, in the context of this example.

1.4 The risk of getting lung cancer at some point in one's life for men who have never smoked is about 13 in 1000. The risk for men who smoke is just over 13 times the risk for nonsmokers. (Source: Villenueve and Lau, 1994)

a. What is the base rate for lung cancer in men over a lifetime?

b. What is the approximate lifetime risk of getting lung cancer for men who smoke?

Relevant conceptual and data analysis **Exercises** have been added and updated throughout the text. All exercises are found at the end of each chapter, with corresponding exercise sets written for each section and chapter. You will find well more than 1500 exercises, allowing for ample opportunity to practice key concepts.

Section 3.2

Skillbuilder Exercises

3.13 Suppose that a regression equation for the relationship between y = weight (pounds) and x = height (inches) for men aged 18 to 29 years old is

$$\text{Average weight} = -250 + 6\,(\text{Height})$$

a. Estimate the average weight for men in this age group who are 70 inches tall.
b. What is the slope of the regression line for average weight and height? Write a sentence that interprets this slope in terms of how much average weight changes when height is increased by 1 inch.

General Section Exercises

3.18 The average August temperatures (y) and geographic latitudes (x) of 20 cities in the United States were given in the table for Exercise 3.9. (The data are part of the **temperature** dataset on the companion website.) The regression equation for these data is

$$\hat{y} = 113.6 - 1.01x$$

a. What is the slope of the line? Interpret the slope in terms of how the mean August temperature is affected by a change in latitude.
b. Estimate the mean August temperature for a city with latitude of 32.

Dataset available but not required   Bold exercises answered in the back

Answers to Selected Odd-Numbered Exercises, indicated by bold numbers in the Exercise sections, have final answers or partial solutions found in the back of the text for checking your answers and guiding your thinking on similar exercises. Most odd-numbered exercises have answers in back of the book.

Answers to Selected Odd-Numbered Exercises

The following are partial or complete answers to the exercises numbered in ***bold*** *in the text.*

Chapter 1

1.1 a. 150 mph. b. 55 mph. c. 95 mph. d. 1/2. e. 51.
1.3 a. .00043. b. .00043. c. Rate is based on past data; risk uses past data to predict an individual's likelihood of developing cervical cancer.
1.5 a. All teens in the U.S. at the time the poll was taken. b. All teens in the U.S. who had dated at the time the poll was taken.
1.7 a. All adults in the U.S. at the time the poll was taken. b. $\frac{1}{\sqrt{1048}} = .031$ or 3.1%. c. 30.9% to 37.1%.
1.9 a. 400.
1.11 a. Self-selected or volunteer sample. b. No; readers with strong opinions will respond.
2.7 Sex and self-reported fastest ever driven speed. b. Students in a statistics class. c. Answer depends on whether interest is in this class only or in a larger group represented by this class.
2.9 Population summary if we restrict interest to fiscal year 1998. Sample summary if 1998 value is used to represent errors in other years.
2.11 a. Categorical. b. Quantitative. c. Quantitative. d. Categorical.
2.13 a. Categorical. b. Ordinal. c. Quantitative
2.15 a. Explanatory is score on the final exam; response is final course grade. b. Explanatory is gender; response is opinion about the death penalty.
2.17 a. Not continuous. b. Continuous. c. Continuous.
2.19 a. Support ban or not; categorical. b. Gain on verbal and math SATs after program; quantitative.

Technology for Developing Concepts and Analyzing Data

MindTap

New for the fifth edition, available via Aplia, is MindTap™ Reader, Cengage Learning's next-generation eBook. MindTap Reader provides robust opportunities for students to annotate, take notes, navigate, and interact with the text (e.g., ReadSpeaker). Annotations captured in MindTap Reader are automatically tied to the Notepad app, where they can be viewed chronologically and in a cogent, linear fashion. Instructors also can edit the text and assets in the Reader, as well as add videos or URLs.

Go to http://www.cengage.com/mindtap for more information.

aplia

Aplia™ (ISBN: 9781285773100) is an online interactive learning solution that improves comprehension and outcomes by increasing student effort and engagement. Founded by a professor to enhance his own courses, Aplia provides automatically graded assignments with detailed, immediate explanations on every question and innovative teaching materials. Aplia's easy-to-use system has been used by more than 1,000,000 students at over 1800 institutions.

Companion Website

CENGAGEbrain.com

To access additional course materials and companion resources, please visit http://www.cengage.com/statistics/Utts5e or www.cengagebrain.com. At the CengageBrain.com home page, search for the ISBN of your title (from the back cover of your book) using the search box at the top of the page. This will take you to the product page where the following free companion resources can be found:

- Interactive teaching and learning tools including:
  - Conceptual applets to accompany almost all chapters, with instructions and exercises
  - Flashcards
  - Videos of examples from throughout the text
  - and more
- Activities manual with engaging activities to accompany every chapter (except Chapter 17)
- Step-by-Step technology manuals for TI-84 Plus calculators, Microsoft® Excel®, Minitab®, SPSS®, and JMP
- Downloadable datasets (in ASCII as well as the native file formats for each software and calculator model covered by the Step-by-Step manuals)
- Original journal articles for select Examples and Case Studies, where you can learn much more about how the research was conducted, what statistical methods were used, and what conclusions the original researchers drew

Step-by-Step technology manuals, written specifically for *Mind on Statistics*, Fifth Edition, walk you through the statistical software and graphing calculator—step by step. You will find manuals for:

- TI-84 Calculators
- Microsoft Excel
- Minitab
- SPSS®
- JMP®

Note: These technology manuals are available in electronic formats. Instructors, contact your sales representative to find out how these manuals can be custom published for your course.

