

GREGORY J. PRIVITERA

# STATISTICS

for the **BEHAVIORAL**  
**SCIENCES**

FOURTH EDITION



# **Statistics for the Behavioral Sciences**

Fourth Edition

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Fourth Edition

Gregory J. Privitera

*St. Bonaventure University*



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# PREFACE TO THE INSTRUCTOR

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## PHILOSOPHICAL APPROACH

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In earlier editions, I opened the preface by highlighting that, “statistics is not something static or antiquated that we used to do in times past; statistics is an ever-evolving discipline with relevance to our daily lives” (Privitera, 2012, 2015, 2018, p. xxvii in all editions). In this spirit, and true to the foundational philosophical approach of this text, the fourth edition includes substantive changes that reflect an adaptive culture of analysis and interpretation in the social and behavioral sciences.

Initially, on the basis of years of experience and student feedback, I was inspired to write a book that instructors could truly teach from—one that relates statistics to science using current, practical research examples and one that is approachable (and dare I say interesting!) to students. I wrote this book in that spirit—to introduce students to statistics as a way of understanding the world around them and encouraging students to be critical consumers of the information they come across each day. This book, more than ever in the fourth edition, emphasizes the ongoing spirit of discovery that emerges using today’s resources and technologies to record, manage, analyze, and interpret data that is reported everywhere from online and print articles to the peer-reviewed scientific literature. The value and rationale for changes in the fourth edition that embody the philosophical approach of this book are discussed under the New to This Edition heading in this preface.

What follows here are key features and pedagogy that promote student learning, make sense of difficult material, connect content across chapters, and build upon the philosophical approach in this book to promote student learning, instill an ongoing spirit of discovery in the sciences, integrate recent advances in our understanding of statistics and analysis, and encourage students to be critical consumers of the information they come across each day.

## THEMES, FEATURES, AND PEDAGOGY

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### Emphasis on Student Learning

- **Conversational writing style.** I write in a conversational tone that speaks to the reader as if they are the researcher. It empowers students to view statistics as something they are capable of understanding and using. It is a positive psychology approach to writing that involves students in the process of statistical analysis and making decisions using statistics. The goal is to motivate and excite students about the topic by making the book easy to read and follow without “dumbing down” the information they need to be successful.
- **Learning objectives.** Clear learning objectives are provided at the start of each chapter to get students focused on and thinking about the material they will be learning. At the close of each chapter, the chapter summaries reiterate these learning objectives and then summarize the key chapter content related to each objective.
- **Learning Checks** are inserted throughout each chapter (for students to review what they learn as they learn it) and aligned with learning objectives and section numbering



to strengthen organization of content. Many figures and tables are provided to illustrate statistical concepts and summarize statistical procedures.

- **Making Sense** sections support critical and difficult material. In many years of teaching statistics, I have found certain areas of statistics where students struggle the most. To address this, I include Making Sense sections in each chapter to break down difficult concepts, review important material, and basically “make sense” of the most difficult material taught in this book. These sections are aimed at easing student stress and making statistics more approachable. Again, this book was written with student learning in mind.
- **Review problems.** At least 32 review problems are included at the end of each chapter in the book—with many more problems included electronically. In each chapter, questions are organized by learning objective and are aligned to ensure even-numbered questions have an answer in the answer key in Appendix E, and odd-numbered questions can be assigned for homework. This format tests student knowledge and application of chapter material while also giving students practice with each learning objective.
- **Additional features.** Additional features in each chapter are aimed at helping students pull out key concepts and recall important material. For example, key terms are bolded and defined as they are introduced to make it easier for students to find these terms when reviewing the material and to grab their attention as they read the chapters. At the end of the book, each key term is summarized in a glossary.

### Focus on Current Research

- **Data in Research.** To introduce the context for using statistics, Chapters 1 through 8 include Data in Research sections that review pertinent research that makes sense of or illustrates important statistical concepts discussed in the chapter. Giving students current research examples can help them “see” statistical methods as they are applied today in research for the behavioral sciences.
- **APA in Focus.** As statistical designs are introduced in Chapters 7 to 18, APA in Focus sections are included to explain how to summarize statistical results for each inferential statistic taught. Together, these sections support student learning by putting statistics into context with research and also explaining how to read and report statistical results in research journals that follow American Psychological Association (APA) style.
- **Current research examples.** Nearly all of the statistics introduced in this book utilize data adapted from published research. This allows students to read the types of questions that behavioral researchers ask while learning about the statistics researchers use to answer research questions. Students do not need a background in research methods to read through the research examples, which is important because most students have not taken a course in research methods prior to taking a statistics course.
- **Problems in Research.** The end-of-chapter review questions include a section of Problems in Research that come straight from the literature. These classroom-tested problems use the data or conclusions drawn from published research to test knowledge of statistics and are taken from a diverse set of research journals and behavioral disciplines. The problems require students to think critically about published research in a way that reinforces statistical concepts taught in each chapter.
- **Balanced coverage of important statistical concepts.** I highlight important concepts to promote thoughtful analysis. For example, although eta-squared is still the

