

# FUNDAMENTALS OF BIOSTATISTICS

SEVENTH EDITION



BERNARD ROSNER

# Fundamentals of Biostatistics

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# Fundamentals of Biostatistics

SEVENTH EDITION

**Bernard Rosner**

*Harvard University*

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*This book is dedicated to my wife, Cynthia,  
and my children, Sarah, David, and Laura*



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# Contents

Preface / xiii

## CHAPTER 1

### General Overview / 1

## CHAPTER 2

### Descriptive Statistics / 5

- 2.1 Introduction / 5
- 2.2 Measures of Location / 6
- 2.3 Some Properties of the Arithmetic Mean / 13
- 2.4 Measures of Spread / 15
- 2.5 Some Properties of the Variance and Standard Deviation / 18
- 2.6 The Coefficient of Variation / 20
- 2.7 Grouped Data / 22
- 2.8 Graphic Methods / 24

- 2.9 Case Study 1: Effects of Lead Exposure on Neurological and Psychological Function in Children / 29
- 2.10 Case Study 2: Effects of Tobacco Use on Bone-Mineral Density in Middle-Aged Women / 30
- 2.11 Obtaining Descriptive Statistics on the Computer / 31
- 2.12 Summary / 31

## PROBLEMS / 33

\*The new sections and the expanded sections for this edition are indicated by an asterisk.

**CHAPTER 3****Probability / 38**

- |  |   |
|--|---|
| 3.1 Introduction / 38<br>3.2 Definition of Probability / 39<br>3.3 Some Useful Probabilistic Notation / 40<br>3.4 The Multiplication Law of Probability / 42<br>3.5 The Addition Law of Probability / 44<br>3.6 Conditional Probability / 46 | 3.7 Bayes' Rule and Screening Tests / 51<br>3.8 Bayesian Inference / 56<br>3.9 ROC Curves / 57<br>3.10 Prevalence and Incidence / 59<br>3.11 Summary / 60 |
|--|---|

PROBLEMS / 60

**CHAPTER 4****Discrete Probability Distributions / 71**

- |  |   |
|--|---|
| 4.1 Introduction / 71<br>4.2 Random Variables / 72<br>4.3 The Probability-Mass Function for a Discrete Random Variable / 73<br>4.4 The Expected Value of a Discrete Random Variable / 75<br>4.5 The Variance of a Discrete Random Variable / 76<br>4.6 The Cumulative-Distribution Function of a Discrete Random Variable / 78<br>4.7 Permutations and Combinations / 79<br>4.8 The Binomial Distribution / 83 | 4.9 Expected Value and Variance of the Binomial Distribution / 88<br>4.10 The Poisson Distribution / 90<br>4.11 Computation of Poisson Probabilities / 93<br>4.12 Expected Value and Variance of the Poisson Distribution / 95<br>4.13 Poisson Approximation to the Binomial Distribution / 96<br>4.14 Summary / 99 |
|--|---|

PROBLEMS / 99

**CHAPTER 5****Continuous Probability Distributions / 108**

- |  |  |
|--|--|
| 5.1 Introduction / 108<br>5.2 General Concepts / 108<br>5.3 The Normal Distribution / 111<br>5.4 Properties of the Standard Normal Distribution / 114<br>5.5 Conversion from an $N(\mu, \sigma^2)$ Distribution to an $N(0,1)$ Distribution / 120<br>5.6 Linear Combinations of Random Variables / 124 | 5.7 Normal Approximation to the Binomial Distribution / 129<br>5.8 Normal Approximation to the Poisson Distribution / 135<br>5.9 Summary / 137 |
|--|--|

PROBLEMS / 138

**CHAPTER 6****Estimation / 149**

- |   |  |
|---|--|
| 6.1 Introduction / 149  | 6.7 Estimation of the Variance of a Distribution / 176 |
| 6.2 The Relationship Between Population and Sample / 150  | 6.8 Estimation for the Binomial Distribution / 181     |
| 6.3 Random-Number Tables / 152  | 6.9 Estimation for the Poisson Distribution / 189      |
| 6.4 Randomized Clinical Trials / 156  | 6.10 One-Sided CIs / 193                               |
| 6.5 Estimation of the Mean of a Distribution / 160  | 6.11 Summary / 195                                     |
| 6.6 Case Study: Effects of Tobacco Use on Bone-Mineral Density (BMD) in Middle-Aged Women / 175 | <b>PROBLEMS / 196</b>                                  |

**CHAPTER 7****Hypothesis Testing: One-Sample Inference / 204**

- |   |  |
|---|--|
| 7.1 Introduction / 204  | 7.9 One-Sample $\chi^2$ Test for the Variance of a Normal Distribution / 241               |
| 7.2 General Concepts / 204  | 7.10 One-Sample Inference for the Binomial Distribution / 244                              |
| 7.3 One-Sample Test for the Mean of a Normal Distribution: One-Sided Alternatives / 207 | 7.11 One-Sample Inference for the Poisson Distribution / 251                               |
| 7.4 One-Sample Test for the Mean of a Normal Distribution: Two-Sided Alternatives / 215 | 7.12 Case Study: Effects of Tobacco Use on Bone-Mineral Density in Middle-Aged Women / 256 |
| 7.5 The Power of a Test / 221   | 7.13 Summary / 257   |
| 7.6 Sample-Size Determination / 228   | <b>PROBLEMS / 259</b>  |

**CHAPTER 8****Hypothesis Testing: Two-Sample Inference / 269**

- |   |  |
|---|--|
| 8.1 Introduction / 269  | 8.5 Interval Estimation for the Comparison of Means from Two Independent Samples (Equal Variance Case) / 280 |
| 8.2 The Paired $t$ Test / 271   | 8.6 Testing for the Equality of Two Variances / 281  |
| 8.3 Interval Estimation for the Comparison of Means from Two Paired Samples / 275 | 8.7 Two-Sample $t$ Test for Independent Samples with Unequal Variances / 287                                 |
| 8.4 Two-Sample $t$ Test for Independent Samples with Equal Variances / 276        |  |

**X** Contents

- 8.8 Case Study: Effects of Lead Exposure on Neurologic and Psychological Function in Children / 293
  - 8.9 The Treatment of Outliers / 295
  - 8.10 Estimation of Sample Size and Power for Comparing Two Means / 301
  - 8.11 Sample-Size Estimation for Longitudinal Studies / 304
  - 8.12 Summary / 307
- PROBLEMS / 309**

**CHAPTER 9****Nonparametric Methods / 327**

- 9.1 Introduction / 327
- 9.2 The Sign Test / 329
- 9.3 The Wilcoxon Signed-Rank Test / 333
- 9.4 The Wilcoxon Rank-Sum Test / 339
- 9.5 Case Study: Effects of Lead Exposure on Neurologic and Psychological Function in Children / 344
- 9.6 Summary / 344

**PROBLEMS / 346****CHAPTER 10****Hypothesis Testing: Categorical Data / 352**

- 10.1 Introduction / 352
- 10.2 Two-Sample Test for Binomial Proportions / 353
- 10.3 Fisher's Exact Test / 367
- 10.4 Two-Sample Test for Binomial Proportions for Matched-Pair Data (McNemar's Test) / 373
- 10.5 Estimation of Sample Size and Power for Comparing Two Binomial Proportions / 381
- 10.6  $R \times C$  Contingency Tables / 390
- 10.7 Chi-Square Goodness-of-Fit Test / 401
- 10.8 The Kappa Statistic / 404
- 10.9 Summary / 408

**PROBLEMS / 409****CHAPTER 11****Regression and Correlation Methods / 427**

- 11.1 Introduction / 427
- 11.2 General Concepts / 428
- 11.3 Fitting Regression Lines—The Method of Least Squares / 431
- 11.4 Inferences About Parameters from Regression Lines / 435
- 11.5 Interval Estimation for Linear Regression / 443
- 11.6 Assessing the Goodness of Fit of Regression Lines / 448
- 11.7 The Correlation Coefficient / 452
- 11.8 Statistical Inference for Correlation Coefficients / 455
- 11.9 Multiple Regression / 468
- 11.10 Case Study: Effects of Lead Exposure on Neurologic and Psychological Function in Children / 484
- 11.11 Partial and Multiple Correlation / 491
- 11.12 Rank Correlation / 494
- \*11.13 Interval Estimation for Rank Correlation Coefficients / 499
- 11.14 Summary / 504

**PROBLEMS / 504**

**CHAPTER 12****Multisample Inference / 516**

- |  |   |
|--|---|
| 12.1 Introduction to the One-Way Analysis of Variance / 516  | 12.6 Two-Way ANOVA / 548                          |
| 12.2 One-Way ANOVA—Fixed-Effects Model / 516   | 12.7 The Kruskal-Wallis Test / 555                |
| 12.3 Hypothesis Testing in One-Way ANOVA—Fixed-Effects Model / 518                                   | 12.8 One-Way ANOVA—The Random-Effects Model / 562 |
| 12.4 Comparisons of Specific Groups in One-Way ANOVA / 522   | 12.9 The Intraclass Correlation Coefficient / 568 |
| 12.5 Case Study: Effects of Lead Exposure on Neurologic and Psychological Function in Children / 538 | *12.10 Mixed Models / 572                         |
|  | 12.11 Summary / 576                               |
|  | <b>PROBLEMS / 577</b>                             |

**CHAPTER 13****Design and Analysis Techniques for Epidemiologic Studies / 588**

- |  |   |
|--|---|
| 13.1 Introduction / 588  | *13.9 Extensions to Logistic Regression / 649 |
| 13.2 Study Design / 588  | 13.10 Meta-Analysis / 658                     |
| 13.3 Measures of Effect for Categorical Data / 591                                       | 13.11 Equivalence Studies / 663               |
| *13.4 Attributable Risk / 601  | 13.12 The Cross-Over Design / 666             |
| 13.5 Confounding and Standardization / 607   | *13.13 Clustered Binary Data / 674            |
| 13.6 Methods of Inference for Stratified Categorical Data—The Mantel-Haenszel Test / 612 | *13.14 Longitudinal Data Analysis / 687       |
| 13.7 Power and Sample-Size Estimation for Stratified Categorical Data / 625              | 13.15 Measurement-Error Methods / 696         |
| 13.8 Multiple Logistic Regression / 628  | 13.16 Missing Data / 706                      |
|  | 13.17 Summary / 711                           |
|  | <b>PROBLEMS / 713</b>                         |

**CHAPTER 14****Hypothesis Testing: Person-Time Data / 725**

- |  |   |
|--|---|
| 14.1 Measure of Effect for Person-Time Data / 725                | 14.6 Power and Sample-Size Estimation for Stratified Person-Time Data / 750 |
| 14.2 One-Sample Inference for Incidence-Rate Data / 727          | 14.7 Testing for Trend: Incidence-Rate Data / 755                           |
| 14.3 Two-Sample Inference for Incidence-Rate Data / 730          | 14.8 Introduction to Survival Analysis / 758                                |
| 14.4 Power and Sample-Size Estimation for Person-Time Data / 738 | 14.9 Estimation of Survival Curves: The Kaplan-Meier Estimator / 760        |
| 14.5 Inference for Stratified Person-Time Data / 742             | 14.10 The Log-Rank Test / 767   |
|  | 14.11 The Proportional-Hazards Model / 774                                  |

14.12	Power and Sample-Size Estimation under the Proportional-Hazards Model / 783	*14.14	Parametric Regression Models for Survival Data / 795
*14.13	Parametric Survival Analysis / 787	14.15	Summary / 802

**PROBLEMS / 802****APPENDIX****Tables / 811**

- 1** Exact Binomial Probabilities  $Pr(X=k) = \binom{n}{k} p^k q^{n-k}$  / 811
- 2** Exact Poisson Probabilities  $Pr(X=k) = \frac{e^{-\mu} \mu^k}{k!}$  / 815
- 3** The Normal Distribution / 818
- 4** Table of 1000 Random Digits / 822
- 5** Percentage Points of the  $t$  Distribution ( $t_{d,u}$ ) / 823
- 6** Percentage Points of the Chi-Square Distribution ( $\chi^2_{d,u}$ ) / 824
- 7a** Exact Two-Sided 100%  $\times (1 - \alpha)$  Confidence Limits for Binomial Proportions ( $\alpha = .05$ ) / 825
- 7b** Exact Two-Sided 100%  $\times (1 - \alpha)$  Confidence Limits for Binomial Proportions ( $\alpha = .01$ ) / 826
- 8** Confidence Limits for the Expectation of a Poisson Variable ( $\mu$ ) / 827
- 9** Percentage Points of the  $F$  Distribution ( $F_{d_1, d_2, p}$ ) / 828
- 10** Critical Values for the ESD (Extreme Studentized Deviate) Outlier Statistic ( $ESD_{n, 1-\alpha}$ ,  $\alpha = .05, .01$ ) / 830
- 11** Two-Tailed Critical Values for the Wilcoxon Signed-Rank Test / 830
- 12** Two-Tailed Critical Values for the Wilcoxon Rank-Sum Test / 831
- 13** Fisher's  $z$  Transformation / 833
- 14** Two-Tailed Upper Critical Values for the Spearman Rank-Correlation Coefficient ( $r_s$ ) / 834
- 15** Critical Values for the Kruskal-Wallis Test Statistic ( $H$ ) for Selected Sample Sizes for  $k = 3$  / 835
- 16** Critical Values for the Studentized Range Statistic  $q^*$ ,  $\alpha = .05$  / 836

**Answers to Selected Problems / 837****FLOWCHART: Methods of Statistical Inference / 841****Index of Data Sets / 847****Index / 849**

# Preface

This introductory-level biostatistics text is designed for upper-level undergraduate or graduate students interested in medicine or other health-related areas. It requires no previous background in statistics, and its mathematical level assumes only a knowledge of algebra.

*Fundamentals of Biostatistics* evolved from notes that I have used in a biostatistics course taught to Harvard University undergraduates and Harvard Medical School students over the past 30 years. I wrote this book to help motivate students to master the statistical methods that are most often used in the medical literature. From the student's viewpoint, it is important that the example material used to develop these methods is representative of what actually exists in the literature. Therefore, most of the examples and exercises in this book are based either on actual articles from the medical literature or on actual medical research problems I have encountered during my consulting experience at the Harvard Medical School.

## The Approach

Most introductory statistics texts either use a completely nonmathematical, cookbook approach or develop the material in a rigorous, sophisticated mathematical framework. In this book, however, I follow an intermediate course, minimizing the amount of mathematical formulation but giving complete explanations of all the important concepts. Every new concept in this book is developed systematically through completely worked-out examples from current medical research problems. In addition, I introduce computer output where appropriate to illustrate these concepts.

I initially wrote this text for the introductory biostatistics course. However, the field has changed rapidly over the past 10 years; because of the increased power of newer statistical packages, we can now perform more sophisticated data analyses than ever before. Therefore, a second goal of this text is to present these new techniques *at an introductory level* so that students can become familiar with them without having to wade through specialized (and, usually, more advanced) statistical texts.

To differentiate these two goals more clearly, I included most of the content for the introductory course in the first 12 chapters. More advanced statistical techniques used in recent epidemiologic studies are covered in Chapter 13, "Design and Analysis Techniques for Epidemiologic Studies" and Chapter 14, "Hypothesis Testing: Person-Time Data."

## Changes in the Seventh Edition

For this edition, I have added seven new sections and added new content to one other section. Features new to this edition include the following:

- The data sets are now available on the book's Companion Website at [www.cengage.com/statistics/rosner](http://www.cengage.com/statistics/rosner) in an expanded set of formats, including Excel, Minitab®, SPSS, JMP, SAS, Stata, R, and ASCII formats.
- Data and medical research findings in Examples have been updated.
- New or expanded coverage of the following topics:
  - Interval estimates for rank correlation coefficients (Section 11.13)
  - Mixed effect models (Section 12.10)
  - Attributable risk (Section 13.4)
  - Extensions to logistic regression (Section 13.9)
  - Regression models for clustered binary data (Section 13.13)
  - Longitudinal data analysis (Section 13.14)
  - Parametric survival analysis (Section 14.13)
  - Parametric regression models for survival data (Section 14.14)

The new sections and the expanded sections for this edition have been indicated by an asterisk in the table of contents.

## Exercises

This edition contains 1438 exercises; 244 of these exercises are new. Data and medical research findings in the problems have been updated where appropriate. All problems based on the data sets are included. Problems marked by an asterisk (\*) at the end of each chapter have corresponding brief solutions in the answer section at the back of the book. Based on requests from students for more completely solved problems, approximately 600 additional problems and complete solutions are presented in the *Study Guide* available on the Companion Website accompanying this text. In addition, approximately 100 of these problems are included in a Miscellaneous Problems section and are randomly ordered so that they are not tied to a specific chapter in the book. This gives the student additional practice in determining what method to use in what situation. Complete instructor solutions to all exercises are available in secure online format through Cengage's *Solution Builder* service. Adopting instructors can sign up for access at [www.cengage.com/solutionbuilder](http://www.cengage.com/solutionbuilder).

## Computation Method

The method of handling computations is similar to that used in the sixth edition. All intermediate results are carried to full precision (10+ significant digits), even though they are presented with fewer significant digits (usually 2 or 3) in the text. Thus, intermediate results may seem inconsistent with final results in some instances; this, however, is not the case.

## Organization

*Fundamentals of Biostatistics*, Seventh Edition, is organized as follows.

**Chapter 1** is an *introductory* chapter that contains an outline of the development of an actual medical study with which I was involved. It provides a unique sense of the role of biostatistics in medical research.

**Chapter 2** concerns *descriptive statistics* and presents all the major numeric and graphic tools used for displaying medical data. This chapter is especially important

for both consumers and producers of medical literature because much information is actually communicated via descriptive material.

**Chapters 3 through 5** discuss *probability*. The basic principles of probability are developed, and the most common probability distributions—such as the binomial and normal distributions—are introduced. These distributions are used extensively in later chapters of the book. The concepts of prior probability and posterior probability are also introduced.

**Chapters 6 through 10** cover some of the basic methods of *statistical inference*.

**Chapter 6** introduces the concept of drawing random samples from populations. The difficult notion of a sampling distribution is developed and includes an introduction to the most common sampling distributions, such as the *t* and chi-square distributions. The basic methods of *estimation*, including an extensive discussion of confidence intervals, are also presented.

**Chapters 7 and 8** contain the basic principles of *hypothesis testing*. The most elementary hypothesis tests for normally distributed data, such as the *t* test, are also fully discussed for one- and two-sample problems. The fundamentals of Bayesian inference are explored.

**Chapter 9** covers the basic principles of *nonparametric statistics*. The assumptions of normality are relaxed, and distribution-free analogues are developed for the tests in Chapters 7 and 8.

**Chapter 10** contains the basic concepts of *hypothesis testing* as applied to categorical data, including some of the most widely used statistical procedures, such as the chi-square test and Fisher's exact test.

**Chapter 11** develops the principles of *regression analysis*. The case of simple linear regression is thoroughly covered, and extensions are provided for the multiple-regression case. Important sections on goodness-of-fit of regression models are also included. Also, rank correlation is introduced. Interval estimates for rank correlation coefficients are covered for the first time. Methods for comparing correlation coefficients from dependent samples are also included.

**Chapter 12** introduces the basic principles of the *analysis of variance* (ANOVA). The one-way analysis of variance fixed- and random-effects models are discussed. In addition, two-way ANOVA, the analysis of covariance, and mixed effects models are covered. Finally, we discuss nonparametric approaches to one-way ANOVA. Multiple comparison methods including material on the false discovery rate are also provided. A section of mixed models is also included for the first time.

**Chapter 13** discusses methods of design and analysis for *epidemiologic studies*. The most important study designs, including the prospective study, the case-control study, the cross-sectional study, and the cross-over design are introduced. The concept of a confounding variable—that is, a variable related to both the disease and the exposure variable—is introduced, and methods for controlling for confounding, which include the Mantel-Haenszel test and multiple-logistic regression, are discussed in detail. Extensions to logistic regression models, including conditional logistic regression, polytomous logistic regression, and ordinal logistic regression, are discussed for the first time. This discussion is followed by the exploration of topics of current interest in epidemiologic data analysis, including meta-analysis (the combination of results from more than one study); correlated binary data techniques (techniques that can be applied when replicate measures, such as data from multiple teeth from the same person, are available for an individual); measurement error methods (useful when there is substantial measurement error in the exposure data collected); equivalence studies (whose objective it is to establish bioequivalence between two treatment modalities rather than that one treatment is superior to the other); and missing-data methods for how to handle missing data in epidemiologic

studies. Longitudinal data analysis and generalized estimating equation (GEE) methods are also briefly discussed.

**Chapter 14** introduces methods of analysis for *person-time data*. The methods covered in this chapter include those for incidence-rate data, as well as several methods of survival analysis: the Kaplan-Meier survival curve estimator, the log-rank test, and the proportional-hazards model. Methods for testing the assumptions of the proportional-hazards model have also been included. Parametric survival analysis methods are covered for the first time.

Throughout the text—particularly in Chapter 13—I discuss the elements of study designs, including the concepts of matching; cohort studies; case-control studies; retrospective studies; prospective studies; and the sensitivity, specificity, and predictive value of screening tests. These designs are presented in the context of actual samples. In addition, Chapters 7, 8, 10, 11, 13, and 14 contain specific sections on sample-size estimation for different statistical situations.

A flowchart of appropriate methods of statistical inference (see pages 841–846) is a handy reference guide to the methods developed in this book. Page references for each major method presented in the text are also provided. In Chapters 7–8 and Chapters 10–14, I refer students to this flowchart to give them some perspective on how the methods discussed in a given chapter fit with all the other statistical methods introduced in this book.

In addition, I have provided an index of applications, grouped by *medical specialty*, summarizing all the examples and problems this book covers.

## Acknowledgments

I am indebted to Debra Sheldon, the late Marie Sheehan, and Harry Taplin for their invaluable help typing the manuscript, to Dale Rinkel for invaluable help in typing problem solutions, and to Marion McPhee for helping to prepare the data sets on the Companion Website. I am also indebted to Brian Claggett for updating solutions to problems for this edition, and to Daad Abraham for typing the Index of Applications. In addition, I wish to thank the manuscript reviewers, among them: Emilia Bagiella, Columbia University; Ron Brookmeyer, Johns Hopkins University; Mark van der Laan, University of California, Berkeley; and John Wilson, University of Pittsburgh. I would also like to thank my colleagues Nancy Cook, who was instrumental in helping me develop the part of Section 12.4 on the false-discovery rate, and Robert Glynn, who was instrumental in developing Section 13.16 on missing data and Section 14.11 on testing the assumptions of the proportional-hazards model.