JMP is a statistics software for Windows and Macintosh computers from SAS, the market leader in analytics software and services for industry. JMP Student Edition is a streamlined, easy-to-use version that provides all the statistical analysis and graphics covered in this textbook. Once data is imported, students will find that most procedures require just two or three mouse clicks. JMP can import data from a variety of formats, including Excel and other statistical packages, and you can easily copy and paste graphs and output into documents.

JMP also provides an interface to explore data visually and interactively, which will help your students develop a healthy relationship with their data, work more efficiently with data, and tackle difficult statistical problems more easily. Because its output provides both statistics and graphs together, the student will better see and understand the application of concepts covered in this book as well. JMP Student Edition also contains some unique platforms for student projects, such as mapping and scripting. JMP functions in the same way on both Windows and Mac platforms and instructions contained with this book apply to both platforms.

Access to this software is available with new copies of the book. Students can purchase JMP standalone via CengageBrain.com or www.jmp.com/getse.

Minitab, Excel, TI-84, and SPSS Tips in the text offer key details on the use of technology.

MINITAB TIP **Computing a Chi-Square Test for a Two-Way Table**

- If the raw data are stored in columns of the worksheet, use **Stat > Tables > Cross Tabulation and Chi-Square**. Specify a categorical variable in the "For rows" box and a second categorical variable in the "For columns" box. Then click the ***Chi-Square*** button and select "Chi-Square analysis."
- If the data are already summarized into counts, enter the table of counts (excluding totals) into columns of the worksheet, and then use **Stat > Tables > Chi-Square Test (Table in Worksheet)**. In the dialog box, specify the columns that contain the counts.

EXCEL TIP The *p*-value can also be computed by using Microsoft Excel. The function CHIDIST(x,df) provides the *p*-value, where x is the value of the chi-square statistic and df is a number called "degrees of freedom," which will be explained later in this book. The formula for df is (# of rows − 1)(# of columns − 1). For instance, corresponding to the information in Example 4.13, df = (2 − 1)(2 − 1) = 1, and the *p*-value is CHIDIST(7.659,1) = .005649, or about .006 as given by Minitab.

Tools for Review

Key Terms at the end of each chapter, organized by section, can be used as a "quick-finder" and as a review tool.

Key Terms

UPDATED! In Summary boxes serve as a useful study tool, appearing at appropriate points to enhance key concepts and calculations. More In Summary boxes have been added for this edition.

IN SUMMARY **Bell-Shaped Distributions and Standard Deviation**

- The standard deviation measures the variability among data values.
- The formula for **sample standard deviation** is $s = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$
- For bell-shaped data, about 68% of the data values fall within 1 standard deviation of the mean either way, about 95% fall within 2 standard deviations of the mean either way, and about 99.7% fall within 3 standard deviations of the mean either way.
- A **standardized score**, also called a ***z*-score**, measures how far a value is from the mean in terms of standard deviations.

In Summary Boxes

Tools for Active Learning

To access additional course materials and companion resources, please visit www.cengagebrain.com. At the CengageBrain.com home page, search for the ISBN of your title (from the back cover of your book) using the search box at the top of the page. This will take you to the product page where free companion resources can be found.

The **Student Solutions Manual** (ISBN 9781285770208), prepared by Jessica M. Utts and Robert F. Heckard, provides worked-out solutions to most of the odd-numbered problems in the text.

The online **Activities Manual**, written by Jessica M. Utts and Robert F. Heckard, includes a variety of activities for students to explore individually or in teams. These activities guide students through key features of the text, help them understand statistical concepts, provide hands-on data collection and interpretation team-work, include exercises with tips incorporated for solution strategies, and provide bonus dataset activities. Information can be found on the companion website on CourseMate.

Instructor Resources: Tools for Assessment

Companion Website: The companion website at http://www.cengage.com/Utts5e contains a variety of resources.

- Microsoft® PowerPoint® lecture slides for all chapters
- Figures from the book
- Data sets in a variety of formats
- Technology guides for a variety of programs
- Course outlines and syllabi
- Suggestions for class projects for Chapters 2 to 16
- Suggested discussions for the Thought Questions located throughout the text
- Supplemental Topics: Chapters S.1 to S.5 and Supplemental Topic solutions
- List of applications and methods
- Index of exercises by subject matter
- **JoinIn**™ on **TurningPoint**® is also available on the PowerLecture and offers instructors text-specific content for electronic response systems. You can transform your classroom and assess students' progress with instant in-class quizzes and polls. TurningPoint software lets you pose book-specific questions and display students' answers seamlessly within Microsoft PowerPoint lecture slides, in conjunction with a choice of "clicker" hardware. Enhance how your students interact with you, your lecture, and each other.

Solution Builder: This online instructor database offers complete worked solutions to all exercises in the text, allowing you to create customized, secure solutions printouts (in PDF format) matched exactly to the problems you assign in class. Access available via www.cengage.com/solutionbuilder or the PowerLecture CD (see PowerLecture description).

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A Note to Instructors

The entire *Mind on Statistics* learning package has been informed by the recommendations put forth by the ASA/MAA Joint Curriculum Committee and the GAISE (Guidelines for Assessment and Instruction in Statistics Education) College Report, for which Jessica Utts was one of the authors. Each of the pedagogical features and ancillaries listed in the section entitled "Student Resources: Tools for Expanded Learning" and "Instructor Resources: Tools for Assessment" has been categorized by suggested use to provide you with options for designing a course that best fits the needs of your students.