most popular estimate for effect size, there is a great deal of research showing that it overestimates the size of an effect. That being said, a modification to eta-squared, called omega-squared, is considered a better estimate for effect size and is being used more and more in published articles. I teach both, giving students a full appreciation for where statistics currently stands and where it is likely going in the future. Other examples include balanced coverage of null hypothesis significance testing with confidence intervals in the  $t$  test chapters, detailed discussion of factors that influence power (a key requirement for obtaining grant money and conducting an effective program of research), and an emphasis on assumption testing to ensure students are exposed to “best practices” in statistical analysis and interpretation.

## Integration of SPSS

- **Guide to using IBM® SPSS® Statistics<sup>1</sup> with this book that includes assumption testing for inferential statistics.** For instructors who teach statistics and SPSS, teaching from a textbook and a separate SPSS manual can be difficult. The manual often includes different research examples or language that is inconsistent with what appears in the textbook and overall can be difficult for students to follow. This book changes all that by nesting SPSS coverage into the textbook and includes the assumption testing for inferential statistics in Chapters 9–17. It begins with the guide at the front of the book, “How to Use SPSS With This Book,” which provides students with an easy-to-follow, classroom-tested overview of how SPSS is set up, how to read the Data View and Variable View screens, and how to use the SPSS in Focus sections in the book.
- **SPSS in Focus.** Many statistics textbooks for the behavioral sciences omit SPSS, include it in an appendix separate from the main chapters in the book, include it at the end of chapters with no useful examples or context, or include it in ancillary materials that often are not included with course content. In this edition of *Statistics for the Behavioral Sciences*, SPSS is included in each chapter as statistical concepts are taught and includes the assumption testing for inferential statistics in Chapters 9–17. This instruction is given in the SPSS in Focus sections. These sections provide step-by-step, classroom-tested instruction using practical research examples for how the concepts taught in each chapter can be applied using SPSS. Screenshot figures are fully annotated to provide support for reading SPSS outputs. In Appendix C, a guide for using SPSS is given for each SPSS in Focus section in the book, with page number references provided to make it simple for students to find those SPSS sections in the book.

In addition, there is one more overarching feature that I refer to as *teachability*. Although this book is comprehensive and a great reference for any undergraduate student, it is often too difficult for instructors to cover every topic in this book. For this reason, the chapters are organized into sections, each of which can largely stand alone. This gives instructors the ability to more easily manage course content by assigning students particular sections in each chapter when they do not want to teach all topics covered in the entire chapter. So this book was not only written with the student in mind; it was also written with the instructor in mind. Here are some brief highlights of what you will find in each chapter:

<sup>1</sup> SPSS is a registered trademark of International Business Machines Corporation.

## CHAPTER OVERVIEWS

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### Chapter 1. Introduction to Statistics

Students are introduced to scientific thinking and basic research design relevant to the statistical methods discussed in this book. In addition, the types of data that researchers measure and observe are introduced in this chapter. The chapter is to the point and provides an introduction to statistics in the context of research.

### Chapter 2. Summarizing Data: Frequency Distributions in Tables and Graphs

This chapter provides a comprehensive introduction to frequency distributions and graphing using research examples that give students a practical context for when these tables and graphs are used. In addition, students are exposed to summaries for percentage data and percentile points. Throughout the chapter, an emphasis is placed on showing students how to decide between the many tables and graphs used to summarize various data sets.

### Chapter 3. Summarizing Data: Central Tendency

This chapter places particular emphasis on what measures of central tendency are, how they are computed, and when they are used. A special emphasis is placed on interpretation and use of the mean, the median, and the mode. Students learn to appropriately use these measures to describe data for many different types of distributions.