In addition, I wish to thank Molly Taylor, Daniel Seibert, Shaylin Walsh, and Laura Wheel, who were instrumental in providing editorial advice and in preparing the manuscript.

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Bernard Rosner

## About the Author

**Bernard Rosner** is Professor of Medicine (Biostatistics) at Harvard Medical School and Professor of Biostatistics in the Harvard School of Public Health. He received a B.A. in Mathematics from Columbia University in 1967, an M.S. in Statistics from Stanford University in 1968, and a Ph.D. in Statistics from Harvard University in 1971.

He has more than 30 years of biostatistical consulting experience with other investigators at the Harvard Medical School. Special areas of interest include cardiovascular disease, hypertension, breast cancer, and ophthalmology. Many of the examples and exercises used in the text reflect data collected from actual studies in conjunction with his consulting experience. In addition, he has developed new biostatistical methods, mainly in the areas of longitudinal data analysis, analysis of clustered data (such as data collected in families or from paired organ systems in the same person), measurement error methods, and outlier detection methods. You will see some of these methods introduced in this book at an elementary level. He was married in 1972 to his wife, Cynthia, and has three children, Sarah, David, and Laura, each of whom has contributed examples for this book.

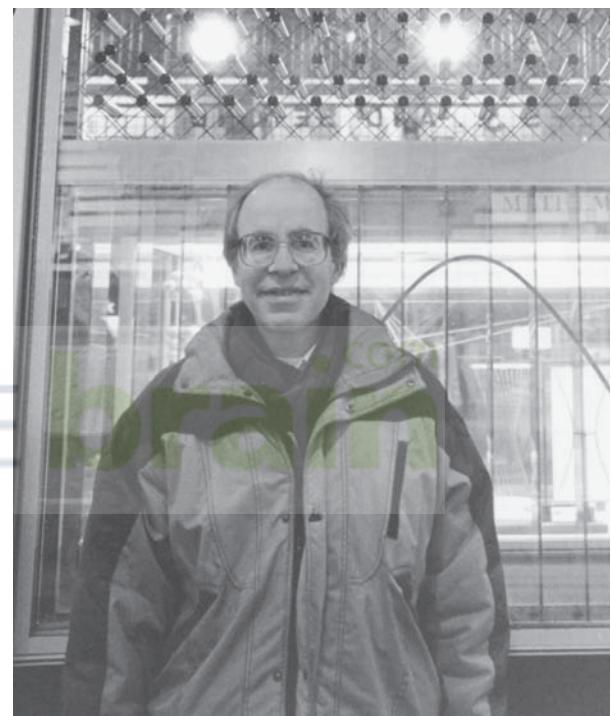


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# APPENDIX

## Tables

**Table 1** Exact binomial probabilities  $Pr(X = k) = \binom{n}{k} p^k q^{n-k}$

<i>n</i>	<i>k</i>	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50
2	0	.9025	.8100	.7225	.6400	.5625	.4900	.4225	.3600	.3025	.2500
	1	.0950	.1800	.2550	.3200	.3750	.4200	.4550	.4800	.4950	.5000
	2	.0025	.0100	.0225	.0400	.0625	.0900	.1225	.1600	.2025	.2500
3	0	.8574	.7290	.6141	.5120	.4219	.3430	.2746	.2160	.1664	.1250
	1	.1354	.2430	.3251	.3840	.4219	.4410	.4436	.4320	.4084	.3750
	2	.0071	.0270	.0574	.0960	.1406	.1890	.2389	.2880	.3341	.3750
	3	.0001	.0010	.0034	.0080	.0156	.0270	.0429	.0640	.0911	.1250
4	0	.8145	.6561	.5220	.4096	.3164	.2401	.1785	.1296	.0915	.0625
	1	.1715	.2916	.3685	.4096	.4219	.4116	.3845	.3456	.2995	.2500
	2	.0135	.0486	.0975	.1536	.2109	.2646	.3105	.3456	.3675	.3750
	3	.0005	.0036	.0115	.0256	.0469	.0756	.1115	.1536	.2005	.2500
	4	.0000	.0001	.0005	.0016	.0039	.0081	.0150	.0256	.0410	.0625
5	0	.7738	.5905	.4437	.3277	.2373	.1681	.1160	.0778	.0503	.0313
	1	.2036	.3280	.3915	.4096	.3955	.3602	.3124	.2592	.2059	.1563
	2	.0214	.0729	.1382	.2048	.2637	.3087	.3364	.3456	.3369	.3125
	3	.0011	.0081	.0244	.0512	.0879	.1323	.1811	.2304	.2757	.3125
	4	.0000	.0004	.0022	.0064	.0146	.0283	.0488	.0768	.1128	.1563
	5	.0000	.0000	.0001	.0003	.0010	.0024	.0053	.0102	.0185	.0313
6	0	.7351	.5314	.3771	.2621	.1780	.1176	.0754	.0467	.0277	.0156
	1	.2321	.3543	.3993	.3932	.3560	.3025	.2437	.1866	.1359	.0938
	2	.0305	.0984	.1762	.2458	.2966	.3241	.3280	.3110	.2780	.2344
	3	.0021	.0146	.0415	.0819	.1318	.1852	.2355	.2765	.3032	.3125
	4	.0001	.0012	.0055	.0154	.0330	.0595	.0951	.1382	.1861	.2344
	5	.0000	.0001	.0004	.0015	.0044	.0102	.0205	.0369	.0609	.0938
7	6	.0000	.0000	.0000	.0001	.0002	.0007	.0018	.0041	.0083	.0156
	0	.6983	.4783	.3206	.2097	.1335	.0824	.0490	.0280	.0152	.0078
	1	.2573	.3720	.3960	.3670	.3115	.2471	.1848	.1306	.0872	.0547
	2	.0406	.1240	.2097	.2753	.3115	.3177	.2985	.2613	.2140	.1641
	3	.0036	.0230	.0617	.1147	.1730	.2269	.2679	.2903	.2918	.2734
	4	.0002	.0026	.0109	.0287	.0577	.0972	.1442	.1935	.2388	.2734
	5	.0000	.0002	.0012	.0043	.0115	.0250	.0466	.0774	.1172	.1641
8	6	.0000	.0000	.0001	.0004	.0013	.0036	.0084	.0172	.0320	.0547
	7	.0000	.0000	.0000	.0000	.0001	.0002	.0006	.0016	.0037	.0078
	0	.6634	.4305	.2725	.1678	.1001	.0576	.0319	.0168	.0084	.0039
	1	.2793	.3826	.3847	.3355	.2670	.1977	.1373	.0896	.0548	.0313
	2	.0515	.1488	.2376	.2936	.3115	.2965	.2587	.2090	.1569	.1094
	3	.0054	.0331	.0839	.1468	.2076	.2541	.2786	.2787	.2568	.2188

(continued on next page)

**Table 1** Exact binomial probabilities  $Pr(X = k) = \binom{n}{k} p^k q^{n-k}$  (continued)

<i>n</i>	<i>k</i>	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50
	4	.0004	.0046	.0185	.0459	.0865	.1361	.1875	.2322	.2627	.2734
	5	.0000	.0004	.0026	.0092	.0231	.0467	.0808	.1239	.1719	.2188
	6	.0000	.0000	.0002	.0011	.0038	.0100	.0217	.0413	.0703	.1094
	7	.0000	.0000	.0000	.0001	.0004	.0012	.0033	.0079	.0164	.0313
	8	.0000	.0000	.0000	.0000	.0000	.0001	.0002	.0007	.0017	.0039
9	0	.6302	.3874	.2316	.1342	.0751	.0404	.0207	.0101	.0046	.0020
	1	.2985	.3874	.3679	.3020	.2253	.1556	.1004	.0605	.0339	.0176
	2	.0629	.1722	.2597	.3020	.3003	.2668	.2162	.1612	.1110	.0703
	3	.0077	.0446	.1069	.1762	.2336	.2668	.2716	.2508	.2119	.1641
	4	.0006	.0074	.0283	.0661	.1168	.1715	.2194	.2508	.2600	.2461
	5	.0000	.0008	.0050	.0165	.0389	.0735	.1181	.1672	.2128	.2461
	6	.0000	.0001	.0006	.0028	.0087	.0210	.0424	.0743	.1160	.1641
	7	.0000	.0000	.0000	.0003	.0012	.0039	.0098	.0212	.0407	.0703
	8	.0000	.0000	.0000	.0000	.0001	.0004	.0013	.0035	.0083	.0176
	9	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0003	.0008	.0020
10	0	.5987	.3487	.1969	.1074	.0563	.0282	.0135	.0060	.0025	.0010
	1	.3151	.3874	.3474	.2684	.1877	.1211	.0725	.0403	.0207	.0098
	2	.0746	.1937	.2759	.3020	.2816	.2335	.1757	.1209	.0763	.0439
	3	.0105	.0574	.1298	.2013	.2503	.2668	.2522	.2150	.1665	.1172
	4	.0010	.0112	.0401	.0881	.1460	.2001	.2377	.2508	.2384	.2051
	5	.0001	.0015	.0085	.0264	.0584	.1029	.1536	.2007	.2340	.2461
	6	.0000	.0001	.0012	.0055	.0162	.0368	.0689	.1115	.1596	.2051
	7	.0000	.0000	.0001	.0008	.0031	.0090	.0212	.0425	.0746	.1172
	8	.0000	.0000	.0000	.0001	.0004	.0014	.0043	.0106	.0229	.0439
	9	.0000	.0000	.0000	.0000	.0000	.0001	.0005	.0016	.0042	.0098
	10	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0003	.0010
11	0	.5688	.3138	.1673	.0859	.0422	.0198	.0088	.0036	.0014	.0005
	1	.3293	.3835	.3248	.2362	.1549	.0932	.0518	.0266	.0125	.0054
	2	.0867	.2131	.2866	.2953	.2581	.1998	.1395	.0887	.0513	.0269
	3	.0137	.0710	.1517	.2215	.2581	.2568	.2254	.1774	.1259	.0806
	4	.0014	.0158	.0536	.1107	.1721	.2201	.2428	.2365	.2060	.1611
	5	.0001	.0025	.0132	.0388	.0803	.1321	.1830	.2207	.2360	.2256
	6	.0000	.0003	.0023	.0097	.0268	.0566	.0985	.1471	.1931	.2256
	7	.0000	.0000	.0003	.0017	.0064	.0173	.0379	.0701	.1128	.1611
	8	.0000	.0000	.0000	.0002	.0011	.0037	.0102	.0234	.0462	.0806
	9	.0000	.0000	.0000	.0000	.0001	.0005	.0018	.0052	.0126	.0269
	10	.0000	.0000	.0000	.0000	.0000	.0000	.0002	.0007	.0021	.0054
	11	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0002	.0005
12	0	.5404	.2824	.1422	.0687	.0317	.0138	.0057	.0022	.0008	.0002
	1	.3413	.3766	.3012	.2062	.1267	.0712	.0368	.0174	.0075	.0029
	2	.0988	.2301	.2924	.2835	.2323	.1678	.1088	.0639	.0339	.0161
	3	.0173	.0852	.1720	.2362	.2581	.2397	.1954	.1419	.0923	.0537
	4	.0021	.0213	.0683	.1329	.1936	.2311	.2367	.2128	.1700	.1208
	5	.0002	.0038	.0193	.0532	.1032	.1585	.2039	.2270	.2225	.1934
	6	.0000	.0005	.0040	.0155	.0401	.0792	.1281	.1766	.2124	.2256
	7	.0000	.0000	.0006	.0033	.0115	.0291	.0591	.1009	.1489	.1934
	8	.0000	.0000	.0001	.0005	.0024	.0078	.0199	.0420	.0762	.1208
	9	.0000	.0000	.0000	.0001	.0004	.0015	.0048	.0125	.0277	.0537
	10	.0000	.0000	.0000	.0000	.0000	.0002	.0008	.0025	.0068	.0161
	11	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0003	.0010	.0029
	12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0002
13	0	.5133	.2542	.1209	.0550	.0238	.0097	.0037	.0013	.0004	.0001
	1	.3512	.3672	.2774	.1787	.1029	.0540	.0259	.0113	.0045	.0016
	2	.1109	.2448	.2937	.2680	.2059	.1388	.0836	.0453	.0220	.0095
	3	.0214	.0997	.1900	.2457	.2517	.2181	.1651	.1107	.0660	.0349
	4	.0028	.0277	.0838	.1535	.2097	.2337	.2222	.1845	.1350	.0873
	5	.0003	.0055	.0266	.0691	.1258	.1803	.2154	.2214	.1989	.1571

(continued on next page)

**Table 1** Exact binomial probabilities  $Pr(X = k) = \binom{n}{k} p^k q^{n-k}$  (continued)

<i>n</i>	<i>k</i>	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50
	6	.0000	.0008	.0063	.0230	.0559	.1030	.1546	.1968	.2169	.2095
	7	.0000	.0001	.0011	.0058	.0186	.0442	.0833	.1312	.1775	.2095
	8	.0000	.0000	.0001	.0011	.0047	.0142	.0336	.0656	.1089	.1571
	9	.0000	.0000	.0000	.0001	.0009	.0034	.0101	.0243	.0495	.0873
	10	.0000	.0000	.0000	.0000	.0001	.0006	.0022	.0065	.0162	.0349
	11	.0000	.0000	.0000	.0000	.0000	.0001	.0003	.0012	.0036	.0095
	12	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0005	.0016
	13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001
14	0	.4877	.2288	.1028	.0440	.0178	.0068	.0024	.0008	.0002	.0001
	1	.3593	.3559	.2539	.1539	.0832	.0407	.0181	.0073	.0027	.0009
	2	.1229	.2570	.2912	.2501	.1802	.1134	.0634	.0317	.0141	.0056
	3	.0259	.1142	.2056	.2501	.2402	.1943	.1366	.0845	.0462	.0222
	4	.0037	.0349	.0998	.1720	.2202	.2290	.2022	.1549	.1040	.0611
	5	.0004	.0078	.0352	.0860	.1468	.1963	.2178	.2066	.1701	.1222
	6	.0000	.0013	.0093	.0322	.0734	.1262	.1759	.2066	.2088	.1833
	7	.0000	.0002	.0019	.0092	.0280	.0618	.1082	.1574	.1952	.2095
	8	.0000	.0000	.0003	.0020	.0082	.0232	.0510	.0918	.1398	.1833
	9	.0000	.0000	.0000	.0003	.0018	.0066	.0183	.0408	.0762	.1222
	10	.0000	.0000	.0000	.0000	.0003	.0014	.0049	.0136	.0312	.0611
	11	.0000	.0000	.0000	.0000	.0000	.0002	.0010	.0033	.0093	.0222
	12	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0005	.0019	.0056
	13	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0002	.0009
	14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001
15	0	.4633	.2059	.0874	.0352	.0134	.0047	.0016	.0005	.0001	.0000
	1	.3658	.3432	.2312	.1319	.0668	.0305	.0126	.0047	.0016	.0005
	2	.1348	.2669	.2856	.2309	.1559	.0916	.0476	.0219	.0090	.0032
	3	.0307	.1285	.2184	.2501	.2252	.1700	.1110	.0634	.0318	.0139
	4	.0049	.0428	.1156	.1876	.2252	.2186	.1792	.1268	.0780	.0417
	5	.0006	.0105	.0449	.1032	.1651	.2061	.2123	.1859	.1404	.0916
	6	.0000	.0019	.0132	.0430	.0917	.1472	.1906	.2066	.1914	.1527
	7	.0000	.0003	.0030	.0138	.0393	.0811	.1319	.1771	.2013	.1964
	8	.0000	.0000	.0005	.0035	.0131	.0348	.0710	.1181	.1647	.1964
	9	.0000	.0000	.0001	.0007	.0034	.0116	.0298	.0612	.1048	.1527
	10	.0000	.0000	.0000	.0001	.0007	.0030	.0096	.0245	.0515	.0916
	11	.0000	.0000	.0000	.0000	.0001	.0006	.0024	.0074	.0191	.0417
	12	.0000	.0000	.0000	.0000	.0000	.0001	.0004	.0016	.0052	.0139
	13	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0003	.0010	.0032
	14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0005
	15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
16	0	.4401	.1853	.0743	.0281	.0100	.0033	.0010	.0003	.0001	.0000
	1	.3706	.3294	.2097	.1126	.0535	.0228	.0087	.0030	.0009	.0002
	2	.1463	.2745	.2775	.2111	.1336	.0732	.0353	.0150	.0056	.0018
	3	.0359	.1423	.2285	.2463	.2079	.1465	.0888	.0468	.0215	.0085
	4	.0061	.0514	.1311	.2001	.2252	.2040	.1553	.1014	.0572	.0278
	5	.0008	.0137	.0555	.1201	.1802	.2099	.2008	.1623	.1123	.0667
	6	.0001	.0028	.0180	.0550	.1101	.1649	.1982	.1983	.1684	.1222
	7	.0000	.0004	.0045	.0197	.0524	.1010	.1524	.1889	.1969	.1746
	8	.0000	.0001	.0009	.0055	.0197	.0487	.0923	.1417	.1812	.1964
	9	.0000	.0000	.0001	.0012	.0058	.0185	.0442	.0840	.1318	.1746
	10	.0000	.0000	.0000	.0002	.0014	.0056	.0167	.0392	.0755	.1222
	11	.0000	.0000	.0000	.0000	.0002	.0013	.0049	.0142	.0337	.0667
	12	.0000	.0000	.0000	.0000	.0000	.0002	.0011	.0040	.0115	.0278
	13	.0000	.0000	.0000	.0000	.0000	.0000	.0002	.0008	.0029	.0085
	14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0005	.0018
	15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0002
	16	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

(continued on next page)

**Table 1** Exact binomial probabilities  $Pr(X = k) = \binom{n}{k} p^k q^{n-k}$  (continued)

<i>n</i>	<i>k</i>	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50
17	0	.4181	.1668	.0631	.0225	.0075	.0023	.0007	.0002	.0000	.0000
	1	.3741	.3150	.1893	.0957	.0426	.0169	.0060	.0019	.0005	.0001
	2	.1575	.2800	.2673	.1914	.1136	.0581	.0260	.0102	.0035	.0010
	3	.0415	.1556	.2359	.2393	.1893	.1245	.0701	.0341	.0144	.0052
	4	.0076	.0605	.1457	.2093	.2209	.1868	.1320	.0796	.0411	.0182
	5	.0010	.0175	.0668	.1361	.1914	.2081	.1849	.1379	.0875	.0472
	6	.0001	.0039	.0236	.0680	.1276	.1784	.1991	.1839	.1432	.0944
	7	.0000	.0007	.0065	.0267	.0668	.1201	.1685	.1927	.1841	.1484
	8	.0000	.0001	.0014	.0084	.0279	.0644	.1134	.1606	.1883	.1855
	9	.0000	.0000	.0003	.0021	.0093	.0276	.0611	.1070	.1540	.1855
	10	.0000	.0000	.0000	.0004	.0025	.0095	.0263	.0571	.1008	.1484
	11	.0000	.0000	.0000	.0001	.0005	.0026	.0090	.0242	.0525	.0944
	12	.0000	.0000	.0000	.0000	.0001	.0006	.0024	.0081	.0215	.0472
	13	.0000	.0000	.0000	.0000	.0000	.0001	.0005	.0021	.0068	.0182
	14	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0004	.0016	.0052
	15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0003	.0010
	16	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001
	17	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
18	0	.3972	.1501	.0536	.0180	.0056	.0016	.0004	.0001	.0000	.0000
	1	.3763	.3002	.1704	.0811	.0338	.0126	.0042	.0012	.0003	.0001
	2	.1683	.2835	.2556	.1723	.0958	.0458	.0190	.0069	.0022	.0006
	3	.0473	.1680	.2406	.2297	.1704	.1046	.0547	.0246	.0095	.0031
	4	.0093	.0700	.1592	.2153	.2130	.1681	.1104	.0614	.0291	.0117
	5	.0014	.0218	.0787	.1507	.1988	.2017	.1664	.1146	.0666	.0327
	6	.0002	.0052	.0301	.0816	.1436	.1873	.1941	.1655	.1181	.0708
	7	.0000	.0010	.0091	.0350	.0820	.1376	.1792	.1892	.1657	.1214
	8	.0000	.0002	.0022	.0120	.0376	.0811	.1327	.1734	.1864	.1669
	9	.0000	.0000	.0004	.0033	.0139	.0386	.0794	.1284	.1694	.1855
	10	.0000	.0000	.0001	.0008	.0042	.0149	.0385	.0771	.1248	.1669
	11	.0000	.0000	.0000	.0001	.0010	.0046	.0151	.0374	.0742	.1214
	12	.0000	.0000	.0000	.0000	.0002	.0012	.0047	.0145	.0354	.0708
	13	.0000	.0000	.0000	.0000	.0000	.0002	.0012	.0045	.0134	.0327
	14	.0000	.0000	.0000	.0000	.0000	.0000	.0002	.0011	.0039	.0117
	15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0002	.0009	.0031
	16	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0006
	17	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001
	18	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
19	0	.3774	.1351	.0456	.0144	.0042	.0011	.0003	.0001	.0000	.0000
	1	.3774	.2852	.1529	.0685	.0268	.0093	.0029	.0008	.0002	.0000
	2	.1787	.2852	.2428	.1540	.0803	.0358	.0138	.0046	.0013	.0003
	3	.0533	.1796	.2428	.2182	.1517	.0869	.0422	.0175	.0062	.0018
	4	.0112	.0798	.1714	.2182	.2023	.1491	.0909	.0467	.0203	.0074
	5	.0018	.0266	.0907	.1636	.2023	.1916	.1468	.0933	.0497	.0222
	6	.0002	.0069	.0374	.0955	.1574	.1916	.1844	.1451	.0949	.0518
	7	.0000	.0014	.0122	.0443	.0974	.1525	.1844	.1797	.1443	.0961
	8	.0000	.0002	.0032	.0166	.0487	.0981	.1489	.1797	.1771	.1442
	9	.0000	.0000	.0007	.0051	.0198	.0514	.0980	.1464	.1771	.1762
	10	.0000	.0000	.0001	.0013	.0066	.0220	.0528	.0976	.1449	.1762
	11	.0000	.0000	.0000	.0003	.0018	.0077	.0233	.0532	.0970	.1442
	12	.0000	.0000	.0000	.0000	.0004	.0022	.0083	.0237	.0529	.0961
	13	.0000	.0000	.0000	.0000	.0001	.0005	.0024	.0085	.0233	.0518
	14	.0000	.0000	.0000	.0000	.0000	.0001	.0006	.0024	.0082	.0222
	15	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0005	.0022	.0074
	16	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0005	.0018
	17	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0003