Acknowledgments

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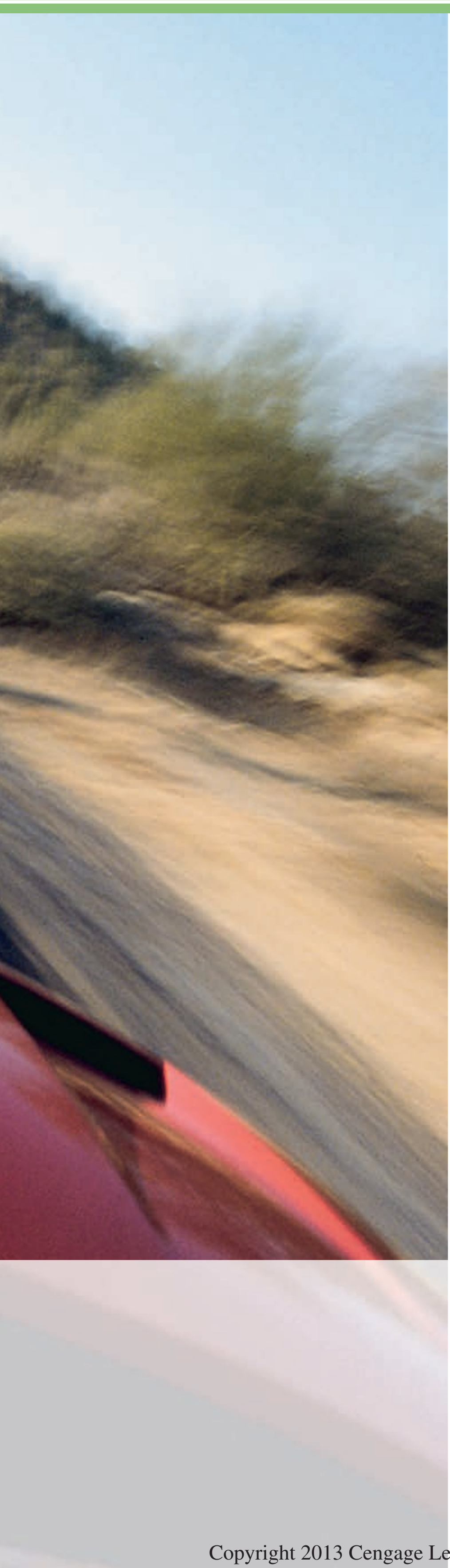
Jessica M. Utts
Robert F. Heckard

1

Is a male or a female more likely to be behind the wheel of this speeding car?

See Case Study 1.1 *(p. 2)*

Statistics Success Stories and Cautionary Tales



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"The eight stories in this chapter are meant to bring life to the term *statistics*. After reading these stories, if you think the subject of statistics is lifeless or gruesome, check your pulse!"

Let's face it. You're a busy person. Why should you spend your time learning about statistics? In this chapter, we give eight examples of situations in which statistics provide either enlightenment or misinformation. After reading these examples, we hope you will agree that learning about statistics may be interesting and useful.

Each of the stories in this chapter illustrates one or more concepts that will be developed in this book. These concepts are given as "the moral of the story" after a case is presented. Definitions of some terms used in the story also are provided following each case. By the time you have read all of these stories, you already will have an overview of what statistics is all about.

1.1 What Is Statistics?

When you hear the word *statistics* you probably think of lifeless or gruesome numbers, such as the population of your state or the number of violent crimes committed in your city last year. The word *statistics,* however, actually is used to mean two different things. The better-known definition is that statistics are numbers measured for some purpose. A more complete definition, and the one that forms the substance of this book, is the following:

DEFINITION **Statistics** is a collection of procedures and principles for gathering data and analyzing information to help people make decisions when faced with uncertainty.

The eight stories in this chapter are meant to bring life to this definition. After reading them, if you think the subject of statistics is lifeless or gruesome, check your pulse!

1.2 Eight Statistical Stories with Morals

The best way to gain an understanding of some of the ideas and methods used in statistical studies is to see them in action. As you read each of the eight stories presented in this section, think about how the situation was used to extract information from data. The methods and ideas used differ for each of these stories, and together they will give you an excellent overview of why it is useful to study statistics. To help you understand some basic statistical principles, each case study is accompanied by a "moral of the story" and by some definitions. All of the ideas and definitions will be discussed in greater detail in subsequent chapters.

CASE STUDY 1.1 Who Are Those Speedy Drivers?

A survey taken in a large statistics class at Penn State University contained the question "What's the fastest you have ever driven a car? ____ mph." The *data* provided by the 87 males and 102 females who responded are listed here.

Males: 110 109 90 140 105 150 120 110 110 90 115 95 145 140 110 105 85 95 100 115 124 95 100 125 140 85 120 115 105 125 102 85 120 110 120 115 94 125 80 85 140 120 92 130 125 110 90 110 110 95 95 110 105 80 100 110 130 105 105 120 90 100 105 100 120 100 100 80 100 120 105 60 125 120 100 115 95 110 101 80 112 120 110 115 125 55 90

Females: 80 75 83 80 100 100 90 75 95 85 90 85 90 90 120 85 100 120 75 85 80 70 85 110 85 75 105 95 75 70 90 70 82 85 100 90 75 90 110 80 80 110 110 95 75 130 95 110 110 80 90 105 90 110 75 100 90 110 85 90 80 80 85 50 80 100 80 80 80 95 100 90 100 95 80 80 50 88 90 90 85 70 90 30 85 85 87 85 90 85 75 90 102 80 100 95 110 80 95 90 80 90

From these numbers, can you tell which sex tends to have driven faster and by how much? Notice how difficult it is to make sense of the *data* when you are simply presented with a list. Even if the numbers had been presented in numerical order, it would be difficult to compare the two groups.