### Chapter 4. Summarizing Data: Variability

Variability is often a difficult concept to understand. So I begin with an illustration of what variability is actually measuring. I clarify immediately that variability can never be negative, and I give a simple explanation for why. These are difficult obstacles for students, so I begin with this to support student learning from the very beginning of the chapter. The remainder of the chapter introduces various measures of variability, including variance and standard deviation, for data in a sample and population.

### Chapter 5. Probability

This is a true probability chapter with many current research examples. This chapter does not ask about the probability of rolling dice; it looks at how probability problems—from simple probability, to Bayes's theorem, to expected values—are applied to answer questions about behavior. After reading this chapter, students will not feel like they have to gamble in order to apply probability.

### Chapter 6. Probability, Normal Distributions, and $z$ Scores

At an introductory level, the normal distribution is center stage. It is at least mentioned in almost every chapter of this book. It is the basis for statistical theory and the precursor to most other distributions students will learn about. For this reason, I dedicate an entire chapter to its introduction. This chapter uses a variety of research examples to help students work through locating probabilities above the mean, below the mean, and between two scores, and even to help them calculate  $z$  scores.

## Chapter 7. Probability and Sampling Distributions

This is a comprehensive chapter for sampling distributions of both the mean and variance. This chapter introduces the sampling distribution and standard error in a way that helps students realize how the sample mean and sample variance can inform us about the characteristics we want to learn about in some otherwise unknown population. In addition, the chapter is organized in a way that allows instructors to easily manage reading assignments for students that are consistent with what they want to discuss in class.

## Chapter 8. Hypothesis Testing: Significance, Effect Size, Estimation, and Power

In my experience, shifting from descriptive statistics to inferential statistics is particularly difficult for students. For this reason, this chapter provides a comprehensive introduction to hypothesis testing, significance, effect size, estimation, power, and more. In addition, students are introduced to power in a context that emphasizes how essential this concept is for research today, and they are introduced to how content in this chapter relates to the parametric testing in the subsequent chapters. Multiple sections are devoted to these topics; this chapter uses data from published research to introduce hypothesis testing.

## Chapter 9. Testing Means: One-Sample $t$ Test With Confidence Intervals

This chapter introduces students to  $t$  tests for one sample using current research examples. This allows students to apply these tests in context with the situations in which they are used. In addition, students are shown how data for one sample are described using confidence intervals. Two measures for proportion of variance are also introduced: one that is most often used (eta-squared) and one that is less biased and becoming more popular (omega-squared). This gives students a real sense of where statistics is and where it is likely going.

## Chapter 10. Testing Means: Two-Independent-Sample $t$ Test With Confidence Intervals

This chapter introduces students to  $t$  tests for two independent samples using current research examples. This allows students to apply these tests in context with the situations in which they are used. In addition, students are shown how data for the difference between two independent samples are described using confidence intervals. Two measures for proportion of variance are again introduced: eta-squared and omega-squared.

## Chapter 11. Testing Means: Related-Samples $t$ Test With Confidence Intervals

Many textbooks teach the related-samples  $t$  test and spend almost the entire chapter discussing the repeated-measures design. It unnecessarily leads students to believe that this test is limited to a repeated-measures design, and it is not: The matched-pairs design is also analyzed using this  $t$  test. For this reason, I teach the related-samples  $t$  test for both designs, explaining that the assumptions, advantages, and disadvantages vary depending on the design used. Students are clearly introduced to the context for using this test and the research situations that require its use.

## Chapter 12. Analysis of Variance: One-Way Between-Subjects Design

The one-way between-subjects analysis of variance (ANOVA) and its assumptions, hypotheses, and calculations are all reviewed. A particular emphasis is placed on reviewing post hoc designs and what should be done following a significant result. Two post hoc tests are reviewed in order

of how powerful they are at detecting effects, to give students a decision-focused introduction by showing them how to choose statistics and analyses that are associated with the greatest power to detect an effect.

### **Chapter 13. Analysis of Variance: One-Way Within-Subjects (Repeated-Measures) Design**

The one-way within-subjects ANOVA and its assumptions, hypotheses, and calculations are all reviewed. Students are also introduced to post hoc tests that are most appropriate when samples are related. This is important because many statistics textbooks fail to even recognize that other commonly published post hoc tests are not well adapted for related samples. In addition, a full discussion of consistency and power is included to help students realize how this design can increase the power of an analysis to detect an effect.

