

TENTH EDITION



# Biostatistics

A Foundation for Analysis in the Health Sciences

Wayne W. Daniel



Chad L. Cross



TENTH EDITION

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in the Health Sciences



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A Foundation for Analysis  
in the Health Sciences

**WAYNE W. DANIEL, PH.D.**

Professor Emeritus  
*Georgia State University*

**CHAD L. CROSS, PH.D., PSTAT<sup>®</sup>**

Statistician  
Office of Informatics and Analytics  
*Veterans Health Administration*

Associate Graduate Faculty  
*University of Nevada, Las Vegas*

**WILEY**

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***Dr. Daniel***

*To my children, Jean, Carolyn,  
and John, and to the memory of  
their mother, my wife, Mary.*

***Dr. Cross***

*To my wife Pamela  
and to my children, Annabella Grace  
and Breanna Faith.*





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# PREFACE

This 10th edition of *Biostatistics: A Foundation for Analysis in the Health Sciences* was prepared with the objective of appealing to a wide audience. Previous editions of the book have been used by the authors and their colleagues in a variety of contexts. For undergraduates, this edition should provide an introduction to statistical concepts for students in the biosciences, health sciences, and for mathematics majors desiring exposure to applied statistical concepts. Like its predecessors, this edition is designed to meet the needs of beginning graduate students in various fields such as nursing, applied sciences, and public health who are seeking a strong foundation in quantitative methods. For professionals already working in the health field, this edition can serve as a useful desk reference.

The breadth of coverage provided in this text, along with the hundreds of practical exercises, allow instructors extensive flexibility in designing courses at many levels. To that end, we offer below some ideas on topical coverage that we have found to be useful in the classroom setting.

Like the previous editions of this book, this edition requires few mathematical prerequisites beyond a solid proficiency in college algebra. We have maintained an emphasis on practical and intuitive understanding of principles rather than on abstract concepts that underlie some methods, and that require greater mathematical sophistication. With that in mind, we have maintained a reliance on problem sets and examples taken directly from the health sciences literature instead of contrived examples. We believe that this makes the text more interesting for students, and more practical for practicing health professionals who reference the text while performing their work duties.

For most of the examples and statistical techniques covered in this edition, we discuss the use of computer software for calculations. Experience has informed our decision to include example printouts from a variety of statistical software in this edition (e.g., MINITAB, SAS, SPSS, and R). We feel that the inclusion of examples from these particular packages, which are generally the most commonly utilized by practitioners, provides a rich presentation of the material and allows the student the opportunity to appreciate the various technologies used by practicing statisticians.

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## CHANGES AND UPDATES TO THIS EDITION

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The majority of the chapters include corrections and clarifications that enhance the material that is presented and make it more readable and accessible to the audience. We did, however, make several specific changes and improvements that we believe are valuable contributions to this edition, and we thank the reviewers of the previous edition for their comments and suggestions in that regard.

Specific changes to this edition include additional text concerning measures of dispersion in Chapter 2, additional text and examples using program R in Chapter 6, a new introduction to linear models in Chapter 8 that ties together the regression and ANOVA concepts in Chapters 8–11, the addition of two-factor repeated measures ANOVA in Chapter 8, a discussion of the similarities of ANOVA and regression in Chapter 11, and extensive new text and examples on testing the fit of logistic regression models in Chapter 11.

Most important to this new edition is a new Chapter 14 on Survival Analysis. This new chapter was borne out of requests from reviewers of the text and from the experience of the authors in terms of the growing use of these methods in applied research. In this new chapter, we included some of the material found in Chapter 12 in previous editions, and added extensive material and examples. We provide introductory coverage of censoring, Kaplan–Meier estimates, methods for comparing survival curves, and the Cox Regression Proportional Hazards model. Owing to this new material, we elected to move the contents of the vital statistics chapter to a new Chapter 15 and make it available online ([www.wiley.com/college/daniel](http://www.wiley.com/college/daniel)).

## COURSE COVERAGE IDEAS

In the table below we provide some suggestions for topical coverage in a variety of contexts, with “X” indicating those chapters we believe are most relevant for a variety of courses for which this text is appropriate. The text has been designed to be flexible in order to accommodate various teaching styles and various course presentations. Although the text is designed with progressive presentation of concepts in mind, certain of the topics may be skipped or covered briefly so that focus can be placed on concepts important to instructors.

Course	Chapters														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Undergraduate course for health sciences students	X	X	X	X	X	X	X	X	X	O	O	X	O	O	O
Undergraduate course in applied statistics for mathematics majors	X	O	O	O	X	X	X	X	X	X	O	X	X	X	O
First biostatistics course for beginning graduate students	X	X	X	X	X	X	X	X	X	X	O	X	X	X	O
Biostatistics course for graduate health sciences students who have completed an introductory statistics course	X	O	O	O	O	X	X	X	X	X	X	X	X	X	X

X: Suggested coverage; O: Optional coverage.

## SUPPLEMENTS

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**Instructor's Solutions Manual.** Prepared by Dr. Chad Cross, this manual includes solutions to all problems found in the text. This manual is available only to instructors who have adopted the text.

**Student Solutions Manual.** Prepared by Dr. Chad Cross, this manual includes solutions to all odd-numbered exercises. This manual may be packaged with the text at a discounted price.

**Data Sets.** More than 250 data sets are available online to accompany the text. These data sets include those data presented in examples, exercises, review exercises, and the large data sets found in some chapters. These are available in SAS, SPSS, and Minitab formats as well as CSV format for importing into other programs. Data are available for downloading at

[www.wiley.com/college/daniel](http://www.wiley.com/college/daniel)

Those without Internet access may contact Wiley directly at 111 River Street, Hoboken, NJ 07030-5774; telephone: 1-877-762-2974.

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There are three additional important acknowledgments that must be made to important contributors of the text. Dr. John. P. Holcomb of Cleveland State University updated many of the examples and exercises found in the text. Dr. Edward Danial of Morgan State University provided an extensive accuracy review of the ninth edition of the text, and his valuable comments added greatly to the book. Dr. Jodi B. A. McKibben of the Uniformed Services University of the Health Sciences provided an extensive accuracy review of the current edition of the book.

We wish to acknowledge the cooperation of Minitab, Inc. for making available to the authors over many years and editions of the book the latest versions of their software.

Thanks are due to Professors Geoffrey Churchill and Brian Schott of Georgia State University who wrote computer programs for generating some of the Appendix tables, and to Professor Lillian Lin, who read and commented on the logistic regression material in earlier editions of the book. Additionally, Dr. James T. Wassell provided useful

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assistance with some of the survival analysis methods presented in earlier editions of the text.

We are grateful to the many researchers in the health sciences field who publish their results and hence make available data that provide valuable practice to the students of biostatistics.

**Wayne W. Daniel**  
**Chad L. Cross\***

\*The views presented in this book are those of the author and do not necessarily represent the views of the U.S. Department of Veterans Affairs.