Your first lesson in using statistics is how to formulate a simple summary of a long list of numbers. The **dotplot** shown in Figure 1.1 helps us see the pattern in the data. In the plot, each dot represents the response of an individual student. We can see that the men tend to claim a higher "fastest ever driven" speed than do the women.

The graph shows us a lot, and calculating some **summary statistics** will provide additional insight. There are a variety of ways to do so, but for this example, we examine a **five-number summary** of the data for males and females. The five numbers are the lowest value; the cut-off points for one-fourth, one-half, and three-fourths of the ordered data; and the highest value. The three middle values of the summary (the cutoff points for one-fourth, one-half, and three-fourths of the ordered data) are called the *lower quartile, median, and upper quartile,* respectively. Five-number summaries can be represented as shown in the table underneath Figure 1.1.

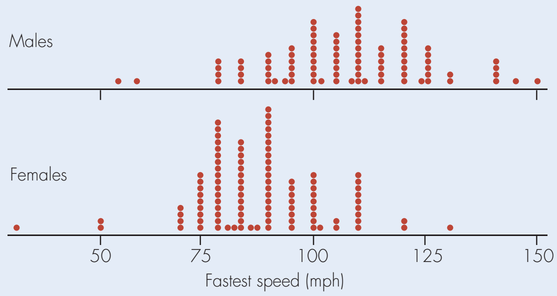

FIGURE 1.1 Responses to "What's the fastest you've ever driven?"

	Males (87 Students)			Females (102 Students)		
Median		110			89	
Quartiles	95		120	80		95
Extremes	55		150	30		130

Some interesting facts become immediately obvious from these summaries. By looking at the medians, you see that half of the men have driven 110 miles per hour or more, whereas the halfway point for the women is only 89 miles per hour. In fact, three-fourths of the men have driven 95 miles per hour or more, but only one-fourth of the women have done so. These facts were not at all obvious from the original lists of numbers.

Moral of the Story: *Simple summaries of data can tell an interesting story and are easier to digest than long lists.*

Definitions: Data is a plural word referring to numbers or nonnumerical labels (such as male/female) collected from a set of entities (people, cities, and so on). The **median** of a numerical list of data is the value in the middle when the numbers are put in order. For an even number of entities, the median is the average of the middle two values. The **lower quartile** and **upper quartile** are (roughly) the medians of the lower and upper halves of the ordered data.

CASE STUDY 1.2 Safety in the Skies?

If you fly often, you may have been relieved to see the *New York Times* headline on October 1, 2007, proclaiming "Fatal airline crashes drop 65%" (Wald, 2007). And you may have been dismayed if you had seen an earlier headline in *USA Today* that read, "Planes get closer in midair as traffic control errors rise" (Levin, 1999). The details were even more disturbing: "Errors by air traffic controllers climbed from 746 in fiscal 1997 to 878 in fiscal 1998, an 18% increase."

So, are the risks of a fatal airline crash or an air traffic control error something that should be a major concern for airline passengers? Don't cancel your next vacation yet. A look at the statistics indicates that the news is actually pretty good! The low risk becomes obvious when we are told the *base rate* or *baseline risk* for these problems. According to the *New York Times* article, "the drop in the accident rate [from 1997 to 2007] will be about 65%, to one fatal accident in about 4.5 million departures, from 1 in nearly 2 million in 1997." And according to the 1999 *USA Today* story, "The errors per million flights handled by controllers climbed from 4.8 to 5.5." So the *rate* of fatal accidents changed from about 1 in 2 million departures in 1997 to 1 in 4.5 million departures in 2007, and the ominous rise in air traffic controller errors in 1998 still led to a very low rate of only 5.5 errors per million flights.

Fortunately, the rates of these occurrences were provided in both stories. This is not always the case in news reports of changes in rates or risk. For instance, an article may say that the risk of a certain type of cancer is doubled if you eat a certain unhealthful food. But what good is that information unless you know the actual risk? Doubling your chance of getting cancer from 1 in a million to 2 in a million is trivial, but doubling your chance from 1 in 50 to 2 in 50 is not.

Moral of the Story: *When you read about the change in the rate or risk of occurrence of something, make sure you also find out the base rate or baseline risk.*

Definitions: The **rate** at which something occurs is simply the number of times it occurs per number of opportunities for it to occur. In fiscal year 1998, the rate of air traffic controller errors was 5.5 per million flights. The **risk** of a bad outcome in the future can be estimated using the past rate for that outcome, if it is assumed the future will be like the past. Based on recent data, the estimated risk of a fatal accident for any given flight is 1 in 4.5 million, which is 1/4,500,000 or about .00000022. The **base rate** or **baseline risk** is the rate or risk at a beginning time period or under specific conditions. For instance, the base rate of fatal airline crashes from which the 65% decrease for 2007 was calculated was about 1 crash per 2 million flights for fiscal year 1997.

CASE STUDY 1.3 Did Anyone Ask Whom You've Been Dating?

In the late 1990s interracial dating was a sensitive topic. So it was newsworthy to learn that "According to a new *USA Today*/Gallup Poll of teenagers across the country, 57% of teens who go out on dates say they've been out with someone of another race or ethnic group" (Peterson, 1997). That was over half of the dating teenagers, so it was natural for the headline in the *Sacramento Bee* to read, "Interracial dates common among today's teenagers." The article contained other information as well, such as "In most cases, parents aren't a major obstacle. Sixty-four percent of teens say their parents don't mind that they date interracially, or wouldn't mind if they did."

There were millions of teenagers in the United States whose experiences appeared to be being reflected in this story. How could the polltakers manage to ask so many teenagers these questions? The answer is that they didn't. The article states that "the results of the new poll of 602 teens, conducted Oct. 13–20, reflect the ubiquity of interracial dating today." They asked only 602 teens? Could such a small sample possibly tell us anything about the millions of teenagers in the United States? The answer is "yes" if those teens constituted a *random sample* from the *population* of interest.