(continued on next page)

**Table 1** Exact binomial probabilities  $Pr(X = k) = \binom{n}{k} p^k q^{n-k}$  (continued)

<i>n</i>	<i>k</i>	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50
	18	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	19	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
20	0	.3585	.1216	.0388	.0115	.0032	.0008	.0002	.0000	.0000	.0000
	1	.3774	.2702	.1368	.0576	.0211	.0068	.0020	.0005	.0001	.0000
	2	.1887	.2852	.2293	.1369	.0669	.0278	.0100	.0031	.0008	.0002
	3	.0596	.1901	.2428	.2054	.1339	.0716	.0323	.0123	.0040	.0011
	4	.0133	.0898	.1821	.2182	.1897	.1304	.0738	.0350	.0139	.0046
	5	.0022	.0319	.1028	.1746	.2023	.1789	.1272	.0746	.0365	.0148
	6	.0003	.0089	.0454	.1091	.1686	.1916	.1712	.1244	.0746	.0370
	7	.0000	.0020	.0160	.0546	.1124	.1643	.1844	.1659	.1221	.0739
	8	.0000	.0004	.0046	.0222	.0609	.1144	.1614	.1797	.1623	.1201
	9	.0000	.0001	.0011	.0074	.0271	.0654	.1158	.1597	.1771	.1602
	10	.0000	.0000	.0002	.0020	.0099	.0308	.0686	.1171	.1593	.1762
	11	.0000	.0000	.0000	.0005	.0030	.0120	.0336	.0710	.1185	.1602
	12	.0000	.0000	.0000	.0001	.0008	.0039	.0136	.0355	.0727	.1201
	13	.0000	.0000	.0000	.0000	.0002	.0010	.0045	.0146	.0366	.0739
	14	.0000	.0000	.0000	.0000	.0000	.0002	.0012	.0049	.0150	.0370
	15	.0000	.0000	.0000	.0000	.0000	.0000	.0003	.0013	.0049	.0148
	16	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0003	.0013	.0046
	17	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0002	.0011
	18	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0002
	19	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
	20	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

**Table 2** Exact Poisson probabilities  $Pr(X = k) = \frac{e^{-\mu} \mu^k}{k!}$ 

<i>k</i>	$\mu$									
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
0	.6065	.3679	.2231	.1353	.0821	.0498	.0302	.0183	.0111	.0067
1	.3033	.3679	.3347	.2707	.2052	.1494	.1057	.0733	.0500	.0337
2	.0758	.1839	.2510	.2707	.2565	.2240	.1850	.1465	.1125	.0842
3	.0126	.0613	.1255	.1804	.2138	.2240	.2158	.1954	.1687	.1404
4	.0016	.0153	.0471	.0902	.1336	.1680	.1888	.1954	.1898	.1755
5	.0002	.0031	.0141	.0361	.0668	.1008	.1322	.1563	.1708	.1755
6	.0000	.0005	.0035	.0120	.0278	.0504	.0771	.1042	.1281	.1462
7	.0000	.0001	.0008	.0034	.0099	.0216	.0385	.0595	.0824	.1044
8	.0000	.0000	.0001	.0009	.0031	.0081	.0169	.0298	.0463	.0653
9	.0000	.0000	.0000	.0002	.0009	.0027	.0066	.0132	.0232	.0363
10	.0000	.0000	.0000	.0000	.0002	.0008	.0023	.0053	.0104	.0181
11	.0000	.0000	.0000	.0000	.0000	.0002	.0007	.0019	.0043	.0082
12	.0000	.0000	.0000	.0000	.0000	.0001	.0002	.0006	.0016	.0034
13	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0002	.0006	.0013
14	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0002	.0005
15	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0002
16	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
<i>k</i>	$\mu$									
	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
0	.0041	.0025	.0015	.0009	.0006	.0003	.0002	.0001	.0001	.0000
1	.0225	.0149	.0098	.0064	.0041	.0027	.0017	.0011	.0007	.0005
2	.0618	.0446	.0318	.0223	.0156	.0107	.0074	.0050	.0034	.0023
3	.1133	.0892	.0688	.0521	.0389	.0286	.0208	.0150	.0107	.0076

(continued on next page)

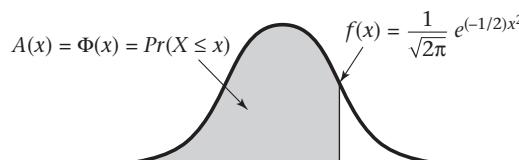
**Table 2** Exact Poisson probabilities  $Pr(X = k) = \frac{e^{-\mu}\mu^k}{k!}$  (continued)

k	$\mu$									
	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
4	.1558	.1339	.1118	.0912	.0729	.0573	.0443	.0337	.0254	.0189
5	.1714	.1606	.1454	.1277	.1094	.0916	.0752	.0607	.0483	.0378
6	.1571	.1606	.1575	.1490	.1367	.1221	.1066	.0911	.0764	.0631
7	.1234	.1377	.1462	.1490	.1465	.1396	.1294	.1171	.1037	.0901
8	.0849	.1033	.1188	.1304	.1373	.1396	.1375	.1318	.1232	.1126
9	.0519	.0688	.0858	.1014	.1144	.1241	.1299	.1318	.1300	.1251
10	.0285	.0413	.0558	.0710	.0858	.0993	.1104	.1186	.1235	.1251
11	.0143	.0225	.0330	.0452	.0585	.0722	.0853	.0970	.1067	.1137
12	.0065	.0113	.0179	.0263	.0366	.0481	.0604	.0728	.0844	.0948
13	.0028	.0052	.0089	.0142	.0211	.0296	.0395	.0504	.0617	.0729
14	.0011	.0022	.0041	.0071	.0113	.0169	.0240	.0324	.0419	.0521
15	.0004	.0009	.0018	.0033	.0057	.0090	.0136	.0194	.0265	.0347
16	.0001	.0003	.0007	.0014	.0026	.0045	.0072	.0109	.0157	.0217
17	.0000	.0001	.0003	.0006	.0012	.0021	.0036	.0058	.0088	.0128
18	.0000	.0000	.0001	.0002	.0005	.0009	.0017	.0029	.0046	.0071
19	.0000	.0000	.0000	.0001	.0002	.0004	.0008	.0014	.0023	.0037
20	.0000	.0000	.0000	.0000	.0001	.0002	.0003	.0006	.0011	.0019
21	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0003	.0005	.0009
22	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0002	.0004
23	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0002
24	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001
25	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
k	$\mu$									
	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0003	.0002	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000
2	.0015	.0010	.0007	.0004	.0003	.0002	.0001	.0001	.0001	.0000
3	.0053	.0037	.0026	.0018	.0012	.0008	.0006	.0004	.0003	.0002
4	.0139	.0102	.0074	.0053	.0038	.0027	.0019	.0013	.0009	.0006
5	.0293	.0224	.0170	.0127	.0095	.0070	.0051	.0037	.0027	.0019
6	.0513	.0411	.0325	.0255	.0197	.0152	.0115	.0087	.0065	.0048
7	.0769	.0646	.0535	.0437	.0353	.0281	.0222	.0174	.0135	.0104
8	.1009	.0888	.0769	.0655	.0551	.0457	.0375	.0304	.0244	.0194
9	.1177	.1085	.0982	.0874	.0765	.0661	.0563	.0473	.0394	.0324
10	.1236	.1194	.1129	.1048	.0956	.0859	.0760	.0663	.0571	.0486
11	.1180	.1194	.1181	.1144	.1087	.1015	.0932	.0844	.0753	.0663
12	.1032	.1094	.1131	.1144	.1132	.1099	.1049	.0984	.0910	.0829
13	.0834	.0926	.1001	.1056	.1089	.1099	.1089	.1060	.1014	.0956
14	.0625	.0728	.0822	.0905	.0972	.1021	.1050	.1060	.1051	.1024
15	.0438	.0534	.0630	.0724	.0810	.0885	.0945	.0989	.1016	.1024
16	.0287	.0367	.0453	.0543	.0633	.0719	.0798	.0866	.0920	.0960
17	.0177	.0237	.0306	.0383	.0465	.0550	.0633	.0713	.0785	.0847
18	.0104	.0145	.0196	.0255	.0323	.0397	.0475	.0554	.0632	.0706
19	.0057	.0084	.0119	.0161	.0213	.0272	.0337	.0409	.0483	.0557
20	.0030	.0046	.0068	.0097	.0133	.0177	.0228	.0286	.0350	.0418
21	.0015	.0024	.0037	.0055	.0079	.0109	.0146	.0191	.0242	.0299
22	.0007	.0012	.0020	.0030	.0045	.0065	.0090	.0121	.0159	.0204
23	.0003	.0006	.0010	.0016	.0024	.0037	.0053	.0074	.0100	.0133
24	.0001	.0003	.0005	.0008	.0013	.0020	.0030	.0043	.0061	.0083
25	.0001	.0001	.0002	.0004	.0006	.0010	.0016	.0024	.0035	.0050
26	.0000	.0000	.0001	.0002	.0003	.0005	.0008	.0013	.0020	.0029
27	.0000	.0000	.0000	.0001	.0001	.0002	.0004	.0007	.0011	.0016
28	.0000	.0000	.0000	.0000	.0001	.0001	.0002	.0003	.0005	.0009

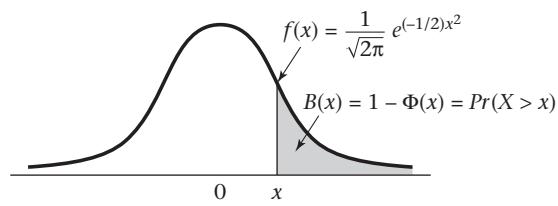
(continued on next page)

**Table 2** Exact Poisson probabilities  $Pr(X = k) = \frac{e^{-\mu}\mu^k}{k!}$  (continued)

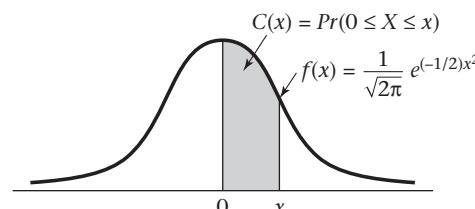
k	$\mu$										
	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	
29	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0002	.0003	.0004	
30	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0002	
31	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0001	
32	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	
33	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	
k	$\mu$										
	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
3	.0001	.0001	.0001	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
4	.0004	.0003	.0002	.0001	.0001	.0001	.0000	.0000	.0000	.0000	.0000
5	.0014	.0010	.0007	.0005	.0003	.0002	.0002	.0001	.0001	.0001	.0001
6	.0036	.0026	.0019	.0014	.0010	.0007	.0005	.0004	.0003	.0002	
7	.0079	.0060	.0045	.0034	.0025	.0019	.0014	.0010	.0007	.0005	
8	.0153	.0120	.0093	.0072	.0055	.0042	.0031	.0024	.0018	.0013	
9	.0264	.0213	.0171	.0135	.0107	.0083	.0065	.0050	.0038	.0029	
10	.0409	.0341	.0281	.0230	.0186	.0150	.0120	.0095	.0074	.0058	
11	.0577	.0496	.0422	.0355	.0297	.0245	.0201	.0164	.0132	.0106	
12	.0745	.0661	.0580	.0504	.0432	.0368	.0310	.0259	.0214	.0176	
13	.0888	.0814	.0736	.0658	.0582	.0509	.0441	.0378	.0322	.0271	
14	.0983	.0930	.0868	.0800	.0728	.0655	.0583	.0514	.0448	.0387	
15	.1016	.0992	.0955	.0906	.0849	.0786	.0719	.0650	.0582	.0516	
16	.0984	.0992	.0985	.0963	.0929	.0884	.0831	.0772	.0710	.0646	
17	.0897	.0934	.0956	.0963	.0956	.0936	.0904	.0863	.0814	.0760	
18	.0773	.0830	.0876	.0909	.0929	.0936	.0930	.0911	.0882	.0844	
19	.0630	.0699	.0761	.0814	.0856	.0887	.0905	.0911	.0905	.0888	
20	.0489	.0559	.0628	.0692	.0749	.0798	.0837	.0866	.0883	.0888	
21	.0361	.0426	.0493	.0560	.0624	.0684	.0738	.0783	.0820	.0846	
22	.0254	.0310	.0370	.0433	.0496	.0560	.0620	.0676	.0727	.0769	
23	.0171	.0216	.0265	.0320	.0378	.0438	.0499	.0559	.0616	.0669	
24	.0111	.0144	.0182	.0226	.0275	.0328	.0385	.0442	.0500	.0557	
25	.0069	.0092	.0120	.0154	.0193	.0237	.0285	.0336	.0390	.0446	
26	.0041	.0057	.0076	.0101	.0130	.0164	.0202	.0246	.0293	.0343	
27	.0023	.0034	.0047	.0063	.0084	.0109	.0139	.0173	.0211	.0254	
28	.0013	.0019	.0028	.0038	.0053	.0070	.0092	.0117	.0147	.0181	
29	.0007	.0011	.0016	.0023	.0032	.0044	.0058	.0077	.0099	.0125	
30	.0004	.0006	.0009	.0013	.0019	.0026	.0036	.0049	.0064	.0083	
31	.0002	.0003	.0005	.0007	.0010	.0015	.0022	.0030	.0040	.0054	
32	.0001	.0001	.0002	.0004	.0006	.0009	.0012	.0018	.0025	.0034	
33	.0000	.0001	.0001	.0002	.0003	.0005	.0007	.0010	.0015	.0020	
34	.0000	.0000	.0001	.0001	.0002	.0002	.0004	.0006	.0008	.0012	
35	.0000	.0000	.0000	.0000	.0001	.0001	.0002	.0003	.0005	.0007	
36	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0002	.0003	.0004	
37	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0001	.0002	
38	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	.0001	
39	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0001	
40	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	

**Table 3** The normal distribution

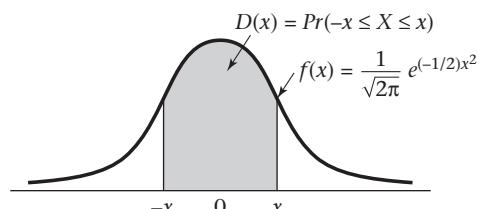
(a)



(b)



(c)



(d)

$x$	$A^a$	$B^b$	$C^c$	$D^d$	$x$	$A$	$B$	$C$	$D$
0.0	.5000	.5000	.0	.0	0.32	.6255	.3745	.1255	.2510
0.01	.5040	.4960	.0040	.0080	0.33	.6293	.3707	.1293	.2586
0.02	.5080	.4920	.0080	.0160	0.34	.6331	.3669	.1331	.2661
0.03	.5120	.4880	.0120	.0239	0.35	.6368	.3632	.1368	.2737
0.04	.5160	.4840	.0160	.0319	0.36	.6406	.3594	.1406	.2812
0.05	.5199	.4801	.0199	.0399	0.37	.6443	.3557	.1443	.2886
0.06	.5239	.4761	.0239	.0478	0.38	.6480	.3520	.1480	.2961
0.07	.5279	.4721	.0279	.0558	0.39	.6517	.3483	.1517	.3035
0.08	.5319	.4681	.0319	.0638	0.40	.6554	.3446	.1554	.3108
0.09	.5359	.4641	.0359	.0717	0.41	.6591	.3409	.1591	.3182
0.10	.5398	.4602	.0398	.0797	0.42	.6628	.3372	.1628	.3255
0.11	.5438	.4562	.0438	.0876	0.43	.6664	.3336	.1664	.3328
0.12	.5478	.4522	.0478	.0955	0.44	.6700	.3300	.1700	.3401
0.13	.5517	.4483	.0517	.1034	0.45	.6736	.3264	.1736	.3473
0.14	.5557	.4443	.0557	.1113	0.46	.6772	.3228	.1772	.3545
0.15	.5596	.4404	.0596	.1192	0.47	.6808	.3192	.1808	.3616
0.16	.5636	.4364	.0636	.1271	0.48	.6844	.3156	.1844	.3688
0.17	.5675	.4325	.0675	.1350	0.49	.6879	.3121	.1879	.3759
0.18	.5714	.4286	.0714	.1428	0.50	.6915	.3085	.1915	.3829
0.19	.5753	.4247	.0753	.1507	0.51	.6950	.3050	.1950	.3899
0.20	.5793	.4207	.0793	.1585	0.52	.6985	.3015	.1985	.3969
0.21	.5832	.4168	.0832	.1663	0.53	.7019	.2981	.2019	.4039
0.22	.5871	.4129	.0871	.1741	0.54	.7054	.2946	.2054	.4108
0.23	.5910	.4090	.0910	.1819	0.55	.7088	.2912	.2088	.4177
0.24	.5948	.4052	.0948	.1897	0.56	.7123	.2877	.2123	.4245
0.25	.5987	.4013	.0987	.1974	0.57	.7157	.2843	.2157	.4313
0.26	.6026	.3974	.1026	.2051	0.58	.7190	.2810	.2190	.4381
0.27	.6064	.3936	.1064	.2128	0.59	.7224	.2776	.2224	.4448
0.28	.6103	.3897	.1103	.2205	0.60	.7257	.2743	.2257	.4515
0.29	.6141	.3859	.1141	.2282	0.61	.7291	.2709	.2291	.4581
0.30	.6179	.3821	.1179	.2358	0.62	.7324	.2676	.2324	.4647
0.31	.6217	.3783	.1217	.2434	0.63	.7357	.2643	.2357	.4713

(continued on next page)

**Table 3** The normal distribution (*continued*)

<i>x</i>	<i>A</i> <sup>a</sup>	<i>B</i> <sup>b</sup>	<i>C</i> <sup>c</sup>	<i>D</i> <sup>d</sup>	<i>x</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
0.64	.7389	.2611	.2389	.4778	1.23	.8907	.1093	.3907	.7813
0.65	.7422	.2578	.2422	.4843	1.24	.8925	.1075	.3925	.7850
0.66	.7454	.2546	.2454	.4907	1.25	.8944	.1056	.3944	.7887
0.67	.7486	.2514	.2486	.4971	1.26	.8962	.1038	.3962	.7923
0.68	.7517	.2483	.2517	.5035	1.27	.8980	.1020	.3980	.7959
0.69	.7549	.2451	.2549	.5098	1.28	.8997	.1003	.3997	.7995
0.70	.7580	.2420	.2580	.5161	1.29	.9015	.0985	.4015	.8029
0.71	.7611	.2389	.2611	.5223	1.30	.9032	.0968	.4032	.8064
0.72	.7642	.2358	.2642	.5285	1.31	.9049	.0951	.4049	.8098
0.73	.7673	.2327	.2673	.5346	1.32	.9066	.0934	.4066	.8132
0.74	.7703	.2297	.2703	.5407	1.33	.9082	.0918	.4082	.8165
0.75	.7734	.2266	.2734	.5467	1.34	.9099	.0901	.4099	.8198
0.76	.7764	.2236	.2764	.5527	1.35	.9115	.0885	.4115	.8230
0.77	.7793	.2207	.2793	.5587	1.36	.9131	.0869	.4131	.8262
0.78	.7823	.2177	.2823	.5646	1.37	.9147	.0853	.4147	.8293
0.79	.7852	.2148	.2852	.5705	1.38	.9162	.0838	.4162	.8324
0.80	.7881	.2119	.2881	.5763	1.39	.9177	.0823	.4177	.8355
0.81	.7910	.2090	.2910	.5821	1.40	.9192	.0808	.4192	.8385
0.82	.7939	.2061	.2939	.5878	1.41	.9207	.0793	.4207	.8415
0.83	.7967	.2033	.2967	.5935	1.42	.9222	.0778	.4222	.8444
0.84	.7995	.2005	.2995	.5991	1.43	.9236	.0764	.4236	.8473
0.85	.8023	.1977	.3023	.6047	1.44	.9251	.0749	.4251	.8501
0.86	.8051	.1949	.3051	.6102	1.45	.9265	.0735	.4265	.8529
0.87	.8078	.1922	.3078	.6157	1.46	.9279	.0721	.4279	.8557
0.88	.8106	.1894	.3106	.6211	1.47	.9292	.0708	.4292	.8584
0.89	.8133	.1867	.3133	.6265	1.48	.9306	.0694	.4306	.8611
0.90	.8159	.1841	.3159	.6319	1.49	.9319	.0681	.4319	.8638
0.91	.8186	.1814	.3186	.6372	1.50	.9332	.0668	.4332	.8664
0.92	.8212	.1788	.3212	.6424	1.51	.9345	.0655	.4345	.8690
0.93	.8238	.1762	.3238	.6476	1.52	.9357	.0643	.4357	.8715
0.94	.8264	.1736	.3264	.6528	1.53	.9370	.0630	.4370	.8740
0.95	.8289	.1711	.3289	.6579	1.54	.9382	.0618	.4382	.8764
0.96	.8315	.1685	.3315	.6629	1.55	.9394	.0606	.4394	.8789
0.97	.8340	.1660	.3340	.6680	1.56	.9406	.0594	.4406	.8812
0.98	.8365	.1635	.3365	.6729	1.57	.9418	.0582	.4418	.8836
0.99	.8389	.1611	.3389	.6778	1.58	.9429	.0571	.4429	.8859
1.00	.8413	.1587	.3413	.6827	1.59	.9441	.0559	.4441	.8882
1.01	.8438	.1562	.3438	.6875	1.60	.9452	.0548	.4452	.8904
1.02	.8461	.1539	.3461	.6923	1.61	.9463	.0537	.4463	.8926
1.03	.8485	.1515	.3485	.6970	1.62	.9474	.0526	.4474	.8948
1.04	.8508	.1492	.3508	.7017	1.63	.9484	.0516	.4484	.8969
1.05	.8531	.1469	.3531	.7063	1.64	.9495	.0505	.4495	.8990
1.06	.8554	.1446	.3554	.7109	1.65	.9505	.0495	.4505	.9011
1.07	.8577	.1423	.3577	.7154	1.66	.9515	.0485	.4515	.9031
1.08	.8599	.1401	.3599	.7199	1.67	.9525	.0475	.4525	.9051
1.09	.8621	.1379	.3621	.7243	1.68	.9535	.0465	.4535	.9070
1.10	.8643	.1357	.3643	.7287	1.69	.9545	.0455	.4545	.9090
1.11	.8665	.1335	.3665	.7330	1.70	.9554	.0446	.4554	.9109
1.12	.8686	.1314	.3686	.7373	1.71	.9564	.0436	.4564	.9127
1.13	.8708	.1292	.3708	.7415	1.72	.9573	.0427	.4573	.9146
1.14	.8729	.1271	.3729	.7457	1.73	.9582	.0418	.4582	.9164
1.15	.8749	.1251	.3749	.7499	1.74	.9591	.0409	.4591	.9181
1.16	.8770	.1230	.3770	.7540	1.75	.9599	.0401	.4599	.9199
1.17	.8790	.1210	.3790	.7580	1.76	.9608	.0392	.4608	.9216
1.18	.8810	.1190	.3810	.7620	1.77	.9616	.0384	.4616	.9233
1.19	.8830	.1170	.3830	.7660	1.78	.9625	.0375	.4625	.9249
1.20	.8849	.1151	.3849	.7699	1.79	.9633	.0367	.4633	.9265
1.21	.8869	.1131	.3869	.7737	1.80	.9641	.0359	.4641	.9281
1.22	.8888	.1112	.3888	.7775	1.81	.9649	.0351	.4649	.9297