### **Chapter 14. Analysis of Variance: Two-Way Between-Subjects Factorial Design**

This chapter provides students with an introduction to the two-way between-subjects factorial design. Students are given illustrations showing exactly how to interpret main effects and interactions, as well as given guidance as to which effects are most informative and how to describe these effects. This is a decision-focused chapter, helping students understand the various effects in a two-way ANOVA design and how they can be analyzed and interpreted to answer a variety of research questions.

### **Chapter 15. Correlation**

This chapter is unique in that it is organized in a way that introduces the Pearson correlation coefficient, effect size, significance, assumptions, and additional considerations up front before introducing the Spearman, point-biserial, and phi correlation coefficients. This makes it easier for instructors who only want to discuss the Pearson correlation (or any other correlation coefficient) to assign students readings that are specific to the concepts they will discuss in lectures. This also minimizes confusion among students and gives instructors more control to manage course content and readings.

### **Chapter 16. Linear Regression and Multiple Regression**

This chapter introduces how a straight line can be used to predict behavioral outcomes. Many figures and tables are included to illustrate and conceptualize regression and how it describes behavior. Also, an analysis of regression is introduced for one (linear regression) and two (multiple regression) predictor variables. Parallels between regression and ANOVA are also drawn to help students relate this analysis to other tests taught in previous chapters.

### **Chapter 17. Nonparametric Tests: Chi-Square Tests**

One of the most difficult parts of teaching chi-square tests can be explaining their interpretation. Much of the interpretation of the results of a chi-square is intuitive or speculative. These issues and the purposes for using these tests are included. In addition, this chapter is linked with the previous chapter by showing students how measures of effect size for the chi-square test are linked with phi correlations. This gives students an appreciation for how these measures are related.

## Chapter 18. Nonparametric Tests: Tests for Ordinal Data

This final chapter is aimed at introducing alternative tests for ordinal data. A key emphasis is to relate each test to those already introduced in previous chapters. The tests taught in this chapter are alternatives for tests taught in Chapters 9–13. The tests are introduced in separate sections that make it easier for instructors to assign sections of readings for only those tests they want to teach. Again, this can minimize confusion among students and gives the instructors more control to manage course content and readings.

## APPENDIXES

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**Appendix A** is a narrative summary of the material covered in the text. This appendix is more than just “Cliff’s notes” for the book. Instead, it integrates the content taught in this book to “tell a story” or narrative about how content relates across chapters, the role of statistics in science, and to bring to light how statistics can be understood in a broader context. This review is more than just a valuable epilogue for students at the end of a course; it is also a valuable prelude to a research methods course, and more than this, a valuable refresher for students looking to sharpen their statistical acumen in graduate school and into their careers.

**Appendix B** gives students a basic math review specific to the skills they need for the course. The appendix is specifically written to be unthreatening. From the beginning, students are reassured that the level of math is basic and that they do not need a strong background in mathematics to be successful in statistics. Learning Checks are included throughout this appendix, and more than 100 end-of-chapter review problems are included to give students all the practice they need to feel comfortable.

**Appendix C** provides a general instructions guide for using SPSS, with assumption testing for inferential statistics included in Chapters 9–17. Throughout this book, these instructions are provided with an example for how to analyze and interpret data. However, it would be difficult for students to thumb through the book to find each test when needing to refer to these tests later. Therefore, this appendix provides a single place where students can go to get directions for any statistical test taught in this chapter. Each instruction also provides the location within the text where readers can find an example of how to compute each test using SPSS.

**Appendix D** gives the tables needed to find critical values for the test statistics taught in this book.

**Appendix E** provides answers for even-numbered problems for the end-of-chapter questions. This allows students to practice additional questions and be able to check their answers in the appendix.

## NEW TO THIS EDITION

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As stated to open this preface, in earlier editions I highlighted that, “statistics is not something static or antiquated that we used to do in times past; statistics is an ever-evolving discipline with relevance to our daily lives” (Privitera, 2012, 2015, 2018, p. xxvii in all editions). In this spirit, and true to the foundational philosophical approach of this text, the fourth edition includes substantive changes that reflect a greater awareness of analysis and interpretation in the social and behavioral sciences—specifically in terms of our *transparency* in how we record, manage, analyze, and interpret data.

Since this book’s first edition, there has been an awakening of sorts—a culture that is more aware than ever of the use and the misuse of statistics (Appelbaum et al., 2018; Badenes-Ribera et al., 2018; Bakker & Wicherts, 2011). To apply statistics, this awareness encompasses, in part, the need to be more transparent—in terms of what we know and what we do. More than ever, we