The featured statistic of the article is that "57 percent of teens who go out on dates say they've been out with someone of another race or ethnic group." Only 496 of the 602 teens in the poll said that they date, so the 57% value is actually a percentage

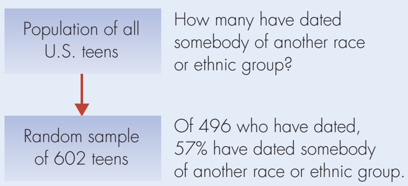

FIGURE 1.2 Population and sample for the survey.

based on 496 responses. In other words, the pollsters were using information from only 496 teenagers to estimate something about all teenagers who date. Figure 1.2 illustrates this situation.

How accurate could this *sample survey* possibly be? The answer may surprise you. The results of this *poll* are accurate to within a *margin of error* of about 4.5%. As surprising as it may seem, the true percentage of all dating teens in the United States at that time who had dated interracially is reasonably likely to be within 4.5% of the reported percentage that's based only on the 496 teens asked! We'll be conservative and round the 4.5% margin of error up to 5%. At the time the poll was taken, the percentage of all dating teenagers in the United States that would say they had dated someone of another race or ethnic group was likely to be in the range 57% $\pm$ 5%, or between 52% and 62%.

(continued)

(The symbol ± is read "plus and minus" and means that the value on the right should be added to and subtracted from the value on the left to create an interval.)

Polls and *sample surveys* are frequently used to assess public opinion and to estimate population characteristics such as the percent of teens who have dated interracially or the proportion of voters who plan to vote for a certain candidate. Many sophisticated methods have been developed that allow pollsters to gain the information they need from a very small number of individuals. The trick is to know how to select those individuals. In Chapter 5, we examine a number of other strategies that are used to ensure that sample surveys provide reliable information about populations.

Moral of the Story: *A representative sample of only a few thousand, or perhaps even a few hundred, can give reasonably accurate information about a population of many millions.*

Definitions: A **population** is a collection of all individuals about which information is desired. The "individuals" are usually people, but could also be schools, cities, pet dogs, agricultural fields, and so on. A **random sample** is a subset of the population selected so that every individual has a specified probability of being part of the sample. (Often, but not always, it is specified that every individual has the *same* chance of being selected for the sample.) In a **poll** or **sample survey,** the investigators gather opinions or other information from each individual included in the sample. The **margin of error** for a properly conducted survey is a number that is added to and subtracted from the sample information to produce an interval that is 95% certain to contain the true value for the population. In the most common types of sample surveys, the margin of error is approximately equal to 1 divided by the square root of the number of individuals in the sample.

Hence, a sample of 496 teenagers who have dated produces a margin of error of about $1/\sqrt{496} = .045$, or about 4.5%. In some polls the margin of error is called the **margin of sampling error** to distinguish it from other sources of errors and biases that can distort the results. The next Case Study illustrates a common source of bias that can occur in surveys, discussed more fully in Chapter 5.

CASE STUDY 1.4 Who Are Those Angry Women?

A well-conducted survey can be very informative, but a poorly conducted one can be a complete disaster. As an extreme example, Moore (1997, p. 11) reports that Shere Hite sent questionnaires to 100,000 women asking about love, sex, and relationships for her book *Women and Love* (1987). Only 4.5% of the women responded, and Hite used those responses to write her book. As Moore notes, "The women who responded were fed up with men and eager to fight them. For example, 91% of those who were divorced said that they had initiated the divorce. The anger of women toward men became the theme of the book." Do you think that women who were angry with men would be likely to answer questions about love relationships in the same way as the general population of women?

The Hite sample exemplifies one of the most common problems with surveys: The sample data may not represent the population. Extensive *nonparticipation (nonresponse)* from a random sample, or the use of a *self-selected* (i.e., a *volunteer*) *sample,* will probably produce biased results. Those who voluntarily respond to surveys tend to care about the issue and therefore have stronger and different opinions than those who do not respond.

Moral of the Story: *An unrepresentative sample, even a large one, tells you almost nothing about the population.*

Definitions: Nonparticipation bias (also called **nonresponse bias**) can occur when many people who are selected for the sample either do not respond at all or do not respond to some of the key survey questions. This may occur even when an appropriate random sample is selected and contacted. The survey is then based on a nonrepresentative sample, usually those who feel strongly about the issues. Some surveys don't even attempt to contact a random sample but instead ask anyone who wishes to respond to do so. Magazines, television stations, and Internet websites routinely conduct this kind of poll, and those who respond are called a **self-selected sample** or a **volunteer sample.** In most cases, this kind of sample tells you nothing about the larger population at all; it tells you only about those who responded.

CASE STUDY 1.5 Does Prayer Lower Blood Pressure?

News headlines are notorious for making one of the most common mistakes in the interpretation of statistical studies: jumping to unwarranted conclusions. A headline in *USA Today* read, "Prayer can lower blood pressure" (Davis, 1998). The story that followed continued the possible fallacy it began by stating, "Attending religious services lowers blood pressure more than tuning into religious TV or radio, a new study says." The words "attending religious services lowers blood pressure" imply a direct cause-and-effect relationship. This is a strong statement, but it is not justified by the research project described in the article.

The article was based on an *observational study* conducted by the U.S. National Institutes of Health, which followed 2391 people aged 65 or older for 6 years (Figure 1.3). The article described one of the study's principal findings: "People who attended a religious service once a week and prayed or studied the Bible once a day were 40% less likely to have high blood pressure than those who don't go to church every week and prayed and studied the Bible less" (Davis, 1998). So the researchers did observe a relationship, but it's a mistake to think that this justifies the conclusion that prayer actually *causes* lower blood pressure.