(continued on next page)

**Table 3** The normal distribution (*continued*)

<i>x</i>	<i>A</i> <sup>a</sup>	<i>B</i> <sup>b</sup>	<i>C</i> <sup>c</sup>	<i>D</i> <sup>d</sup>	<i>x</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
1.82	.9656	.0344	.4656	.9312	2.39	.9916	.0084	.4916	.9832
1.83	.9664	.0336	.4664	.9327	2.40	.9918	.0082	.4918	.9836
1.84	.9671	.0329	.4671	.9342	2.41	.9920	.0080	.4920	.9840
1.85	.9678	.0322	.4678	.9357	2.42	.9922	.0078	.4922	.9845
1.86	.9686	.0314	.4686	.9371	2.43	.9925	.0075	.4925	.9849
1.87	.9693	.0307	.4693	.9385	2.44	.9927	.0073	.4927	.9853
1.88	.9699	.0301	.4699	.9399	2.45	.9929	.0071	.4929	.9857
1.89	.9706	.0294	.4706	.9412	2.46	.9931	.0069	.4931	.9861
1.90	.9713	.0287	.4713	.9426	2.47	.9932	.0068	.4932	.9865
1.91	.9719	.0281	.4719	.9439	2.48	.9934	.0066	.4934	.9869
1.92	.9726	.0274	.4726	.9451	2.49	.9936	.0064	.4936	.9872
1.93	.9732	.0268	.4732	.9464	2.50	.9938	.0062	.4938	.9876
1.94	.9738	.0262	.4738	.9476	2.51	.9940	.0060	.4940	.9879
1.95	.9744	.0256	.4744	.9488	2.52	.9941	.0059	.4941	.9883
1.96	.9750	.0250	.4750	.9500	2.53	.9943	.0057	.4943	.9886
1.97	.9756	.0244	.4756	.9512	2.54	.9945	.0055	.4945	.9889
1.98	.9761	.0239	.4761	.9523	2.55	.9946	.0054	.4946	.9892
1.99	.9767	.0233	.4767	.9534	2.56	.9948	.0052	.4948	.9895
2.00	.9772	.0228	.4772	.9545	2.57	.9949	.0051	.4949	.9898
2.01	.9778	.0222	.4778	.9556	2.58	.9951	.0049	.4951	.9901
2.02	.9783	.0217	.4783	.9566	2.59	.9952	.0048	.4952	.9904
2.03	.9788	.0212	.4788	.9576	2.60	.9953	.0047	.4953	.9907
2.04	.9793	.0207	.4793	.9586	2.61	.9955	.0045	.4955	.9909
2.05	.9798	.0202	.4798	.9596	2.62	.9956	.0044	.4956	.9912
2.06	.9803	.0197	.4803	.9606	2.63	.9957	.0043	.4957	.9915
2.07	.9808	.0192	.4808	.9615	2.64	.9959	.0041	.4959	.9917
2.08	.9812	.0188	.4812	.9625	2.65	.9960	.0040	.4960	.9920
2.09	.9817	.0183	.4817	.9634	2.66	.9961	.0039	.4961	.9922
2.10	.9821	.0179	.4821	.9643	2.67	.9962	.0038	.4962	.9924
2.11	.9826	.0174	.4826	.9651	2.68	.9963	.0037	.4963	.9926
2.12	.9830	.0170	.4830	.9660	2.69	.9964	.0036	.4964	.9929
2.13	.9834	.0166	.4834	.9668	2.70	.9965	.0035	.4965	.9931
2.14	.9838	.0162	.4838	.9676	2.71	.9966	.0034	.4966	.9933
2.15	.9842	.0158	.4842	.9684	2.72	.9967	.0033	.4967	.9935
2.16	.9846	.0154	.4846	.9692	2.73	.9968	.0032	.4968	.9937
2.17	.9850	.0150	.4850	.9700	2.74	.9969	.0031	.4969	.9939
2.18	.9854	.0146	.4854	.9707	2.75	.9970	.0030	.4970	.9940
2.19	.9857	.0143	.4857	.9715	2.76	.9971	.0029	.4971	.9942
2.20	.9861	.0139	.4861	.9722	2.77	.9972	.0028	.4972	.9944
2.21	.9864	.0136	.4864	.9729	2.78	.9973	.0027	.4973	.9946
2.22	.9868	.0132	.4868	.9736	2.79	.9974	.0026	.4974	.9947
2.23	.9871	.0129	.4871	.9743	2.80	.9974	.0026	.4974	.9949
2.24	.9875	.0125	.4875	.9749	2.81	.9975	.0025	.4975	.9950
2.25	.9878	.0122	.4878	.9756	2.82	.9976	.0024	.4976	.9952
2.26	.9881	.0119	.4881	.9762	2.83	.9977	.0023	.4977	.9953
2.27	.9884	.0116	.4884	.9768	2.84	.9977	.0023	.4977	.9955
2.28	.9887	.0113	.4887	.9774	2.85	.9978	.0022	.4978	.9956
2.29	.9890	.0110	.4890	.9780	2.86	.9979	.0021	.4979	.9958
2.30	.9893	.0107	.4893	.9786	2.87	.9979	.0021	.4979	.9959
2.31	.9896	.0104	.4896	.9791	2.88	.9980	.0020	.4980	.9960
2.32	.9898	.0102	.4898	.9797	2.89	.9981	.0019	.4981	.9961
2.33	.9901	.0099	.4901	.9802	2.90	.9981	.0019	.4981	.9963
2.34	.9904	.0096	.4904	.9807	2.91	.9982	.0018	.4982	.9964
2.35	.9906	.0094	.4906	.9812	2.92	.9982	.0018	.4982	.9965
2.36	.9909	.0091	.4909	.9817	2.93	.9983	.0017	.4983	.9966
2.37	.9911	.0089	.4911	.9822	2.94	.9984	.0016	.4984	.9967
2.38	.9913	.0087	.4913	.9827	2.95	.9984	.0016	.4984	.9968

(continued on next page)

**Table 3** The normal distribution (*continued*)

<i>x</i>	<i>A</i> <sup>a</sup>	<i>B</i> <sup>b</sup>	<i>C</i> <sup>c</sup>	<i>D</i> <sup>d</sup>	<i>x</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>
2.96	.9985	.0015	.4985	.9969	3.49	.9998	.0002	.4998	.9995
2.97	.9985	.0015	.4985	.9970	3.50	.9998	.0002	.4998	.9995
2.98	.9986	.0014	.4986	.9971	3.51	.9998	.0002	.4998	.9996
2.99	.9986	.0014	.4986	.9972	3.52	.9998	.0002	.4998	.9996
3.00	.9987	.0013	.4987	.9973	3.53	.9998	.0002	.4998	.9996
3.01	.9987	.0013	.4987	.9974	3.54	.9998	.0002	.4998	.9996
3.02	.9987	.0013	.4987	.9975	3.55	.9998	.0002	.4998	.9996
3.03	.9988	.0012	.4988	.9976	3.56	.9998	.0002	.4998	.9996
3.04	.9988	.0012	.4988	.9976	3.57	.9998	.0002	.4998	.9996
3.05	.9989	.0011	.4989	.9977	3.58	.9998	.0002	.4998	.9997
3.06	.9989	.0011	.4989	.9978	3.59	.9998	.0002	.4998	.9997
3.07	.9989	.0011	.4989	.9979	3.60	.9998	.0002	.4998	.9997
3.08	.9990	.0010	.4990	.9979	3.61	.9998	.0002	.4998	.9997
3.09	.9990	.0010	.4990	.9980	3.62	.9999	.0001	.4999	.9997
3.10	.9990	.0010	.4990	.9981	3.63	.9999	.0001	.4999	.9997
3.11	.9991	.0009	.4991	.9981	3.64	.9999	.0001	.4999	.9997
3.12	.9991	.0009	.4991	.9982	3.65	.9999	.0001	.4999	.9997
3.13	.9991	.0009	.4991	.9983	3.66	.9999	.0001	.4999	.9997
3.14	.9992	.0008	.4992	.9983	3.67	.9999	.0001	.4999	.9998
3.15	.9992	.0008	.4992	.9984	3.68	.9999	.0001	.4999	.9998
3.16	.9992	.0008	.4992	.9984	3.69	.9999	.0001	.4999	.9998
3.17	.9992	.0008	.4992	.9985	3.70	.9999	.0001	.4999	.9998
3.18	.9993	.0007	.4993	.9985	3.71	.9999	.0001	.4999	.9998
3.19	.9993	.0007	.4993	.9986	3.72	.9999	.0001	.4999	.9998
3.20	.9993	.0007	.4993	.9986	3.73	.9999	.0001	.4999	.9998
3.21	.9993	.0007	.4993	.9987	3.74	.9999	.0001	.4999	.9998
3.22	.9994	.0006	.4994	.9987	3.75	.9999	.0001	.4999	.9998
3.23	.9994	.0006	.4994	.9988	3.76	.9999	.0001	.4999	.9998
3.24	.9994	.0006	.4994	.9988	3.77	.9999	.0001	.4999	.9998
3.25	.9994	.0006	.4994	.9988	3.78	.9999	.0001	.4999	.9998
3.26	.9994	.0006	.4994	.9989	3.79	.9999	.0001	.4999	.9998
3.27	.9995	.0005	.4995	.9989	3.80	.9999	.0001	.4999	.9999
3.28	.9995	.0005	.4995	.9990	3.81	.9999	.0001	.4999	.9999
3.29	.9995	.0005	.4995	.9990	3.82	.9999	.0001	.4999	.9999
3.30	.9995	.0005	.4995	.9990	3.83	.9999	.0001	.4999	.9999
3.31	.9995	.0005	.4995	.9991	3.84	.9999	.0001	.4999	.9999
3.32	.9995	.0005	.4995	.9991	3.85	.9999	.0001	.4999	.9999
3.33	.9996	.0004	.4996	.9991	3.86	.9999	.0001	.4999	.9999
3.34	.9996	.0004	.4996	.9992	3.87	.9999	.0001	.4999	.9999
3.35	.9996	.0004	.4996	.9992	3.88	.9999	.0001	.4999	.9999
3.36	.9996	.0004	.4996	.9992	3.89	.9999	.0001	.4999	.9999
3.37	.9996	.0004	.4996	.9992	3.90	1.0000	.0000	.5000	.9999
3.38	.9996	.0004	.4996	.9993	3.91	1.0000	.0000	.5000	.9999
3.39	.9997	.0003	.4997	.9993	3.92	1.0000	.0000	.5000	.9999
3.40	.9997	.0003	.4997	.9993	3.93	1.0000	.0000	.5000	.9999
3.42	.9997	.0003	.4997	.9994	3.94	1.0000	.0000	.5000	.9999
3.43	.9997	.0003	.4997	.9994	3.95	1.0000	.0000	.5000	.9999
3.45	.9997	.0003	.4997	.9994	3.96	1.0000	.0000	.5000	.9999
3.46	.9997	.0003	.4997	.9995	3.97	1.0000	.0000	.5000	.9999
3.47	.9997	.0003	.4997	.9995	3.98	1.0000	.0000	.5000	.9999
3.48	.9997	.0003	.4997	.9995	3.99	1.0000	.0000	.5000	.9999

<sup>a</sup> $A(x) = \Phi(x) = P(X \leq x)$ , where  $X$  is a standard normal distribution.<sup>b</sup> $B(x) = 1 - \Phi(x) = P(X > x)$ , where  $X$  is a standard normal distribution.<sup>c</sup> $C(x) = P(0 \leq X \leq x)$ , where  $X$  is a standard normal distribution.<sup>d</sup> $D(x) = P(-x \leq X \leq x)$ , where  $X$  is a standard normal distribution.

**Table 4 Table of 1000 random digits**

01	32924	22324	18125	09077	26	96772	16443	39877	04653
02	54632	90374	94143	49295	27	52167	21038	14338	01395
03	88720	43035	97081	83373	28	69644	37198	00028	98195
04	21727	11904	41513	31653	29	71011	62004	81712	87536
05	80985	70799	57975	69282	30	31217	75877	85366	55500
06	40412	58826	94868	52632	31	64990	98735	02999	35521
07	43918	56807	75218	46077	32	48417	23569	59307	46550
08	26513	47480	77410	47741	33	07900	65059	48592	44087
09	18164	35784	44255	30124	34	74526	32601	24482	16981
10	39446	01375	75264	51173	35	51056	04402	58353	37332
11	16638	04680	98617	90298	36	39005	93458	63143	21817
12	16872	94749	44012	48884	37	67883	76343	78155	67733
13	65419	87092	78596	91512	38	06014	60999	87226	36071
14	05207	36702	56804	10498	39	93147	88766	04148	42471
15	78807	79243	13729	81222	40	01099	95731	47622	13294
16	69341	79028	64253	80447	41	89252	01201	58138	13809
17	41871	17566	61200	15994	42	41766	57239	50251	64675
18	25758	04625	43226	32986	43	92736	77800	81996	45646
19	06604	94486	40174	10742	44	45118	36600	68977	68831
20	82259	56512	48945	18183	45	73457	01579	00378	70197
21	07895	37090	50627	71320	46	49465	85251	42914	17277
22	59836	71148	42320	67816	47	15745	37285	23768	39302
23	57133	76610	89104	30481	48	28760	81331	78265	60690
24	76964	57126	87174	61025	49	82193	32787	70451	91141
25	27694	17145	32439	68245	50	89664	50242	12382	39379

**Table 5** Percentage points of the *t* distribution ( $t_{d,u}$ )<sup>a</sup>

Degrees of freedom, $d$	<i>u</i>								
	.75	.80	.85	.90	.95	.975	.99	.995	.9995
1	1.000	1.376	1.963	3.078	6.314	12.706	31.821	63.657	636.619
2	0.816	1.061	1.386	1.886	2.920	4.303	6.965	9.925	31.598
3	0.765	0.978	1.250	1.638	2.353	3.182	4.541	5.841	12.924
4	0.741	0.941	1.190	1.533	2.132	2.776	3.747	4.604	8.610
5	0.727	0.920	1.156	1.476	2.015	2.571	3.365	4.032	6.869
6	0.718	0.906	1.134	1.440	1.943	2.447	3.143	3.707	5.959
7	0.711	0.896	1.119	1.415	1.895	2.365	2.998	3.499	5.408
8	0.706	0.889	1.108	1.397	1.860	2.306	2.896	3.355	5.041
9	0.703	0.883	1.100	1.383	1.833	2.262	2.821	3.250	4.781
10	0.700	0.879	1.093	1.372	1.812	2.228	2.764	3.169	4.587
11	0.697	0.876	1.088	1.363	1.796	2.201	2.718	3.106	4.437
12	0.695	0.873	1.083	1.356	1.782	2.179	2.681	3.055	4.318
13	0.694	0.870	1.079	1.350	1.771	2.160	2.650	3.012	4.221
14	0.692	0.868	1.076	1.345	1.761	2.145	2.624	2.977	4.140
15	0.691	0.866	1.074	1.341	1.753	2.131	2.602	2.947	4.073
16	0.690	0.865	1.071	1.337	1.746	2.120	2.583	2.921	4.015
17	0.689	0.863	1.069	1.333	1.740	2.110	2.567	2.898	3.965
18	0.688	0.862	1.067	1.330	1.734	2.101	2.552	2.878	3.922
19	0.688	0.861	1.066	1.328	1.729	2.093	2.539	2.861	3.883
20	0.687	0.860	1.064	1.325	1.725	2.086	2.528	2.845	3.850
21	0.686	0.859	1.063	1.323	1.721	2.080	2.518	2.831	3.819
22	0.686	0.858	1.061	1.321	1.717	2.074	2.508	2.819	3.792
23	0.685	0.858	1.060	1.319	1.714	2.069	2.500	2.807	3.767
24	0.685	0.857	1.059	1.318	1.711	2.064	2.492	2.797	3.745
25	0.684	0.856	1.058	1.316	1.708	2.060	2.485	2.787	3.725
26	0.684	0.856	1.058	1.315	1.706	2.056	2.479	2.779	3.707
27	0.684	0.855	1.057	1.314	1.703	2.052	2.473	2.771	3.690
28	0.683	0.855	1.056	1.313	1.701	2.048	2.467	2.763	3.674
29	0.683	0.854	1.055	1.311	1.699	2.045	2.462	2.756	3.659
30	0.683	0.854	1.055	1.310	1.697	2.042	2.457	2.750	3.646
40	0.681	0.851	1.050	1.303	1.684	2.021	2.423	2.704	3.551
60	0.679	0.848	1.046	1.296	1.671	2.000	2.390	2.660	3.460
120	0.677	0.845	1.041	1.289	1.658	1.980	2.358	2.617	3.373
$\infty$	0.674	0.842	1.036	1.282	1.645	1.960	2.326	2.576	3.291

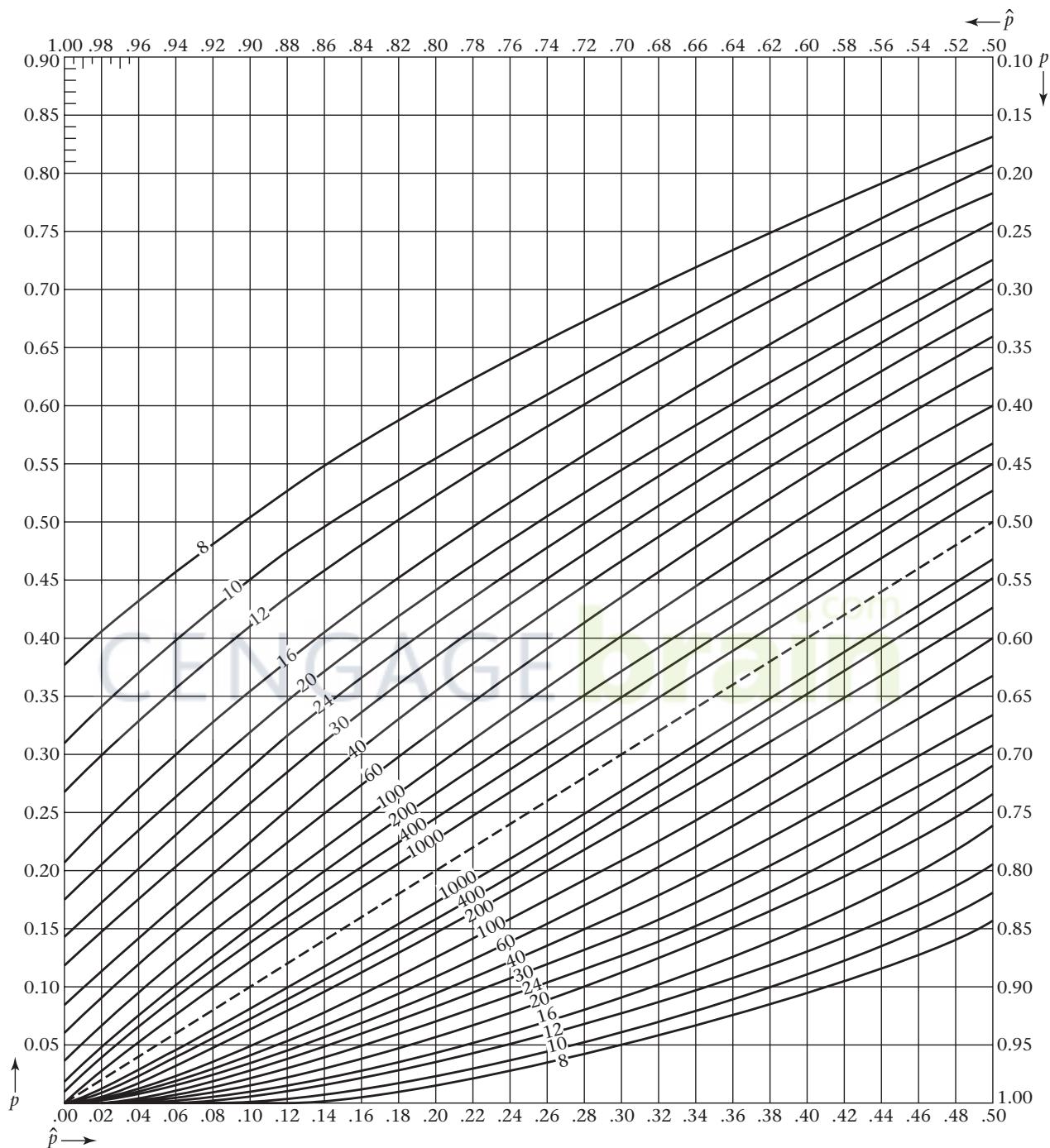
<sup>a</sup>The *u*th percentile of a *t* distribution with *d* degrees of freedom.