When groups are compared in an observational study, the groups usually differ in many important ways that may contribute to the observed relationship. In this example, people who attended church and prayed regularly may have been less likely than the others to smoke or to drink alcohol. These could affect the results because smoking and alcohol use are both believed to affect blood pressure. The regular church attendees may have had a better social network, a factor that could lead to reduced stress, which in turn could reduce blood pressure. People who were generally somewhat ill may not have been as willing or able to go out to church. We're sure you can think of other possibilities for *confounding variables* that may have contributed to the observed relationship between prayer and lower blood pressure.

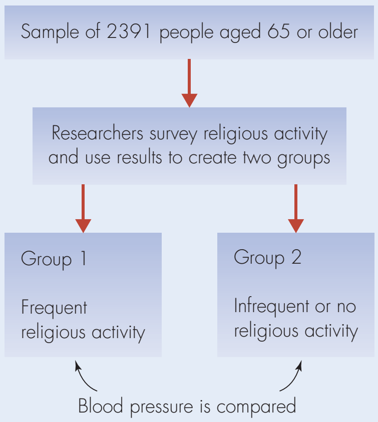

FIGURE 1.3 An observational study in case study 1.5. Researchers survey religious activity and compare blood pressure of frequent and not-frequent activity group.

Moral of the Story: *Cause-and-effect conclusions cannot generally be made on the basis of an observational study.*

Definitions: An **observational study** is one in which participants are merely observed and measured. Comparisons based on observational studies are comparisons of naturally occurring groups. A **variable** is a characteristic that differs from one individual to the next. It may be numerical, such as blood pressure, or it may be categorical, such as whether or not someone attends church regularly. A **confounding variable** is a variable that is not the main concern of the study but may be partially responsible for the observed results.

(*Source:* International Journal of Psychiatry in Medicine *by Koenig, H.G., L.K. George, J.C. Hays, and D.B. Larson. [See p. 701 for complete credit.])*

CASE STUDY 1.6 Does Aspirin Reduce Heart Attack Rates?

Read the original source on the companion website, http://www.cengage.com/statistics/Utts5e.

In 1988, the Steering Committee of the Physicians' Health Study Research Group released the results of a 5-year *randomized experiment* conducted using 22,071 male physicians between the ages of 40 and 84. The purpose of the experiment was to determine whether or not taking aspirin reduces the risk of a heart attack. The physicians had been *randomly assigned* to one of the two *treatment* groups. One group took an ordinary aspirin tablet every other day, while the other group took a *placebo*. None of the physicians knew whether he was taking the actual aspirin or the placebo. Figure 1.4 illustrates the design of this experiment.

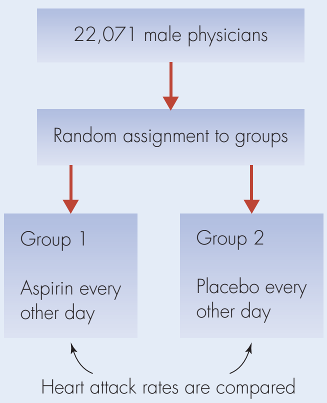

FIGURE 1.4 Randomized experiment for case study 1.6. Physicians were assigned to regularly take either aspirin or a placebo.

Table 1.1 The Effect of Aspirin on Heart Attacks

Treatment	Heart Attacks	Doctors in Group	Attacks per 1000 Doctors
Aspirin	104	11,037	9.42
Placebo	189	11,034	17.13

The results, shown in Table 1.1, support the conclusion that taking aspirin does indeed help to reduce the risk of having a heart attack. The rate of heart attacks in the group taking aspirin was only about half the rate of heart attacks in the placebo group. In the aspirin group, there were 9.42 heart attacks per 1000 participating doctors, while in the placebo group, there were 17.13 heart attacks per 1000 participants.

Because the men in this experiment were randomly assigned to the two conditions, other important risk factors such as age, amount of exercise, and dietary habits should have been similar for the two groups. The only important difference between the two groups should have been whether they took aspirin or a placebo. This makes it possible to conclude that taking aspirin actually *caused* the lower rate of heart attacks for that group. In a later chapter, you will learn how to determine that the difference seen in this sample is *statistically significant*. In other words, the observed sample difference probably reflects a true difference within the population.

(continued)

To what population does the conclusion of this study apply? The participants were all male physicians, so the conclusion that aspirin reduces the risk of a heart attack may not hold for the general population of men. No women were included, so the conclusion may not apply to women at all. More recent evidence, however, has provided additional support for the benefit of aspirin in broader populations.

Moral of the Story: *Unlike with observational studies, cause-and-effect conclusions can generally be made on the basis of randomized experiments.*

Definitions: A **randomized experiment** is a study in which treatments are randomly assigned to participants. A **treatment** is a specific regimen or procedure assigned to participants by the experimenter. A **random assignment** is one in which each participant has a specified probability of being assigned to each treatment. A **placebo** is a pill or treatment designed to look just like the active treatment but with no active ingredients. A **statistically significant** relationship or difference is one that is large enough to be unlikely to have occurred in the sample if there was no relationship or difference in the population.

(*Source:* New England Journal of Medicine, 1989 Jul 20; 321(3), 129–135. Final report on the aspirin component of the ongoing Physicians' Health Study. Steering Committee of the Physicians' Health Study Research Group. Copyright © 1989 Massachusetts Medical Society. All rights reserved.)

CASE STUDY 1.7 Does the Internet Increase Loneliness and Depression?