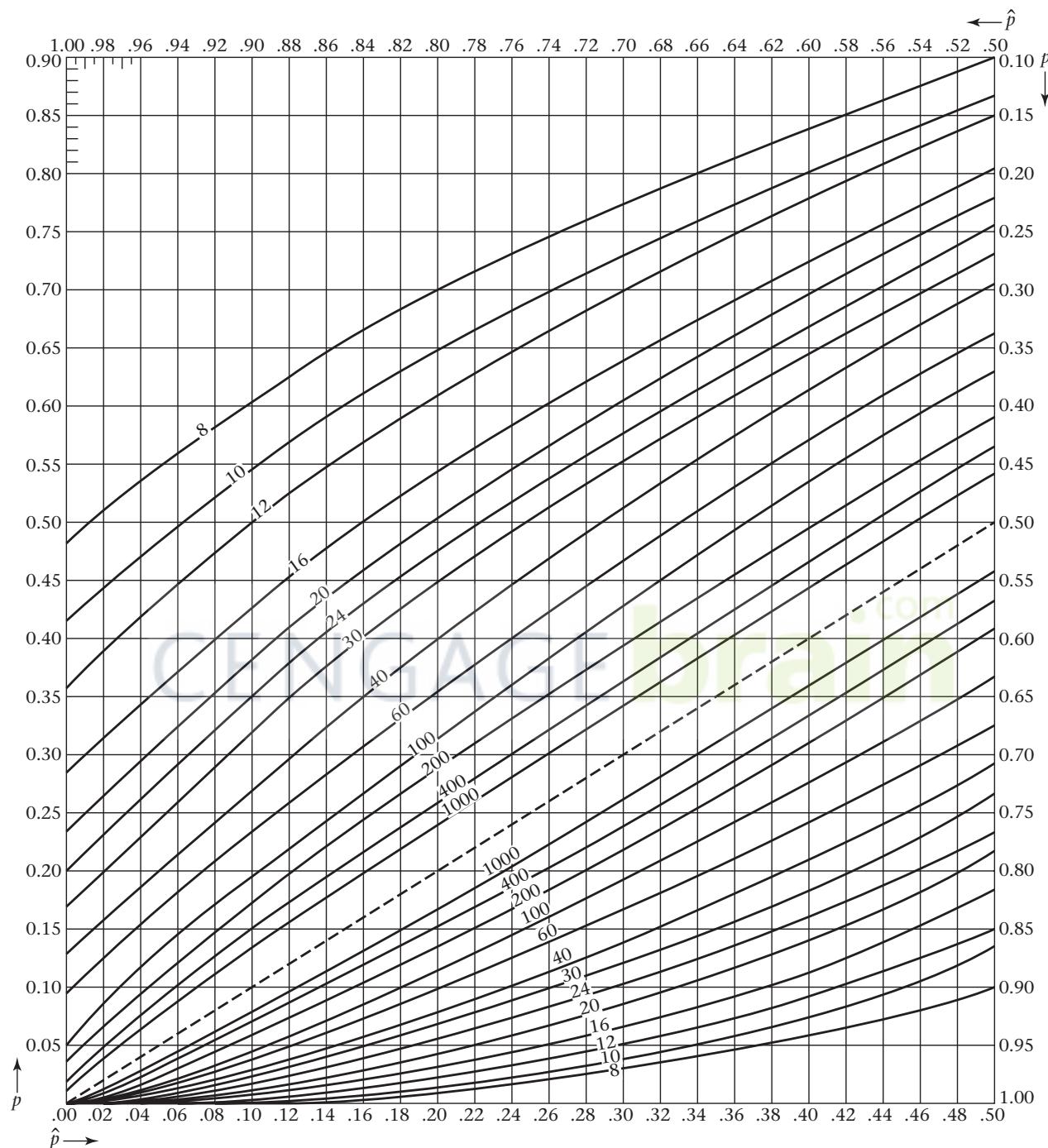
Source: Table 5 is taken from Table III of Fisher and Yates: "Statistical Tables for Biological, Agricultural and Medical Research," published by Longman Group Ltd., London (previously published by Oliver and Boyd Ltd., Edinburgh). Reprinted by permission of Pearson Education Ltd.

**Table 6** Percentage points of the chi-square distribution ( $\chi^2_{d,u}$ )<sup>a</sup>

d	u													
	.005	.01	.025	.05	.10	.25	.50	.75	.90	.95	.975	.99	.995	.999
1	0.0 <sup>b</sup> 393 <sup>b</sup>	0.0 <sup>b</sup> 157 <sup>c</sup>	0.0 <sup>b</sup> 982 <sup>d</sup>	0.00393	0.02	0.10	0.45	1.32	2.71	3.84	5.02	6.63	7.88	10.83
2	0.0100	0.0201	0.0506	0.103	0.21	0.58	1.39	2.77	4.61	5.99	7.38	9.21	10.60	13.81
3	0.0717	0.115	0.216	0.352	0.58	1.21	2.37	4.11	6.25	7.81	9.35	11.34	12.84	16.27
4	0.207	0.297	0.484	0.711	1.06	1.92	3.36	5.39	7.78	9.49	11.14	13.28	14.86	18.47
5	0.412	0.554	0.831	1.15	1.61	2.67	4.35	6.63	9.24	11.07	12.83	15.09	16.75	20.52
6	0.676	0.872	1.24	1.64	2.20	3.45	5.35	7.84	10.64	12.59	14.45	16.81	18.55	22.46
7	0.989	1.24	1.69	2.17	2.83	4.25	6.35	9.04	12.02	14.07	16.01	18.48	20.28	24.32
8	1.34	1.65	2.18	2.73	3.49	5.07	7.34	10.22	13.36	15.51	17.53	20.09	21.95	26.12
9	1.73	2.09	2.70	3.33	4.17	5.90	8.34	11.39	14.68	16.92	19.02	21.67	23.59	27.88
10	2.16	2.56	3.25	3.94	4.87	6.74	9.34	12.55	15.99	18.31	20.48	23.21	25.19	29.59
11	2.60	3.05	3.82	4.57	5.58	7.58	10.34	13.70	17.28	19.68	21.92	24.72	26.76	31.26
12	3.07	3.57	4.40	5.23	6.30	8.44	11.34	14.85	18.55	21.03	23.34	26.22	28.30	32.91
13	3.57	4.11	5.01	5.89	7.04	9.30	12.34	15.98	19.81	22.36	24.74	27.69	29.82	34.53
14	4.07	4.66	5.63	6.57	7.79	10.17	13.34	17.12	21.06	23.68	26.12	29.14	31.32	36.12
15	4.60	5.23	6.27	7.26	8.55	11.04	14.34	18.25	22.31	25.00	27.49	30.58	32.80	37.70
16	5.14	5.81	6.91	7.96	9.31	11.91	15.34	19.37	23.54	26.30	28.85	32.00	34.27	39.25
17	5.70	6.41	7.56	8.67	10.09	12.79	16.34	20.49	24.77	27.59	30.19	33.41	35.72	40.79
18	6.26	7.01	8.23	9.39	10.86	13.68	17.34	21.60	25.99	28.87	31.53	34.81	37.16	42.31
19	6.84	7.63	8.91	10.12	11.65	14.56	18.34	22.72	27.20	30.14	32.85	36.19	38.58	43.82
20	7.43	8.26	9.59	10.85	12.44	15.45	19.34	23.83	28.41	31.41	34.17	37.57	40.00	45.32
21	8.03	8.90	10.28	11.59	13.24	16.34	20.34	24.93	29.62	32.67	35.48	38.93	41.40	46.80
22	8.64	9.54	10.98	12.34	14.04	17.24	21.34	26.04	30.81	33.92	36.78	40.29	42.80	48.27
23	9.26	10.20	11.69	13.09	14.85	18.14	22.34	27.14	32.01	35.17	38.08	41.64	44.18	49.73
24	9.89	10.86	12.40	13.85	15.66	19.04	23.34	28.24	33.20	36.42	39.36	42.98	45.56	51.18
25	10.52	11.52	13.12	14.61	16.47	19.94	24.34	29.34	34.38	37.65	40.65	44.31	46.93	52.62
26	11.16	12.20	13.84	15.38	17.29	20.84	25.34	30.43	35.56	38.89	41.92	45.64	48.29	54.05
27	11.81	12.88	14.57	16.15	18.11	21.75	26.34	31.53	36.74	40.11	43.19	46.96	49.64	55.48
28	12.46	13.56	15.31	16.93	18.94	22.66	27.34	32.62	37.92	41.34	44.46	48.28	50.99	56.89
29	13.12	14.26	16.05	17.71	19.77	23.57	28.34	33.71	39.09	42.56	45.72	49.59	52.34	58.30
30	13.79	14.95	16.79	18.49	20.60	24.48	29.34	34.80	40.26	43.77	46.98	50.89	53.67	59.70
40	20.71	22.16	24.43	26.51	29.05	33.66	39.34	45.62	51.81	55.76	59.34	63.69	66.77	73.40
50	27.99	29.71	32.36	34.76	37.69	42.94	49.33	56.33	63.17	67.50	71.42	76.15	79.49	86.66
60	35.53	37.48	40.48	43.19	46.46	52.29	59.33	66.98	74.40	79.08	83.30	88.38	91.95	99.61
70	43.28	45.44	48.76	51.74	55.33	61.70	69.33	77.58	85.53	90.53	95.02	100.42	104.22	112.32
80	51.17	53.54	57.15	60.39	64.28	71.14	79.33	88.13	96.58	101.88	106.63	112.33	116.32	124.84
90	59.20	61.75	65.65	69.13	73.29	80.62	89.33	98.64	107.56	113.14	118.14	124.12	128.30	137.21
100	67.33	70.06	74.22	77.93	82.36	90.13	99.33	109.14	118.50	124.34	129.56	135.81	140.17	149.45

<sup>a</sup> $\chi^2_{d,u}$  = *u*th percentile of a  $\chi^2$  distribution with *d* degrees of freedom.<sup>b</sup> = 0.0000393<sup>c</sup> = 0.000157<sup>d</sup> = 0.000982Source: Reproduced in part with permission of the Biometrika Trustees, from Table 3 of *Biometrika Tables for Statisticians*, Volume 2, edited by E. S. Pearson and H. O. Hartley, published for the Biometrika Trustees, Cambridge University Press, Cambridge, England, 1972.

**Table 7a** Exact two-sided 100%  $\times (1 - \alpha)$  confidence limits for binomial proportions ( $\alpha = .05$ )

**Table 7b** Exact two-sided 100%  $\times (1 - \alpha)$  confidence limits for binomial proportions ( $\alpha = .01$ )

Source: Tables 7a and 7b have been reproduced with permission of Biometrika Trustees, from Table 41 of *Biometrika Tables for Statisticians*, 3rd edition, Volume 1, edited by E. S. Pearson and H. O. Hartley. Published for the Biometrika Trustees, Cambridge, 1966.

**Table 8** Confidence limits for the expectation of a Poisson variable ( $\mu$ )

(1 - $\alpha$ )	Confidence level ( $1 - \alpha$ )											
	0.998		0.99		0.98		0.95		0.90		(1 - $2\alpha$ )	
	x	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	x
<b>0</b>	0.00000	6.91	0.00000	5.30	0.0000	4.61	0.0000	3.69	0.0000	3.00	<b>0</b>	
<b>1</b>	.00100	9.23	.00501	7.43	.0101	6.64	.0253	5.57	.0513	4.74	<b>1</b>	
<b>2</b>	.0454	11.23	.103	9.27	.149	8.41	.242	7.22	.355	6.30	<b>2</b>	
<b>3</b>	.191	13.06	.338	10.98	.436	10.05	.619	8.77	.818	7.75	<b>3</b>	
<b>4</b>	.429	14.79	.672	12.59	.823	11.60	1.09	10.24	1.37	9.15	<b>4</b>	
<b>5</b>	0.739	16.45	1.08	14.15	1.28	13.11	1.62	11.67	1.97	10.51	<b>5</b>	
<b>6</b>	1.11	18.06	1.54	15.66	1.79	14.57	2.20	13.06	2.61	11.84	<b>6</b>	
<b>7</b>	1.52	19.63	2.04	17.13	2.33	16.00	2.81	14.42	3.29	13.15	<b>7</b>	
<b>8</b>	1.97	21.16	2.57	18.58	2.91	17.40	3.45	15.76	3.98	14.43	<b>8</b>	
<b>9</b>	2.45	22.66	3.13	20.00	3.51	18.78	4.12	17.08	4.70	15.71	<b>9</b>	
<b>10</b>	2.96	24.13	3.72	21.40	4.13	20.14	4.80	18.39	5.43	16.96	<b>10</b>	
<b>11</b>	3.49	25.59	4.32	22.78	4.77	21.49	5.49	19.68	6.17	18.21	<b>11</b>	
<b>12</b>	4.04	27.03	4.94	24.14	5.43	22.82	6.20	20.96	6.92	19.44	<b>12</b>	
<b>13</b>	4.61	28.45	5.58	25.50	6.10	24.14	6.92	22.23	7.69	20.67	<b>13</b>	
<b>14</b>	5.20	29.85	6.23	26.84	6.78	25.45	7.65	23.49	8.46	21.89	<b>14</b>	
<b>15</b>	5.79	31.24	6.89	28.16	7.48	26.74	8.40	24.74	9.25	23.10	<b>15</b>	
<b>16</b>	6.41	32.62	7.57	29.48	8.18	28.03	9.15	25.98	10.04	24.30	<b>16</b>	
<b>17</b>	7.03	33.99	8.25	30.79	8.89	29.31	9.90	27.22	10.83	25.50	<b>17</b>	
<b>18</b>	7.66	35.35	8.94	32.09	9.62	30.58	10.67	28.45	11.63	26.69	<b>18</b>	
<b>19</b>	8.31	36.70	9.64	33.38	10.35	31.85	11.44	29.67	12.44	27.88	<b>19</b>	
<b>20</b>	8.96	38.04	10.35	34.67	11.08	33.10	12.22	30.89	13.25	29.06	<b>20</b>	
<b>21</b>	9.62	39.38	11.07	35.95	11.82	34.36	13.00	32.10	14.07	30.24	<b>21</b>	
<b>22</b>	10.29	40.70	11.79	37.22	12.57	35.60	13.79	33.31	14.89	31.42	<b>22</b>	
<b>23</b>	10.96	42.02	12.52	38.48	13.33	36.84	14.58	34.51	15.72	32.59	<b>23</b>	
<b>24</b>	11.65	43.33	13.25	39.74	14.09	38.08	15.38	35.71	16.55	33.75	<b>24</b>	
<b>25</b>	12.34	44.64	14.00	41.00	14.85	39.31	16.18	36.90	17.38	34.92	<b>25</b>	
<b>26</b>	13.03	45.94	14.74	42.25	15.62	40.53	16.98	38.10	18.22	36.08	<b>26</b>	
<b>27</b>	13.73	47.23	15.49	43.50	16.40	41.76	17.79	39.28	19.06	37.23	<b>27</b>	
<b>28</b>	14.44	48.52	16.24	44.74	17.17	42.98	18.61	40.47	19.90	38.39	<b>28</b>	
<b>29</b>	15.15	49.80	17.00	45.98	17.96	44.19	19.42	41.65	20.75	39.54	<b>29</b>	
<b>30</b>	15.87	51.08	17.77	47.21	18.74	45.40	20.24	42.83	21.59	40.69	<b>30</b>	
<b>35</b>	19.52	57.42	21.64	53.32	22.72	51.41	24.38	48.68	25.87	46.40	<b>35</b>	
<b>40</b>	23.26	63.66	25.59	59.36	26.77	57.35	28.58	54.47	30.20	52.07	<b>40</b>	
<b>45</b>	27.08	69.83	29.60	65.34	30.88	63.23	32.82	60.21	34.56	57.69	<b>45</b>	
<b>50</b>	30.96	75.94	33.66	71.27	35.03	69.07	37.11	65.92	38.96	63.29	<b>50</b>	

Note: If  $X$  is the random variable denoting the observed number of events and  $\mu_1, \mu_2$  are the lower and upper confidence limits for its expectation,  $\mu$ , then  $P(\mu_1 \leq \mu \leq \mu_2) = 1 - \alpha$ .

Source: *Biometrika Tables for Statisticians*, 3rd edition, Volume 1, edited by E. S. Pearson and H. O. Hartley. Published for the Biometrika Trustees, Cambridge University Press, Cambridge, England, 1966.

**Table 9 Percentage points of the *F* distribution ( $F_{d_1, d_2, p}$ )**

		df for numerator, $d_1$										
df for denominator, $d_2$		df for numerator, $d_1$										
$d_2$	$p$	1	2	3	4	5	6	7	8	12	24	$\infty$
1	.90	39.86	49.50	53.59	55.83	57.24	58.20	58.91	59.44	60.71	62.00	63.33
	.95	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	243.9	249.1	254.3
	.975	647.8	799.5	864.2	899.6	921.8	937.1	948.2	956.7	976.7	997.2	1018.
	.99	4052.	5000.	5403.	5625.	5764.	5859.	5928.	5981.	6106.	6235.	6366.
	.995	16211.	20000.	21615.	22500.	23056.	23437.	23715.	23925.	24426.	24940.	25464.
	.999	405280.	500000.	540380.	562500.	576400.	585940.	592870.	598140.	610670.	623500.	636620.
2	.90	8.53	9.00	9.16	9.24	9.29	9.33	9.35	9.37	9.41	9.45	9.49
	.95	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.41	19.45	19.50
	.975	38.51	39.00	39.17	39.25	39.30	39.33	39.36	39.37	39.42	39.46	39.50
	.99	98.50	99.00	99.17	99.25	99.30	99.33	99.36	99.37	99.42	99.46	99.50
	.995	198.5	199.0	199.2	199.2	199.3	199.3	199.4	199.4	199.4	199.5	199.5
	.999	998.5	999.0	999.2	999.2	999.3	999.3	999.4	999.4	999.4	999.5	999.5
3	.90	5.54	5.46	5.39	5.34	5.31	5.28	5.27	5.25	5.22	5.18	5.13
	.95	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.74	8.64	8.53
	.975	17.44	16.04	15.44	15.10	14.88	14.74	14.62	14.54	14.34	14.12	13.90
	.99	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.05	26.60	26.13
	.995	55.55	49.80	47.47	46.20	45.39	44.84	44.43	44.13	43.39	42.62	41.83
	.999	167.00	148.5	141.1	137.1	134.6	132.8	131.6	130.6	128.3	125.9	123.5
4	.90	4.54	4.32	4.19	4.11	4.05	4.01	3.98	3.95	3.90	3.83	3.76
	.95	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	5.91	5.77	5.63
	.975	12.22	10.65	9.98	9.60	9.36	9.20	9.07	8.98	8.75	8.51	8.26
	.99	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80	14.37	13.93	13.46
	.995	31.33	26.28	24.26	23.16	22.46	21.98	21.62	21.35	20.70	20.03	19.32
	.999	74.14	61.25	56.18	53.44	51.71	50.53	49.66	49.00	47.41	45.77	44.05
5	.90	4.06	3.78	3.62	3.52	3.45	3.40	3.37	3.34	3.27	3.19	3.10
	.95	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.68	4.53	4.36
	.975	10.01	8.43	7.76	7.39	7.15	6.98	6.85	6.76	6.52	6.28	6.02
	.99	16.26	13.27	12.06	11.39	10.97	10.67	10.46	10.29	9.89	9.47	9.02
	.995	22.78	18.31	16.53	15.56	14.94	14.51	14.20	13.96	13.38	12.78	12.14
	.999	47.18	37.12	33.20	31.09	29.75	28.83	28.16	27.65	26.42	25.13	23.79
6	.90	3.78	3.46	3.29	3.18	3.11	3.05	3.01	2.98	2.90	2.82	2.72
	.95	5.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.00	3.84	3.67
	.975	8.81	7.26	6.60	6.23	5.99	5.82	5.70	5.60	5.37	5.12	4.85
	.99	13.75	10.92	9.78	9.15	8.75	8.47	8.26	8.10	7.72	7.31	6.88
	.995	18.64	14.54	12.92	12.03	11.46	11.07	10.79	10.57	10.03	9.47	8.88
	.999	35.51	27.00	23.70	21.92	20.80	20.03	19.46	19.03	17.99	16.90	15.75
7	.90	3.59	3.26	3.07	2.96	2.88	2.83	2.78	2.75	2.67	2.58	2.47
	.95	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.57	3.41	3.23
	.975	8.07	6.54	5.89	5.52	5.29	5.12	4.99	4.90	4.67	4.42	4.14
	.99	12.25	9.55	8.45	7.85	7.46	7.19	6.99	6.84	6.47	6.07	5.65
	.995	16.24	12.40	10.88	10.05	9.52	9.16	8.89	8.68	8.18	7.65	7.08
	.999	29.25	21.69	18.77	17.20	16.21	15.52	15.02	14.63	13.71	12.73	11.70
8	.90	3.46	3.11	2.92	2.81	2.73	2.67	2.62	2.59	2.50	2.40	2.29
	.95	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.28	3.12	2.93
	.975	7.57	6.06	5.42	5.05	4.82	4.65	4.53	4.43	4.20	3.95	3.67
	.99	11.26	8.65	7.59	7.01	6.63	6.37	6.18	6.03	5.67	5.28	4.86
	.995	14.69	11.04	9.60	8.81	8.30	7.95	7.69	7.50	7.01	6.50	5.95
	.999	25.42	18.49	15.83	14.39	13.49	12.86	12.40	12.04	11.19	10.30	9.33
9	.90	3.36	3.01	2.81	2.69	2.61	2.55	2.51	2.47	2.38	2.28	2.16
	.95	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.07	2.90	2.71
	.975	7.21	5.71	5.08	4.72	4.48	4.32	4.20	4.10	3.87	3.61	3.33
	.99	10.56	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.11	4.73	4.31
	.995	13.61	10.11	8.72	7.96	7.47	7.13	6.88	6.69	6.23	5.73	5.19
	.999	22.86	16.39	13.90	12.56	11.71	11.13	10.70	10.37	9.57	8.72	7.81
10	.90	3.29	2.92	2.73	2.61	2.52	2.46	2.41	2.38	2.28	2.18	2.06
	.95	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	2.91	2.74	2.54
	.975	6.94	5.46	4.83	4.47	4.24	4.07	3.95	3.85	3.62	3.37	3.08
	.99	10.04	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.71	4.33	3.91
	.995	12.83	9.43	8.08	7.34	6.87	6.54	6.30	6.12	5.66	5.17	4.64
	.999	21.04	14.91	12.55	11.28	10.48	9.93	9.52	9.20	8.45	7.64	6.76
12	.90	3.18	2.81	2.61	2.48	2.39	2.33	2.28	2.24	2.15	2.04	1.90
	.95	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.69	2.51	2.30
	.975	6.55	5.10	4.47	4.12	3.89	3.73	3.61	3.51	3.28	3.02	2.72

(continued on next page)

**Table 9 Percentage points of the  $F$  distribution ( $F_{d_1, d_2, p}$ ) (continued)**

df for denominator, $d_2$		df for numerator, $d_1$										
		1	2	3	4	5	6	7	8	12	24	
14	.99	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.16	3.78	3.36
	.995	11.75	8.51	7.23	6.52	6.07	5.76	5.52	5.35	4.91	4.43	3.90
	.999	18.64	12.97	10.80	9.63	8.89	8.38	8.00	7.71	7.00	6.25	5.42
	.90	3.10	2.73	2.52	2.39	2.31	2.24	2.19	2.15	2.05	1.94	1.80
	.95	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.53	2.35	2.13
	.975	6.30	4.86	4.24	3.89	3.66	3.50	3.38	3.29	3.05	2.79	2.49
16	.99	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	3.80	3.43	3.00
	.995	11.06	7.92	6.68	6.00	5.56	5.26	5.03	4.86	4.43	3.96	3.44
	.999	17.14	11.78	9.73	8.62	7.92	7.44	7.08	6.80	6.13	5.41	4.60
	.90	3.05	2.67	2.46	2.33	2.24	2.18	2.13	2.09	1.99	1.87	1.72
	.95	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.42	2.24	2.01
	.975	6.12	4.69	4.08	3.73	3.50	3.34	3.22	3.12	2.89	2.63	2.32
18	.99	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.55	3.18	2.75
	.995	10.58	7.51	6.30	5.64	5.21	4.91	4.69	4.52	4.10	3.64	3.11
	.999	16.12	10.97	9.01	7.94	7.27	6.80	6.46	6.19	5.55	4.85	4.06
	.90	3.01	2.62	2.42	2.29	2.20	2.13	2.08	2.04	1.93	1.81	1.66
	.95	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.34	2.15	1.92
	.975	5.98	4.56	3.95	3.61	3.38	3.22	3.10	3.01	2.77	2.50	2.19
20	.99	8.29	6.01	5.09	4.58	4.25	4.01	3.84	3.71	3.37	3.00	2.57
	.995	10.22	7.21	6.03	5.37	4.96	4.66	4.44	4.28	3.86	3.40	2.87
	.999	15.38	10.39	8.49	7.46	6.81	6.35	6.02	5.76	5.13	4.45	3.67
	.90	2.97	2.59	2.38	2.25	2.16	2.09	2.04	2.00	1.89	1.77	1.61
	.95	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.28	2.08	1.84
	.975	5.87	4.46	3.86	3.51	3.29	3.13	3.01	2.91	2.68	2.41	2.09
30	.99	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.23	2.86	2.42
	.995	9.94	6.99	5.82	5.17	4.76	4.47	4.26	4.09	3.68	3.22	2.69
	.999	14.82	9.95	8.10	7.10	6.46	6.02	5.69	5.44	4.82	4.15	3.38
	.90	2.88	2.49	2.28	2.14	2.05	1.98	1.93	1.88	1.77	1.64	1.46
	.95	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.09	1.89	1.62
	.975	5.57	4.18	3.59	3.25	3.03	2.87	2.75	2.65	2.41	2.14	1.79
40	.99	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	2.84	2.47	2.01
	.995	9.18	6.35	5.24	4.62	4.23	3.95	3.74	3.58	3.18	2.73	2.18
	.999	13.29	8.77	7.05	6.12	5.53	5.12	4.82	4.58	4.00	3.36	2.59
	.90	2.84	2.44	2.23	2.09	2.00	1.93	1.87	1.83	1.71	1.57	1.38
	.95	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.00	1.79	1.51
	.975	5.42	4.05	3.46	3.13	2.90	2.74	2.62	2.53	2.29	2.01	1.64
60	.99	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.66	2.29	1.80
	.995	8.83	6.07	4.98	4.37	3.99	3.71	3.51	3.35	2.95	2.50	1.93
	.999	12.61	8.25	6.59	5.70	5.13	4.73	4.44	4.21	3.64	3.01	2.23
	.90	2.79	2.39	2.18	2.04	1.95	1.87	1.82	1.77	1.66	1.51	1.29
	.95	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	1.92	1.70	1.39
	.975	5.29	3.93	3.34	3.01	2.79	2.63	2.51	2.41	2.17	1.88	1.48
120	.99	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.50	2.12	1.60
	.995	8.49	5.80	4.73	4.14	3.76	3.49	3.29	3.13	2.74	2.29	1.69
	.999	11.97	7.77	6.17	5.31	4.76	4.37	4.09	3.86	3.32	2.69	1.89
	.90	2.75	2.35	2.13	1.99	1.90	1.82	1.77	1.72	1.60	1.45	1.19
	.95	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.83	1.61	1.25
	.975	5.15	3.80	3.23	2.89	2.67	2.52	2.39	2.30	2.05	1.76	1.31
$\infty$	.99	6.85	4.79	3.95	3.48	3.17	2.96	2.79	2.66	2.34	1.95	1.38
	.995	8.18	5.54	4.50	3.92	3.55	3.28	3.09	2.93	2.54	2.09	1.43
	.999	11.38	7.32	5.78	4.95	4.42	4.04	3.77	3.55	3.02	2.40	1.54
	.90	2.71	2.30	2.08	1.94	1.85	1.77	1.72	1.67	1.55	1.38	1.00
	.95	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.75	1.52	1.00
	.975	5.02	3.69	3.12	2.79	2.57	2.41	2.29	2.19	1.94	1.64	1.00
$\infty$	.99	6.63	4.61	3.78	3.32	3.02	2.80	2.64	2.51	2.18	1.79	1.00
	.995	7.88	5.30	4.28	3.72	3.35	3.09	2.90	2.74	2.36	1.90	1.00
	.999	10.83	6.91	5.42	4.62	4.10	3.74	3.47	3.27	2.74	2.13	1.00

Note:  $F_{d_1, d_2, p}$  =  $p$ th percentile of an  $F$  distribution with  $d_1$  and  $d_2$  degrees of freedom.

Source: This table has been reproduced in part with the permission of the Biometrika Trustees, from *Biometrika Tables for Statisticians*, Volume 2, edited by E. S. Pearson and H. O. Hartley, published for the Biometrika Trustees, Cambridge University Press, Cambridge, England, 1972.

**Table 10** Critical values for the ESD (Extreme Studentized Deviate) outlier statistic ( $ESD_{n,1-\alpha}$ ,  $\alpha = .05, .01$ )

n	1 - $\alpha$		n	1 - $\alpha$	
	.95	.99		.95	.99
5	1.72	1.76	25	2.82	3.14
6	1.89	1.97	26	2.84	3.16
7	2.02	2.14	27	2.86	3.18
8	2.13	2.28	28	2.88	3.20
9	2.21	2.39	29	2.89	3.22
10	2.29	2.48	30	2.91	3.24
11	2.36	2.56	35	2.98	3.32
12	2.41	2.64	40	3.04	3.38
13	2.46	2.70	45	3.09	3.44
14	2.51	2.75	50	3.13	3.48
15	2.55	2.81	60	3.20	3.56
16	2.59	2.85	70	3.26	3.62
17	2.62	2.90	80	3.31	3.67
18	2.65	2.93	90	3.35	3.72
19	2.68	2.97	100	3.38	3.75
20	2.71	3.00	150	3.52	3.89
21	2.73	3.03	200	3.61	3.98
22	2.76	3.06	300	3.72	4.09
23	2.78	3.08	400	3.80	4.17
24	2.80	3.11	500	3.86	4.23

Note: For values of  $n$  not found in the table, the percentiles can be evaluated using the formula  $ESD_{n,1-\alpha} =$

$$\frac{t_{n-2,p}(n-1)}{\sqrt{n(n-2+t_{n-2,p}^2)}} \text{ where } p = 1 - [\alpha/(2n)].$$

**Table 11** Two-tailed critical values for the Wilcoxon signed-rank test

n <sup>a</sup>	.10		.05		.02		.01	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
1	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—
4	—	—	—	—	—	—	—	—
5	0	15	—	—	—	—	—	—
6	2	19	0	21	—	—	—	—
7	3	25	2	26	0	28	—	—
8	5	31	3	33	1	35	0	36
9	8	37	5	40	3	42	1	44
10	10	45	8	47	5	50	3	52
11	13	53	10	56	7	59	5	61
12	17	61	13	65	9	69	7	71
13	21	70	17	74	12	79	9	82
14	25	80	21	84	15	90	12	93
15	30	90	25	95	19	101	15	105

<sup>a</sup>n = number of untied pairs.

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**Table 12** Two-tailed critical values for the Wilcoxon rank-sum test

$\alpha = .10$ $n_1^a$									$\alpha = .05$ $n_1$									
$n_2^b$	4	5	6	7	8	9	4	5	6	7	8	9	4	5	6	7	8	9
	$T_l^c$	$T_r^d$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$
4	11–25	17–33	24–42	32–52	41–63	51–75	10–26	16–34	23–43	31–53	40–64	49–77	10–26	16–34	23–43	31–53	40–64	49–77
5	12–28	19–36	26–46	34–57	44–68	54–81	11–29	17–38	24–48	33–58	42–70	52–83	11–29	17–38	24–48	33–58	42–70	52–83
6	13–31	20–40	28–50	36–62	46–74	57–87	12–32	18–42	26–52	34–64	44–76	55–89	12–32	18–42	26–52	34–64	44–76	55–89
7	14–34	21–44	29–55	39–66	49–79	60–93	13–35	20–45	27–57	36–69	46–82	57–96	13–35	20–45	27–57	36–69	46–82	57–96
8	15–37	23–47	31–59	41–71	51–85	63–99	14–38	21–49	29–61	38–74	49–87	60–102	14–38	21–49	29–61	38–74	49–87	60–102
9	16–40	24–51	33–63	43–76	54–90	66–105	14–42	22–53	31–65	40–79	51–93	62–109	14–42	22–53	31–65	40–79	51–93	62–109
10	17–43	26–54	35–67	45–81	56–96	69–111	15–45	23–57	32–70	42–84	53–99	65–115	15–45	23–57	32–70	42–84	53–99	65–115
11	18–46	27–58	37–71	47–86	59–101	72–117	16–48	24–61	34–74	44–89	55–105	68–121	16–48	24–61	34–74	44–89	55–105	68–121
12	19–49	28–62	38–76	49–91	62–106	75–123	17–51	26–64	35–79	46–94	58–110	71–127	17–51	26–64	35–79	46–94	58–110	71–127
13	20–52	30–65	40–80	52–95	64–112	78–129	18–54	27–68	37–83	48–99	60–116	73–134	18–54	27–68	37–83	48–99	60–116	73–134
14	21–55	31–69	42–84	54–100	67–117	81–135	19–57	28–72	38–88	50–104	62–122	76–140	19–57	28–72	38–88	50–104	62–122	76–140
15	22–58	33–72	44–88	56–105	69–123	84–141	20–60	29–76	40–92	52–109	65–127	79–146	20–60	29–76	40–92	52–109	65–127	79–146
16	24–60	34–76	46–92	58–110	72–128	87–147	21–63	30–80	42–96	54–114	67–133	82–152	21–63	30–80	42–96	54–114	67–133	82–152
17	25–63	35–80	47–97	61–114	75–133	90–153	21–67	32–83	43–101	56–119	70–138	84–159	21–67	32–83	43–101	56–119	70–138	84–159
18	26–66	37–83	49–101	63–119	77–139	93–159	22–70	33–87	45–105	58–124	72–144	87–165	22–70	33–87	45–105	58–124	72–144	87–165
19	27–69	38–87	51–105	65–124	80–144	96–165	23–73	34–91	46–110	60–129	74–150	90–171	23–73	34–91	46–110	60–129	74–150	90–171
20	28–72	40–90	53–109	67–129	83–149	99–171	24–76	35–95	48–114	62–134	77–155	93–177	24–76	35–95	48–114	62–134	77–155	93–177
21	29–75	41–94	55–113	69–134	85–155	102–177	25–79	37–98	50–118	64–139	79–161	95–184	25–79	37–98	50–118	64–139	79–161	95–184
22	30–78	43–97	57–117	72–138	88–160	105–183	26–82	38–102	51–123	66–144	81–167	98–190	26–82	38–102	51–123	66–144	81–167	98–190
23	31–81	44–101	58–122	74–143	90–166	108–189	27–85	39–106	53–127	68–149	84–172	101–196	27–85	39–106	53–127	68–149	84–172	101–196
24	32–84	45–105	60–126	76–148	93–171	111–195	27–89	40–110	54–132	70–154	86–178	104–202	27–89	40–110	54–132	70–154	86–178	104–202
25	33–87	47–108	62–130	78–153	96–176	114–201	28–92	42–113	56–136	72–159	89–183	107–208	28–92	42–113	56–136	72–159	89–183	107–208
26	34–90	48–112	64–134	81–157	98–182	117–207	29–95	43–117	58–140	74–164	91–189	109–215	29–95	43–117	58–140	74–164	91–189	109–215
27	35–93	50–115	66–138	83–162	101–187	120–213	30–98	44–121	59–145	76–169	93–195	112–221	30–98	44–121	59–145	76–169	93–195	112–221
28	36–96	51–119	67–143	85–167	103–193	123–219	31–101	45–125	61–149	78–174	96–200	115–227	31–101	45–125	61–149	78–174	96–200	115–227
29	37–99	53–122	69–147	87–172	106–198	126–225	32–104	47–128	63–153	80–179	98–206	118–233	32–104	47–128	63–153	80–179	98–206	118–233
30	38–102	54–126	71–151	89–177	109–203	129–231	33–107	48–132	64–158	82–184	101–211	121–239	33–107	48–132	64–158	82–184	101–211	121–239
31	39–105	55–130	73–155	92–181	111–209	132–237	34–110	49–136	66–162	84–189	103–217	123–246	34–110	49–136	66–162	84–189	103–217	123–246
32	40–108	57–133	75–159	94–186	114–214	135–243	34–114	50–140	67–167	86–194	106–222	126–252	34–114	50–140	67–167	86–194	106–222	126–252
33	41–111	58–137	77–163	96–191	117–219	138–249	35–117	52–143	69–171	88–199	108–228	129–258	35–117	52–143	69–171	88–199	108–228	129–258
34	42–114	60–140	78–168	98–196	119–225	141–255	36–120	53–147	71–175	90–204	110–234	132–264	36–120	53–147	71–175	90–204	110–234	132–264
35	43–117	61–144	80–172	100–201	122–230	144–261	37–123	54–151	72–180	92–209	113–239	135–270	37–123	54–151	72–180	92–209	113–239	135–270
36	44–120	62–148	82–176	102–206	124–236	148–266	38–126	55–155	74–184	94–214	115–245	137–277	38–126	55–155	74–184	94–214	115–245	137–277
37	45–123	64–151	84–180	105–210	127–241	151–272	39–129	57–158	76–188	96–219	117–251	140–283	39–129	57–158	76–188	96–219	117–251	140–283
38	46–126	65–155	85–185	107–215	130–246	154–278	40–132	58–162	77–193	98–224	120–256	143–289	40–132	58–162	77–193	98–224	120–256	143–289
39	47–129	67–158	87–189	109–220	132–252	157–284	41–135	59–166	79–197	100–229	122–262	146–295	41–135	59–166	79–197	100–229	122–262	146–295
40	48–132	68–162	89–193	111–225	135–257	160–290	41–139	60–170	80–202	102–234	125–267	149–301	41–139	60–170	80–202	102–234	125–267	149–301
41	49–135	69–166	91–197	114–229	138–262	163–296	42–142	61–174	82–206	104–239	127–273	151–308	42–142	61–174	82–206	104–239	127–273	151–308
42	50–138	71–169	93–201	116–234	140–268	166–302	43–145	63–177	84–210	106–244	129–279	154–314	43–145	63–177	84–210	106–244	129–279	154–314
43	51–141	72–173	95–205	118–239	143–273	169–308	44–148	64–181	85–215	108–249	132–284	157–320	44–148	64–181	85–215	108–249	132–284	157–320
44	52–144	74–176	96–210	120–244	146–278	172–314	45–151	65–185	87–219	110–254	134–290	160–326	45–151	65–185	87–219	110–254	134–290	160–326
45	53–147	75–180	98–214	123–248	148–284	175–320	46–154	66–189	88–224	112–259	137–295	163–332	46–154	66–189	88–224	112–259	137–295	163–332
46	55–149	77–183	100–218	125–253	151–289	178–326	47–157	68–192	90–228	114–264	139–301	165–339	47–157	68–192	90–228	114–264	139–301	165–339
47	56–152	78–187	102–222	127–258	154–294	181–332	48–160	69–196	92–232	116–269	141–307	168–345	48–160	69–196	92–232	116–269	141–307	168–345
48	57–155	79–191	104–226	129–263	156–300	184–338	48–164	70–200	93–237	118–274	144–312	171–351	48–164	70–200	93–237	118–274	144–312	171–351
49	58–158	81–194	106–230	132–267	159–305	187–344	49–167	71–204	95–241	120–279	146–318	174–357	49–167	71–204	95–241	120–279	146–318	174–357
50	59–161	82–198	107–235	134–272	162–310	190–350	50–170	73–207	97–245	122–284	149–323	177–363	50–170	73–207	97–245	122–284	149–323	177–363

<sup>a</sup> $n_1$  = minimum of the two sample sizes.<sup>b</sup> $n_2$  = maximum of the two sample sizes.<sup>c</sup> $T_l$  = lower critical value for the rank sum in the first sample.<sup>d</sup> $T_r$  = upper critical value for the rank sum in the first sample.

**Table 12** Two-tailed critical values for the Wilcoxon rank-sum test (*continued*)

$n_2^b$	$\alpha = .02$ $n_1^a$							$\alpha = .01$ $n_1$						
	4	5	6	7	8	9	4	5	6	7	8	9	4	5
	$T_l^c$	$T_r^d$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$	$T_l$	$T_r$
4	—	—	15-35	22-44	29-55	38-66	48-78	—	—	—	21-45	28-56	37-67	46-80
5	10-30	16-39	23-49	31-60	40-72	50-85	—	—	15-40	22-50	29-62	38-74	48-87	
6	11-33	17-43	24-54	32-66	42-78	52-92	10-34	16-44	23-55	31-67	40-80	50-94		
7	11-37	18-47	25-59	34-71	43-85	54-99	10-38	16-49	24-60	32-73	42-86	52-101		
8	12-40	19-51	27-63	35-77	45-91	56-106	11-41	17-53	25-65	34-78	43-93	54-108		
9	13-43	20-55	28-68	37-82	47-97	59-112	11-45	18-57	26-70	35-84	45-99	56-115		
10	13-47	21-59	29-73	39-87	49-103	61-119	12-48	19-61	27-75	37-89	47-105	58-122		
11	14-50	22-63	30-78	40-93	51-109	63-126	12-52	20-65	28-80	38-95	49-111	61-128		
12	15-53	23-67	32-82	42-98	53-115	66-132	13-55	21-69	30-84	40-100	51-117	63-135		
13	15-57	24-71	33-87	44-103	56-120	68-139	13-59	22-73	31-89	41-106	53-123	65-142		
14	16-60	25-75	34-92	45-109	58-126	71-145	14-62	22-78	32-94	43-111	54-130	67-149		
15	17-63	26-79	36-96	47-114	60-132	73-152	15-65	23-82	33-99	44-117	56-136	69-156		
16	17-67	27-83	37-101	49-119	62-138	76-158	15-69	24-86	34-104	46-122	58-142	72-162		
17	18-70	28-87	39-105	51-124	64-144	78-165	16-72	25-90	36-108	47-128	60-148	74-169		
18	19-73	29-91	40-110	52-130	66-150	81-171	16-76	26-94	37-113	49-133	62-154	76-176		
19	19-77	30-95	41-115	54-135	68-156	83-178	17-79	27-98	38-118	50-139	64-160	78-183		
20	20-80	31-99	43-119	56-140	70-162	85-185	18-82	28-102	39-123	52-144	66-166	81-189		
21	21-83	32-103	44-124	58-145	72-168	88-191	18-86	29-106	40-128	53-150	68-172	83-196		
22	21-87	33-107	45-129	59-151	74-174	90-198	19-89	29-111	42-132	55-155	70-178	85-203		
23	22-90	34-111	47-133	61-156	76-180	93-204	19-93	30-115	43-137	57-160	71-185	88-209		
24	23-93	35-115	48-138	63-161	78-186	95-211	20-96	31-119	44-142	58-166	73-191	90-216		
25	23-97	36-119	50-142	64-167	81-191	98-217	20-100	32-123	45-147	60-171	75-197	92-223		
26	24-100	37-123	51-147	66-172	83-197	100-224	21-103	33-127	46-152	61-177	77-203	94-230		
27	25-103	38-127	52-152	68-177	85-203	103-230	22-106	34-131	48-156	63-182	79-209	97-236		
28	26-106	39-131	54-156	70-182	87-209	105-237	22-110	35-135	49-161	64-188	81-215	99-243		
29	26-110	40-135	55-161	71-188	89-215	108-243	23-113	36-139	50-166	66-193	83-221	101-250		
30	27-113	41-139	56-166	73-193	91-221	110-250	23-117	37-143	51-171	68-198	85-227	103-257		
31	28-116	42-143	58-170	75-198	93-227	112-257	24-120	37-148	53-175	68-204	87-233	106-263		
32	28-120	43-147	59-175	77-203	95-233	115-263	24-124	38-152	54-180	71-209	89-239	108-270		
33	29-123	44-151	61-179	78-209	97-239	117-270	25-127	39-156	55-185	72-215	90-246	110-277		
34	30-126	45-155	62-184	79-215	99-245	120-276	26-130	40-160	56-190	73-221	92-252	112-284		
35	30-130	46-159	63-189	81-220	101-251	122-283	26-134	41-164	57-195	75-226	94-258	114-291		
36	31-133	47-163	65-193	83-225	103-257	125-289	27-137	42-168	58-200	76-232	96-264	117-297		
37	32-136	48-167	66-198	84-231	105-263	127-296	28-140	43-172	60-204	78-237	98-270	119-304		
38	32-140	49-171	67-203	86-236	107-269	129-303	28-144	44-176	61-209	79-243	100-276	121-311		
39	33-143	50-175	69-207	88-241	109-275	132-309	29-147	45-180	62-214	81-248	102-282	123-318		
40	34-146	51-179	70-212	90-246	111-281	134-316	29-151	46-184	63-219	82-254	103-289	126-324		
41	34-150	52-183	72-216	91-252	113-287	137-322	30-154	46-189	65-223	84-259	105-295	128-331		
42	35-153	53-187	73-221	93-257	116-292	139-329	31-157	47-193	66-228	85-265	107-301	130-338		
43	35-157	54-191	74-226	95-262	118-298	142-335	31-161	48-197	67-233	87-270	109-307	133-344		
44	36-160	55-195	76-230	97-267	120-304	144-342	32-164	49-201	68-238	88-276	111-313	135-351		
45	37-163	56-199	77-235	98-273	122-310	147-348	32-168	50-205	69-243	90-281	113-319	137-358		
46	37-167	57-203	78-240	100-278	124-316	149-355	33-171	51-209	71-247	91-287	115-325	139-365		
47	38-170	58-207	80-244	102-283	126-322	152-361	34-174	52-213	72-252	93-292	117-331	142-371		
48	39-173	59-211	81-249	103-289	128-328	154-368	34-178	53-217	73-257	95-297	118-338	144-378		
49	39-177	60-215	82-254	105-294	130-334	157-374	35-181	54-221	74-262	96-303	120-344	146-385		
50	40-180	61-219	84-258	107-299	132-340	159-381	36-184	55-225	76-266	98-308	122-350	148-392		

Source: The data of this table are from *Documenta Geigy Scientific Tables*, 6th edition. Reprinted with the kind permission of CIBA-GEIGY Limited, Basel, Switzerland.