It was big news. Researchers at Carnegie Mellon University had found that "greater use of the Internet was associated with declines in participants' communication with family members in the household, declines in size of their social circle, and increases in their depression and loneliness" (Kraut et al., 1998, p. 1017). An article in the *New York Times* reporting on this study was titled "Sad, lonely world discovered in cyberspace" (Harmon, 1998). The study included 169 individuals in 73 households in Pittsburgh, Pennsylvania, who were given free computers and Internet service in 1995, when the Internet was still relatively new. The participants answered a series of questions at the beginning of the study and either 1 or 2 years later, measuring social contacts, stress, loneliness, and depression. The *New York Times* reported:

> In the first concentrated study of the social and psychological effects of Internet use at home, researchers at Carnegie Mellon University have found that people who spend even a few hours a week online have higher levels of depression and loneliness than they would if they used the computer network less frequently. . . . it raises troubling questions about the nature of "virtual" communication and the disembodied relationships that are often formed in cyberspace.
>
> *(Source: "Sad, Lonely World Discovered in Cyberspace," by A. Harmon,* New York Times, *August 30, 1998, p. A3. Reprinted with permission of the New York Times Company.)*

Given these dire reports, one would think that using the Internet for a few hours a week is devastating to one's mental health. But a closer look at the findings reveals that the changes were actually quite small, though statistically significant. Internet use averaged 2.43 hours per week for participants. The number of people in the participants' "local social network" decreased from an average of 23.94 people to an average of 22.90 people, hardly a noticeable loss. On a scale from 1 to 5, self-reported loneliness decreased from an average of 1.99 to 1.89 (lower scores indicate greater loneliness). And on a scale from 0 to 3, self-reported depression dropped from an average of .73 to an average of .62 (lower scores indicate higher depression).

The *New York Times* did report the magnitude of some of the changes, noting for instance that "one hour a week on the Internet was associated, on average, with an increase of .03, or 1% on the depression scale." But the attention the research received masked the fact that the impact of Internet use on depression, loneliness, and social contact was actually quite small, and thus may not have been of much practical significance.

As a follow-up to this study, in July 2001, *USA Today* (Elias, 2001) reported that in continued research, the bad effects had mostly disappeared. The article, titled "Web use not always a downer: Study disputes link to depression," began with the statement "Using the Internet at home doesn't make people more depressed and lonely after all." However, the article noted that the lead researcher, Robert Kraut of Carnegie Mellon University, believes that the earlier findings were correct but that "the Net has become a more social place since the study began in 1995." His explanation for the change in findings is that "either the Internet has changed, or people have learned to use it more constructively, or both." Research on this topic continues to develop. A study released in February 2010 (Morrison and Gore, 2010) identified 18 "Internet addicted" individuals out of 1319 study participants. They found that the Internet addicts scored in the "moderately-to-severely depressed range" on a test called the Beck Depression Inventory, while an equivalent group of non-addicts scored "firmly in the non-depressed range." As the authors point out, it is not clear whether Internet use causes depression, depression causes more Internet use, or some other factors lead to abnormal scores in both for some people.

Moral of the Story: *A statistically significant finding does not necessarily have* **practical significance** *or* **practical importance.** *When a study reports a statistically significant finding, find out the magnitude of the relationship or difference. A secondary moral to this story is that the implied direction of cause and effect may be wrong. In this case, it could be that people who were more lonely and depressed were more prone to using the Internet. And remember that, as the follow-up research makes clear, "truth" doesn't necessarily remain fixed across time. Any study should be viewed in the context of society at the time it was done.*

CASE STUDY 1.8 Did Your Mother's Breakfast Determine Your Sex?

Read the original source on the companion website, http://www.cengage.com/statistics/Utts5e.

You've probably heard that "you are what you eat," but did it ever occur to you that you might be who you are because of what your mother ate? A study published in 2008 by the British Royal Society seemed to find just that. The researchers reported that mothers who ate breakfast cereal prior to conception were more likely to have boys than mothers who did not (Mathews et al., 2008). But 9 months later, just enough time for the potential increased cereal sales to have produced a plethora of little baby boys, another study was published that dashed cold milk on the original claim (Young et al., 2009).

The dispute centered on something statisticians call *multiple testing,* which can lead to erroneous findings of statistical significance. The authors of the original study had asked 740 women about 133 different foods they might have eaten just before getting pregnant. They found that 59% of the women who consumed breakfast cereal daily gave birth to a boy, compared to only 43% of the women who rarely or never ate cereal (http://www.cbsnews.com/stories/2008/04/22/health/webmd/main4036102.shtml). The result was highly statistically significant, but almost none of the other foods tested showed a statistically significant difference in the ratio of male to female births.

As previously discussed, statistical significance is how statisticians assess whether a difference found in a sample, in this case of 740 women, is large enough to conclude that the difference is likely to represent more than just chance. But sometimes what looks like a statistically significant difference is actually a *false positive*—a difference that looks like it wasn't due to chance when it really was. The more differences that are tested, the more likely it is that one of them will be a false positive. The criticism by Young et al. was based on this idea. When 133 food items that in fact do not affect the sex of a baby are all tested, it is likely that at least one of them will show up as a false positive, showing a big enough difference in the proportion of male to female births to be statistically significant when in fact the difference is due to chance.

The authors of the original study defended their work (Mathews et al., 2009). They noted that they only tested the individual food items after an initial test based on total preconception calorie consumption showed a difference in male and female births. They found that 56% of the mothers in the top third of calorie consumption had boys, compared with only 45% of the mothers in the bottom third of calorie consumption. That was one of only two initial tests they did; the other had to do with vitamin intake. With only two tests, it is unlikely that either of them would be a false positive. Unfortunately the media found the cereal connection to be the most interesting result in the study, and that's what received overwhelming publicity. The best way to resolve the debate, as in most areas of science, is to ask the same questions in a new study and see if the results are consistent. The authors of the original study have stated their intention to do that.