**Table 13** Fisher's z transformation

<i>r</i>	<i>z</i>								
.00	.000								
.01	.010	.21	.213	.41	.436	.61	.709	.81	1.127
.02	.020	.22	.224	.42	.448	.62	.725	.82	1.157
.03	.030	.23	.234	.43	.460	.63	.741	.83	1.188
.04	.040	.24	.245	.44	.472	.64	.758	.84	1.221
.05	.050	.25	.255	.45	.485	.65	.775	.85	1.256
.06	.060	.26	.266	.46	.497	.66	.793	.86	1.293
.07	.070	.27	.277	.47	.510	.67	.811	.87	1.333
.08	.080	.28	.288	.48	.523	.68	.829	.88	1.376
.09	.090	.29	.299	.49	.536	.69	.848	.89	1.422
.10	.100	.30	.310	.50	.549	.70	.867	.90	1.472
.11	.110	.31	.321	.51	.563	.71	.887	.91	1.528
.12	.121	.32	.332	.52	.576	.72	.908	.92	1.589
.13	.131	.33	.343	.53	.590	.73	.929	.93	1.658
.14	.141	.34	.354	.54	.604	.74	.950	.94	1.738
.15	.151	.35	.365	.55	.618	.75	.973	.95	1.832
.16	.161	.36	.377	.56	.633	.76	.996	.96	1.946
.17	.172	.37	.388	.57	.648	.77	1.020	.97	2.092
.18	.182	.38	.400	.58	.662	.78	1.045	.98	2.298
.19	.192	.39	.412	.59	.678	.79	1.071	.99	2.647
.20	.203	.40	.424	.60	.693	.80	1.099		

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**Table 14** Two-tailed upper critical values for the Spearman rank-correlation coefficient ( $r_s$ )

$n$	$\alpha$			
	.10	.05	.02	.01
1	—	—	—	—
2	—	—	—	—
3	—	—	—	—
4	1.0	—	—	—
5	.900	1.0	1.0	—
6	.829	.886	.943	1.0
7	.714	.786	.893	.929
8	.643	.738	.833	.881
9	.600	.683	.783	.833

Source: The data for this table have been adapted with permission from E. G. Olds (1938), "Distributions of Sums of Squares of Rank Differences for Small Numbers of Individuals," *Annals of Mathematical Statistics*, 9, 133–148.



**Table 15 Critical values for the Kruskal-Wallis test statistic ( $H$ ) for selected sample sizes for  $k = 3$** 

$n_1$	$n_2$	$n_3$	$\alpha$			
			.10	.05	.02	.01
1	1	2	—	—	—	—
1	1	3	—	—	—	—
1	1	4	—	—	—	—
1	1	5	—	—	—	—
1	2	2	—	—	—	—
1	2	3	4.286	—	—	—
1	2	4	4.500	—	—	—
1	2	5	4.200	5.000	—	—
1	3	3	4.571	5.143	—	—
1	3	4	4.056	5.389	—	—
1	3	5	4.018	4.960	6.400	—
1	4	4	4.167	4.967	6.667	—
1	4	5	3.987	4.986	6.431	6.954
1	5	5	4.109	5.127	6.146	7.309
2	2	2	4.571	—	—	—
2	2	3	4.500	4.714	—	—
2	2	4	4.500	5.333	6.000	—
2	2	5	4.373	5.160	6.000	6.533
2	3	3	4.694	5.361	6.250	—
2	3	4	4.511	5.444	6.144	6.444
2	3	5	4.651	5.251	6.294	6.909
2	4	4	4.554	5.454	6.600	7.036
2	4	5	4.541	5.273	6.541	7.204
2	5	5	4.623	5.338	6.469	7.392
3	3	3	5.067	5.689	6.489	7.200
3	3	4	4.709	5.791	6.564	7.000
3	3	5	4.533	5.648	6.533	7.079
3	4	4	4.546	5.598	6.712	7.212
3	4	5	4.549	5.656	6.703	7.477
3	5	5	4.571	5.706	6.866	7.622
4	4	4	4.654	5.692	6.962	7.654
4	4	5	4.668	5.657	6.976	7.760
4	5	5	4.523	5.666	7.000	7.903
5	5	5	4.580	5.780	7.220	8.000

Source: The data for this table have been adapted from Table F of *A Nonparametric Introduction to Statistics* by C.H. Kraft and C. Van Eeden, Macmillan, New York, 1968.

**Table 16 Critical values for the studentized range statistic  $q^*$ ,  $\alpha = .05$** 

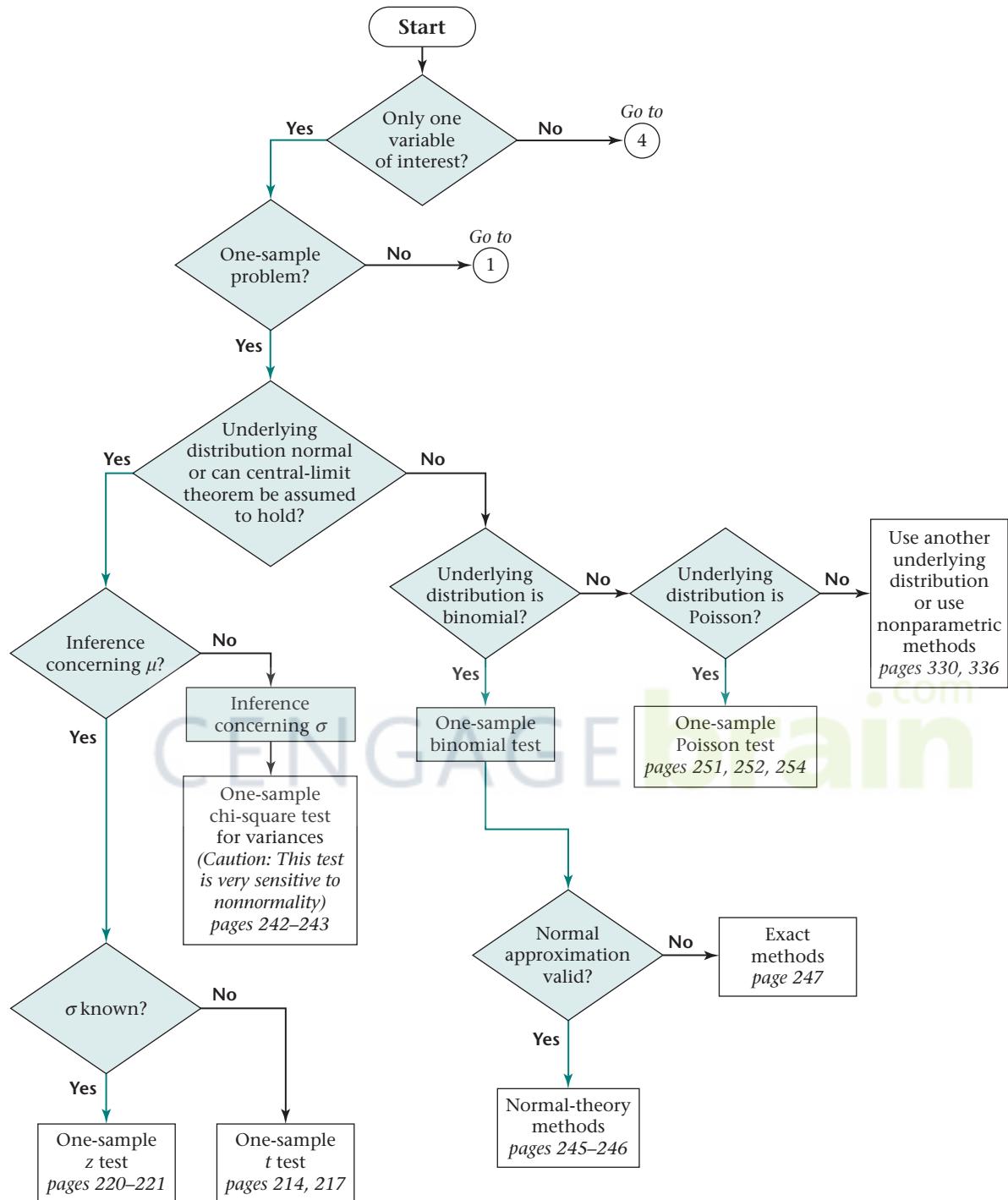
v	k:	2	3	4	5	6	7	8	9	10
1		17.97	26.98	32.82	37.08	40.41	43.12	45.40	47.36	49.07
2		6.085	8.331	9.798	10.88	11.74	12.44	13.03	13.54	13.99
3		4.501	5.910	6.825	7.502	8.037	8.478	8.853	9.177	9.462
4		3.927	5.040	5.757	6.287	6.707	7.053	7.347	7.602	7.826
5		3.635	4.602	5.218	5.673	6.033	5.330	6.582	6.802	6.995
6		3.461	4.339	4.896	5.305	5.628	5.895	6.122	6.319	6.493
7		3.344	4.165	4.681	5.060	5.359	5.606	5.815	5.998	6.158
8		3.261	4.041	4.529	4.886	5.167	5.399	5.597	5.767	5.918
9		3.199	3.949	4.415	4.756	5.024	5.244	5.432	5.595	5.739
10		3.151	3.877	4.327	4.654	4.912	5.124	5.305	5.461	5.599
11		3.113	3.820	4.256	4.574	4.823	5.028	5.202	5.353	5.487
12		3.082	3.773	4.199	4.508	4.751	4.950	5.119	5.265	5.395
13		3.055	3.735	4.151	4.453	4.690	4.885	5.049	5.192	5.318
14		3.033	3.702	4.111	4.407	4.639	4.829	4.990	5.131	5.254
15		3.014	3.674	4.076	4.367	4.595	4.782	4.940	5.077	5.198
16		2.998	3.649	4.046	4.333	4.557	4.741	4.897	5.031	5.150
17		2.984	3.628	4.020	4.303	4.524	4.705	4.858	4.991	5.108
18		2.971	3.609	3.997	4.277	4.495	4.673	4.824	4.956	5.071
19		2.960	3.593	3.977	4.253	4.469	4.645	4.794	4.924	5.038
20		2.950	3.578	3.958	4.232	4.445	4.620	4.768	4.896	5.008
24		2.919	3.532	3.901	4.166	4.373	4.541	4.684	4.807	4.915
30		2.888	3.486	3.845	4.102	4.302	4.464	4.602	4.720	4.824
40		2.858	3.442	3.791	4.039	4.232	4.389	4.521	4.635	4.735
60		2.829	3.399	3.737	3.977	4.163	4.314	4.441	4.550	4.646
120		2.800	3.356	3.685	3.917	4.096	4.241	4.363	4.468	4.560
$\infty$		2.772	3.314	3.633	3.858	4.030	4.170	4.286	4.387	4.474
	k:	11	12	13	14	15	16	17	18	19
1		5.059	51.96	53.20	54.33	55.36	56.32	57.22	58.04	58.83
2		14.39	14.75	15.08	15.38	15.65	15.91	16.14	16.37	16.57
3		9.717	9.946	10.15	10.35	10.53	10.69	10.84	10.98	11.11
4		8.027	8.208	8.373	8.525	8664	8.794	8.914	9.028	9.134
5		7.168	7.324	7.466	7.596	7.717	7.828	7.932	8.030	8.122
6		6.649	6.789	6.917	7.034	7.143	7.244	7.338	7.426	7.508
7		6.302	6.431	6.550	6.658	6.759	6.852	6.939	7.020	7.097
8		6.054	6.175	6.287	6.389	6.483	6.571	6.653	6.729	6.802
9		5.867	5.983	6.089	6.186	6.276	6.359	6.437	6.510	6.579
10		5.722	5.833	5.935	6.028	6.114	6.194	6.269	6.339	6.405
11		5.605	5.713	5.811	5.901	5.984	6.062	6.134	6.202	6.265
12		5.511	5.615	5.710	5.798	5.878	5.953	6.023	6.089	6.151
13		5.431	5.533	5.625	5.711	5.789	5.862	5.931	5.995	6.055
14		5.364	5.463	5.554	5.637	5.714	5.786	5.852	5.915	5.974
15		5.306	5.404	5.493	5.574	5.649	5.720	5.785	5.846	5.904
16		5.256	5.352	5.439	5.520	5.593	5.662	5.727	5.786	5.843
17		5.212	5.307	5.392	5.471	5.544	5.612	5.675	5.734	5.790
18		5.174	5.267	5.352	5.429	5.501	5.568	5.630	5.688	5.242
19		5.140	5.231	5.315	5.391	5.462	5.528	5.589	5.647	5.701
20		5.108	5.199	5.282	5.357	5.427	5.493	5.553	5.610	5.663
24		5.012	5.099	5.179	5.251	5.319	5.381	5.439	5.494	5.545
30		4.917	5.001	5.077	5.147	5.211	5.271	5.327	5.379	5.425
40		4.824	4.904	4.977	5.044	5.106	5.163	5.216	5.266	5.313
50		4.732	4.808	4.878	4.942	5.001	5.056	5.107	5.154	5.199
120		4.641	4.714	4.781	4.842	4.893	4.950	4.998	5.044	5.086
$\infty$		4.522	4.622	4.685	4.743	4.796	4.845	4.891	4.934	4.974

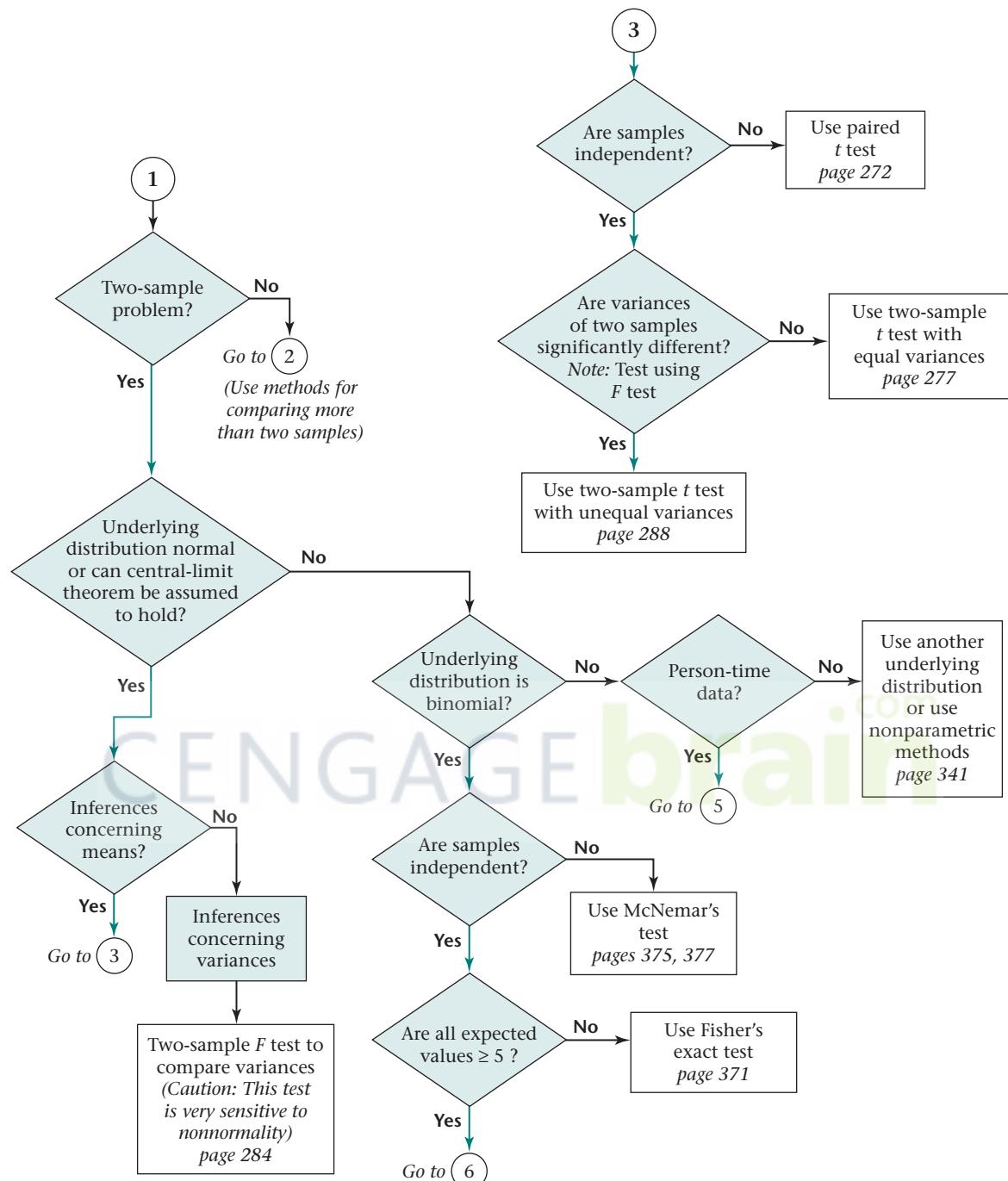
 $*q_{k,v,05}$  = upper 5th percentile of a  $q_{k,v}$  distribution