Moral of the Story: *When you read about a study that found a relationship or difference, try to find out how many different things were tested. The more tests that are performed, the more likely it is that a statistically significant difference is a false positive that can be explained by chance. You should be especially wary if dozens of things are tested and only one or two of them are statistically significant.*

Definitions: Multiple testing or **multiple comparisons** in statistics refers to the fact that researchers often test many different hypotheses in the same study. This practice may result in statistically significant findings by mistake, called **false positive** results. Sometimes this practice is called **data snooping** because researchers snoop around in their data until they find something interesting to report.

1.3 The Common Elements in the Eight Stories

The eight stories were meant to bring life to our definition of statistics. Let's consider that definition again:

> **Statistics** is a collection of procedures and principles for gathering data and analyzing information to help people make decisions when faced with uncertainty.

Think back over the stories. In each of them, *data are used to make a judgment about a situation.* This common theme is what statistics is all about. The stories should also help you realize that you can be misled by the use of data, and learning to recognize how that happens is one of the themes of this book.

The Discovery of Knowledge

Each story illustrates part of the process of discovery of new knowledge, for which statistical methods can be very useful. The basic steps in this process are as follows:

1. *Asking the right question(s)*
2. *Collecting useful data,* which includes deciding how much is needed
3. *Summarizing and analyzing data,* with the goal of answering the questions
4. *Making decisions and generalizations* based on the observed data
5. *Turning the data and subsequent decisions into new knowledge*

We'll explore these five steps throughout the book, concluding with a chapter on "Turning Information into Wisdom." We're confident that your active participation in this exploration will benefit you in your everyday life and in your future professional career.

In a practical sense, almost all decisions in life are based on knowledge obtained by gathering and assimilating data. Sometimes the data are quantitative, as when an instructor must decide what grades to give based on a collection of homework and exam scores. Sometimes the information is more qualitative and the process of assimilating it is informal, such as when you decide what you are going to wear to a party. In either case, the principles in this book will help you to understand how to be a better decision maker.

THOUGHT QUESTION 1.1 Think about a decision that you recently had to make. What "data" did you use to help you make the decision? Did you have as much information as you would have liked? How would you use the principles in this chapter to help you gain more useful information?*

IN SUMMARY

Some Important Statistical Principles

The "moral of the story" items for the case studies presented in this chapter give a good overview of many of the important ideas covered in this book. Here is a summary:

- Simple summaries of data can tell an interesting story and are easier to digest than long lists.
- When you read about the change in the rate or risk of occurrence of something, make sure you also find out the base rate or baseline risk.
- A representative sample of only a few thousand, or perhaps even a few hundred, can give reasonably accurate information about a population of many millions.
- An unrepresentative sample, even a large one, tells you almost nothing about the population.
- Cause-and-effect conclusions cannot generally be made on the basis of an observational study.
- Unlike with observational studies, cause-and-effect conclusions can generally be made on the basis of randomized experiments.
- A statistically significant finding does not necessarily have practical significance or importance. When a study reports a statistically significant finding, find out the magnitude of the relationship or difference.
- When you read about a study that found a relationship or difference, try to find out how many different things were tested. The more tests that are done, the more likely it is that a statistically significant difference is a false positive that can be explained by chance.

***HINT:** As an example, how did you decide to live where you are living? What additional data, if any, would have been helpful?

Key Terms

Every term in this chapter is discussed more extensively in later chapters, so don't worry if you don't understand all of the terminology that has been introduced here. The following list indicates the page number(s) where the important terms in this chapter are introduced and defined.

Section 1.1
statistics, 1

Case Study 1.1
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statistically significant, 5, 6, 7
practical significance, 6
practical importance, 6

Case Study 1.8
multiple testing, 7
multiple comparisons, 7
false positive, 7
data snooping, 7

Exercises

Bold exercises have answers in the back of the text.

Note: Many of these exercises will be repeated in later chapters in which the relevant material is covered in more detail.

Skillbuilder Exercises

1.1 Refer to the data and five-number summaries given in Case Study 1.1. Give a numerical value for each of the following.

a. The fastest speed driven by anyone in the class.
b. The slowest of the "fastest speeds" driven by a male.
c. The speed for which one-fourth of the women had driven at that speed or faster.
d. The proportion of females who had driven 89 mph or faster.
e. The number of females who had driven 89 mph or faster.

1.2 A five-number summary for the heights in inches of the women who participated in the survey in Case Study 1.1 is as shown:

	Female Heights (inches)		
Median		65	
Quartiles	63.5		67.5
Extremes	59		71

a. What is the median height for these women?
b. What is the range of heights—that is, the difference in heights between the shortest woman and the tallest woman?
c. What is the interval of heights containing the shortest one-fourth of the women?
d. What is the interval of heights containing the middle one-half of the women?

1.3 In recent years, Vietnamese American women have had the highest rate of cervical cancer in the country. Suppose that among 200,000 Vietnamese American women, 86 developed cervical cancer in the past year.

a. Calculate the rate of cervical cancer for these women.
b. What is the estimated risk of developing cervical cancer for Vietnamese American women in the next year?
c. Explain the conceptual difference between the rate and the risk, in the context of this example.

1.4 The risk of getting lung cancer at some point in one's life for men who have never smoked is about 13 in 1000. The risk for men who smoke is just over 13 times the risk for nonsmokers. (Source: Villenueve and Lau, 1994)

a. What is the base rate for lung cancer in men over a lifetime?
b. What is the approximate lifetime risk of getting lung cancer for men who smoke?