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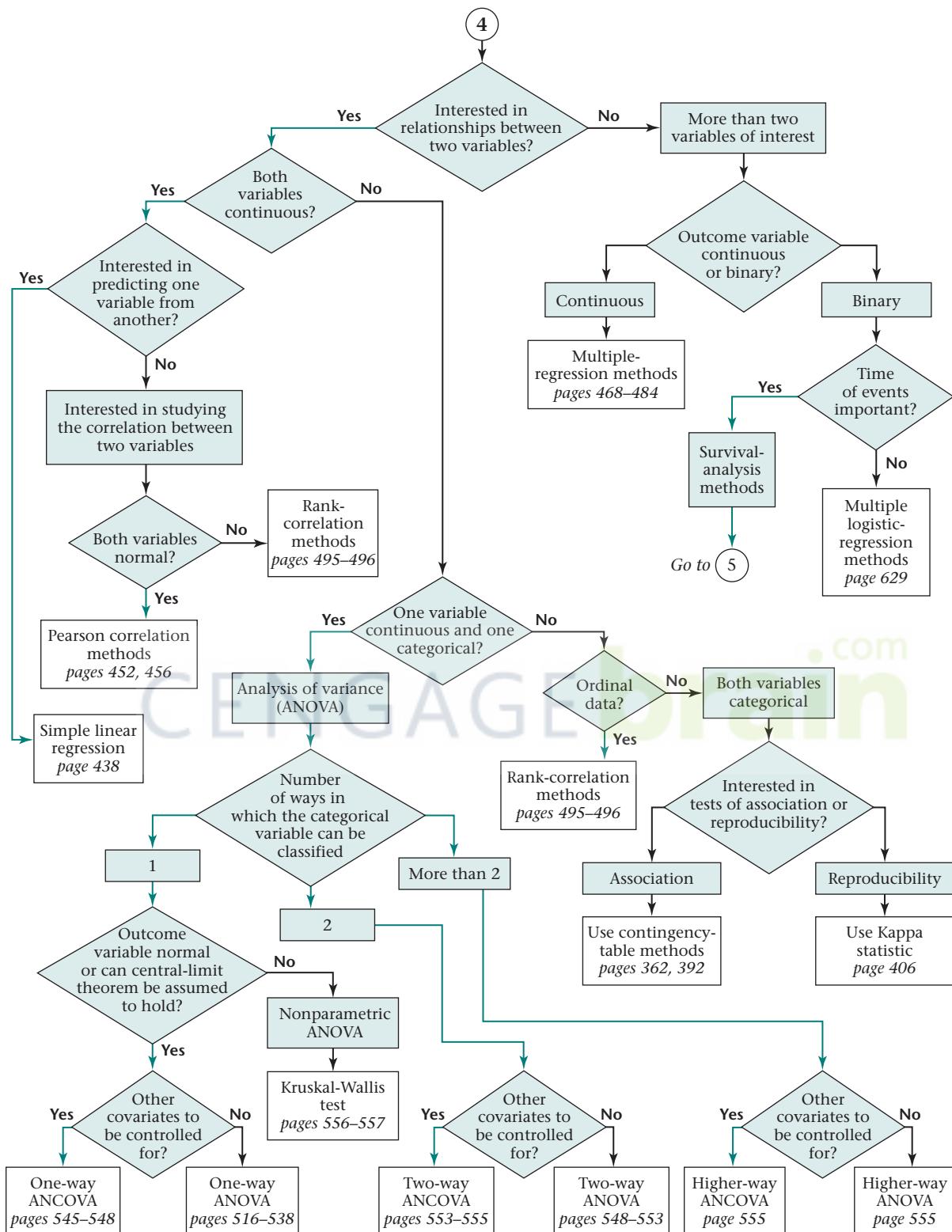
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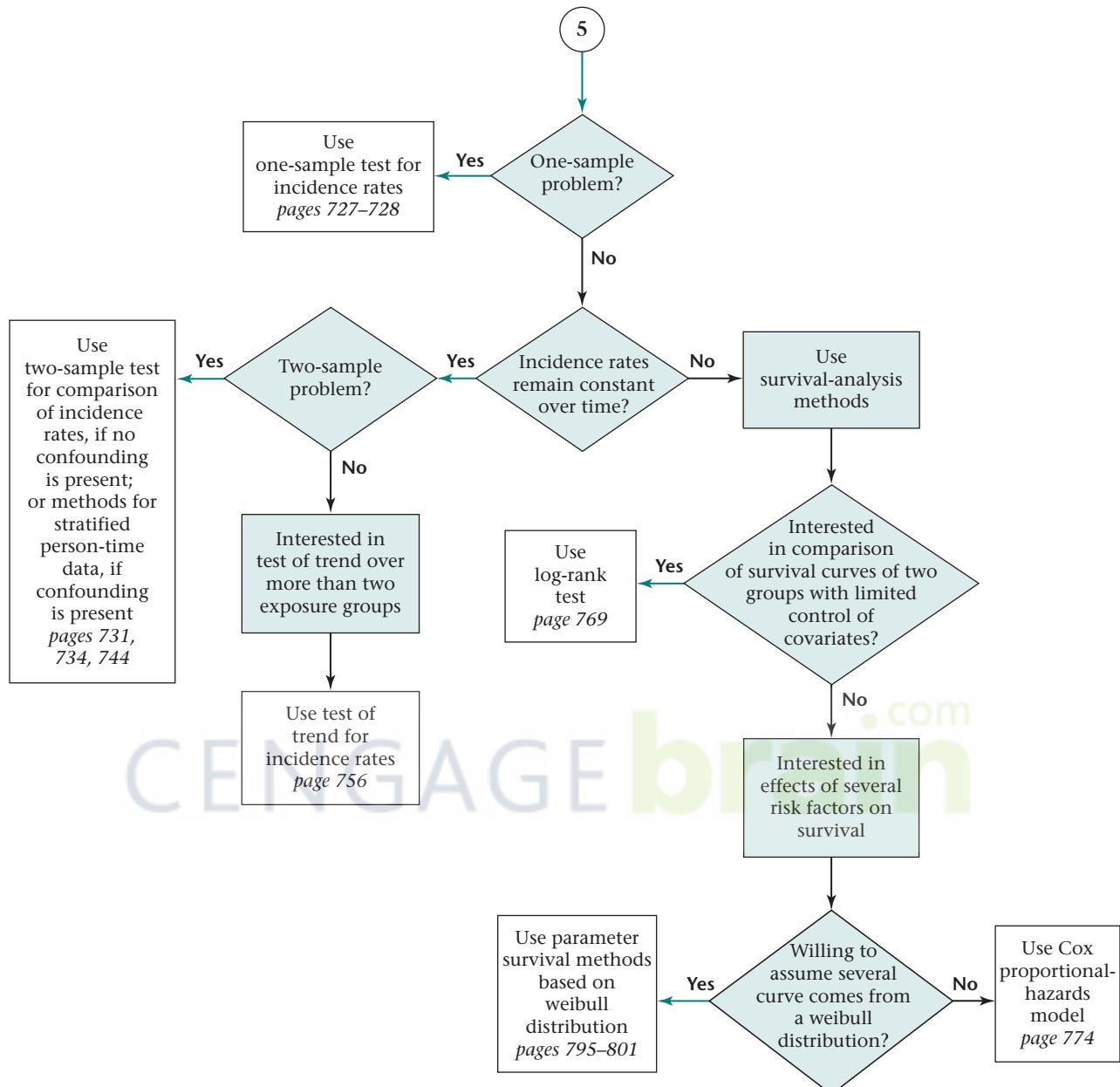
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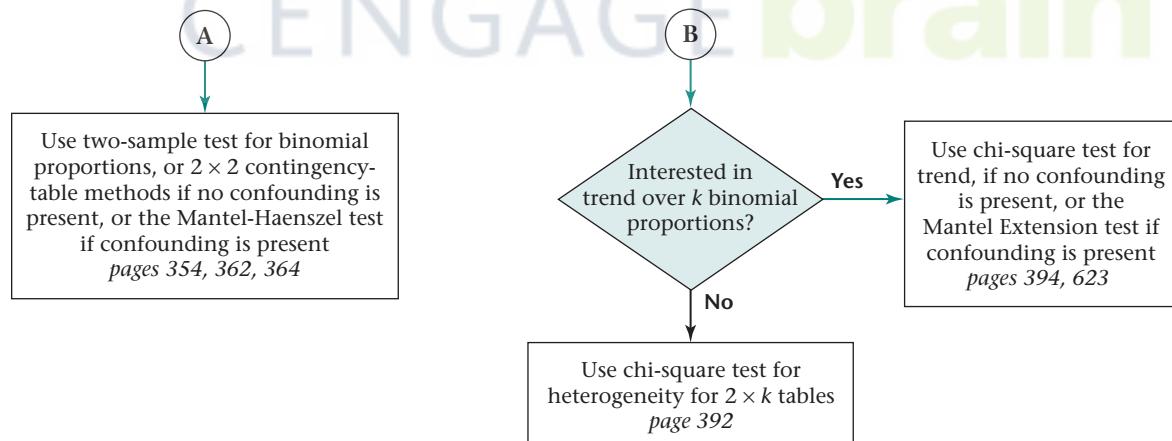
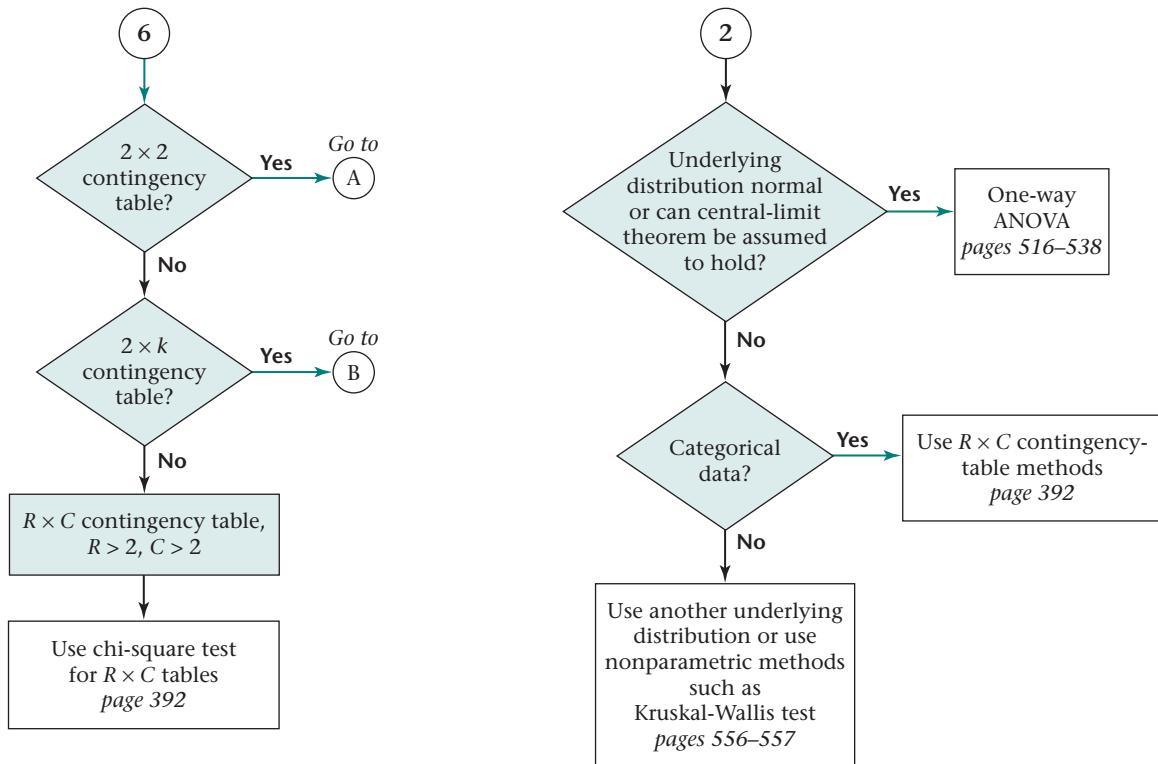




## 844 FLOW CHART ■ Methods of Statistical Inference







## Index of Data Sets

<i>Data Set</i>	<i>Page in text</i>	<i>Data Set</i>	<i>Page in text</i>
BETACAR	579	HOSPITAL	33
BLOOD	721	INFANTBP	199
BONEDEN	30	LEAD	29
BOTOX	806	MICE	582
BREAST	808	NEPHRO	658
CORNEAL	587	NIFED	140
DIABETES	322	OTO	714
EAR	64	PIRIFORM	144
EFF	714	SEXRAT	103
ENDOCRIN	580	SMOKE	102
ESTRADL	422, 511	SWISS	319
ESTROGEN	716	TEAR	265
FEV	35	TEMPERAT	581
FIELD	810	TENNIS1	415
HEART	Study Guide	TENNIS2	316
HORMONE	315	VALID	36

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# Index

Absolute value, 218  
 Accelerating failure time model, 797  
 Acceptance region, 208  
 Bonferroni multiple-comparisons procedure, 532  
 chi-square goodness-of-fit test, 403  
 chi-square test for  $R \times C$  contingency tables, 393  
 chi-square test for trend in binomial proportions, 395  
 Dunn procedure, 560  
 $F$  test for one-way ANOVA, 521  
 $F$  test for simple linear regression, 438  
 Fisher's  $z$  test, 464  
 fixed-effects one-way ANOVA (analysis of variance), 521  
 hypothesis testing in multiple linear regression, 473  
 kappa statistic, 406  
 Kruskal-Wallis test, 557  
 log-rank test, 771  
 Mantel-Haenszel test, 615  
 McNemar's test, 376  
 multiple logistic regression, 637  
 normal-theory test, 355  
 one-sample binomial test (two-sided alternative), 245  
 one-sample  $\chi^2$  test for variance of normal distribution, 242  
 one-sample  $t$  test for correlation coefficient, 457  
 one-sample  $z$  test for correlation coefficient, 459  
 one-way ANOVA, 521, 525  
 $R \times C$  contingency tables, 393  
 rank-correlation coefficients, 497  
 sign test, 330  
 sign test (normal-theory method), 330  
 Spearman rank-correlation coefficient, 497  
 $t$  test for comparison of pairs of groups in one-way ANOVA, 525

$t$  test for multiple linear regression, 474  
 $t$  test for simple linear regression, 442  
 two-sample inference for incidence-rate data, 732  
 two-sample test for binomial proportions (normal-theory test), 355  
 two-sample test for incidence rates (normal-theory method), 732  
 Yates-corrected chi-square test, 363  
 $z$  test, one-sample, 459  
 $z$  test, two-sample, 464  
 Actuarial method, 766  
 Addition law of probability, 44–46  
 Adjusted  $R^2$ , 440  
 Age-standardized risk, 611  
 Analysis-of-variance estimator, 569  
 Apgar score, 495, 501  
 Applied statistics, 1  
 Arithmetic mean, 7–9  
     vs. median, 10  
     properties of, 13–15  
     rescaled sample, 14–15  
     translated sample, 13–14  
 Attributable risk, 601–606  
     estimation with multiple exposed groups, 605–606  
     interval estimation for, 603  
     and risk factor, 602  
 Bar graph, 5–6, 25  
 Bayes' rule, 53–56  
 Bayesian inference, 56–57, 237–241  
 Bayley Mental Development Index, 507–508  
 Behrens-Fisher problem, 288  
 Bell-shaped distribution. *See* Normal distribution  
 Bernoulli trial, 131  
 Between mean square, 520  
 Between sum of squares, 519–520  
 Between-group variability, 518–519  
 Bimodal distribution, 12  
 BINOMDIST function, 87, 132  
 Binomial distribution, 71, 83–88  
     binomial tables, 83–86  
     electronic tables, 87–88  
     estimation for, 181–188  
     expected value of, 88–89  
     interval estimation, exact methods, 186–188  
     interval estimation, normal-theory methods, 184–186  
     maximum-likelihood estimation, 182–184  
     normal approximation to, 129–135  
     one-sample inference, 244–250  
     point estimation, 181–182  
     Poisson approximation, 96–98  
     variance of, 88–89  
 Binomial tables, 83–86  
 Biostatistics, 1  
 Blinding, 159  
 Block randomization, 158  
 BONEDEN.DAT (Data Set), 29–30  
 BONEDEN.DOC (Data Set), 29–30  
 Bone-mineral density study, 30–31, 175–176, 256  
 Bonferroni multiple-comparisons procedure, 531–534  
     acceptance and rejection regions, 532  
     experiment-wise type I error, 532  
 BOTOX.DAT (Data Set), 806  
 Box plots, 26–29  
 Cardinal data, 327  
 Carry-over effect, 667, 670–672  
 Case study examples  
     confidence interval, 175–176  
     graphing of data, 29–31  
     multiple linear regression, 484–491  
     nonparametric statistical methods, 344–345

- one-sample hypothesis testing, 256  
 one-way ANOVA, 538–548  
 two-sample hypothesis testing,  
   293–295  
 Case-control study, 589  
 Categorical data, measures of effect for,  
   591–601  
 Causal pathway, 609–610  
 Censored data, 761–763  
   interval, 763  
   left, 763  
   right, 763  
   treatment of, 761–763  
 Censored observations, 763  
 Central-limit theorem, 166–168  
 CHIDIST function, 244  
 Childhood Respiratory Diseases (CRD)  
   Study, 35, 512  
 Chinese Mini-Mental Status Test  
   (CMMS), 65  
 Chi-square distribution, 177–179, 824  
 Chi-square test  
   acceptance and rejection regions,  
 393, 395  
   goodness-of-fit test, 401–404  
   for homogeneity of odds ratios,  
 619–620  
   for homogeneity of rate ratios,  
 748–749  
   p-value, 393, 396–397  
   for  $R \times C$  contingency tables,  
 392–393  
   for trend in binomial proportions,  
 394–396  
   for trend-multiple strata, 623–624  
   and Wilcoxon rank-sum test,  
 397–400  
*Civil Action, A* (book and movie), 189  
 Clinical trials, 386–389  
 Cluster sampling, 151  
 Clustered binary data, 674–687  
   generalized estimated equations,  
 681  
   hypothesis testing, 674–675  
   power estimation for, 679–680  
   regression models, 681–686  
   sample-size estimation for, 679–680  
   two-sample test for binomial  
 proportions, 675–676, 679  
 CMMS (Chinese Mini-Mental Status  
   Test), 65  
 Coefficient of variation (CV), 20–21,  
   566–567  
 Cohort study, 589  
 Column effect, 550  
 Column margins, 358  
 Combinations, 79–83  
 Complement, 42  
 Complete-case method, 706  
 Compound symmetry correlation  
   structure, 681–682, 687  
 Concordant pair, 374  
 Conditional logistic regression,  
   649–651  
 Conditional probability, 46–51  
   relative risk, 47  
   total-probability rule, 48–51  
 Confidence interval. *See also* Interval  
   estimation  
   comparison of means from two  
 paired samples, 275–276  
   factors affecting length of, 174  
   and hypothesis testing, 235–237  
   for mean of normal distribution,  
 171–175  
   one-sided, 193–195  
   sample-size determination, 233–234  
 Confidence limits  
   for expectation of Poisson variable,  
 827  
   for incidence rates, 729–730  
 Confounding, 607–610  
   causal pathway, 609–610  
   negative confounder, 608  
   positive confounder, 608  
   stratification, 608  
   variable, 607  
 Contingency-table method, 357–359  
   2 x 2 contingency table, 357  
   expected table, 359–362  
   and multiple logistic regression,  
 632–633  
   observed table, 359  
   significance testing, 359–364  
   Yates-corrected chi-square test,  
 362–367  
 Continuity correction, 123  
 Continuous distribution, 3  
 Continuous probability distributions,  
   108–137  
   conversion from  $N(\mu, \sigma^2)$  to  $N(0, 1)$   
   distribution, 120–124  
   general concepts, 108–111  
   linear combinations of random  
 variables, 124–129  
   normal approximation to binomial  
 distribution, 129–135  
   normal approximation to Poisson  
 distribution, 135–137  
   normal distribution, 111–114  
   standard normal distribution,  
 114–120  
 Continuous random variable, 72  
   expected value of, 110  
   variance of, 111  
 Corrected sum of cross products, 432  
 Corrected sum of squares, 432  
 Correlation coefficient, 127–129,  
   452–455  
   dependent, comparison of, 465–467  
   interval estimation for, 460–462  
   multiple correlation, 493–494  
   one-sample  $t$  test, 455–457  
   one-sample  $z$  test, 457–460  
   overview, 452  
   partial correlation, 491–492  
   power and sample-size estimation,  
 463  
 rank correlation, 494–499  
 sample (Pearson) correlation  
   coefficient, 452–453  
 sample regression vs. sample  
   correlation coefficients, 453–455  
 sample vs. population correlation  
   coefficients, 453  
 sample-size estimation for, 462–463  
 statistical inference for, 455–467  
 two-sample  $z$  test, 463–465  
 Covariance, 126  
 Covariates, 546  
 Cox proportional-hazards model,  
   774–783  
   assumptions testing, 781–783  
   hazard ratio estimation for  
 continuous independent  
 variables, 775  
   hazard ratio estimation for  
 dichotomous independent  
 variables, 775  
   power estimation for, 781–783  
   sample-size estimation for, 786–787  
 CRD (Childhood Respiratory Diseases)  
   Study, 35, 512  
 Critical values, 209  
   Kruskal-Wallis test, 835  
   Spearman rank-correlation  
 coefficient, 834  
   standardized statistic, 836  
   Wilcoxon rank-sum test, 831–832  
   Wilcoxon signed-rank test, 830  
 Critical-value method, 209, 212, 836  
 Cross-over design, 666–674  
   assessment of treatment effects,  
 667–670  
   carry-over effect, 667, 670–672  
   definition, 666  
   sample-size estimation for, 672–674  
   washout period, 667  
 Cross-sectional study, 270, 589  
 Cumulative incidence, 59  
 Cumulative incidence rates, 725  
 Cumulative odds ordinal logistic  
   regression model, 656  
 Cumulative-distribution function, 78,  
   110, 115–116  
 CV (coefficient of variation), 20–21,  
   566–567  
 Data  
   cardinal, 327  
   interval scale, 327  
   nominal scale, 328  
   ordinal, 328  
   person-time. *See* Person-time data  
   ratio scale, 327  
 DBP (diastolic blood pressure), 571  
 Deductive reasoning, 149  
 Degrees of freedom, 169  
 Delta method, 593–594  
 Denominator degrees of freedom, 282  
 Dependent correlation coefficient,  
   465–467

- Dependent events, 43–44  
 Dependent random variables, 126–129  
 Dependent variable, 429  
 Descriptive statistics, 5–31  
     arithmetic mean, 13–15  
     case studies, 29–31  
     coefficient of variation, 20–21  
     computer packages, 31  
     graphic methods, 24–29  
     grouped data, 22–24  
     measures of location, 5–13  
     measures of spread, 15–18  
 Diabetes Prevention Study, 320  
 DIABETES.DAT (Data Set), 322, 349, 511  
 Diastolic blood pressure (DBP), 571  
 DIFCHISQ, 647  
 Direct standardization, 611–612  
 Discordant pair, 374–375  
 Discrete distribution, 3  
 Discrete probability distributions, 71–98  
     binomial distribution, 83–88  
     combinations, 79–83  
     cumulative-distribution function of discrete random variable, 78  
     expected value of discrete random variable, 75–76  
     permutations, 79–83  
 Poisson approximation to binomial distribution, 96–98  
 Poisson distribution, 90–93  
 Poisson probabilities, 93–94  
 probability-mass function, 73–75  
 random variable, 72–73  
 variance of discrete random variable, 76–77  
 Discrete random variable, 72  
     cumulative-distribution function, 78  
     expected value of, 75–76  
     probability-mass function for, 73–75  
     variance of, 76–77  
 Disease variable, 589  
 Disease-odds ratio, 596  
 Distribution  
     binomial, 71, 83–89  
     chi-square, 177–179  
     continuous, 3  
     discrete, 3  
     frequency, 3, 22–24, 73–75  
     mode, 11–12  
     negatively skewed, 10–11  
     Poisson, 71  
     positively skewed, 10–11  
     probability, 73–75  
     sampling, 160–161  
     symmetric, 10–11  
 Double blind, 159  
 Drop-in rate, 386  
 Dropout rate, 386  
 Dummy variable, 485, 541–542  
 Dunn procedure, 559–560  
 Effect modification, 618–620  
 El Paso Lead Study (LEAD.DAT), 29–30  
 ENDOCRIT.DAT, 580  
 EPESE (Established Populations for Epidemiologic Studies of the Elderly), 706  
 Epidemiologic studies  
     attributable risk, 601–606  
     clustered binary data, 674–687  
     confounding, 607–610  
     cross-over design, 666–674  
     equivalence studies, 663–666  
     extensions to logistic regression, 649–657  
     longitudinal data analysis, 687–696  
     Mantel-Haenszel test, 612–624  
     measures of effect for categorical data, 591–601  
     meta-analysis, 658–663  
     missing data, 706–711  
     multiple logistic regression, 628–649  
     power estimation for stratified categorical data, 625–628  
     sample-size estimation for stratified categorical data, 628  
     standardization, 610–612  
     study design, 588–591  
 Equal variances, 281–287  
     F distribution, 282–284  
     F test, 284–287  
 Equivalence studies, 663–666  
     definition, 663  
     inference based on confidence-interval estimation, 663–664  
     sample-size estimation for, 664–666  
 Error, in estimate, 4  
 Error mean square, 565  
 Error term, 550  
 ESD (Extreme Studentized Deviate) statistic, 296–300, 830  
 Established Populations for Epidemiologic Studies of the Elderly (EPESE), 706  
 Estimate, 4  
     error in, 4  
 Estimated mean difference, 4  
 Estimated regression line, 431, 433  
 Estimation, 149–195. *See also* Interval estimation; Point estimation; Power estimation; Sample-size estimation  
     binomial distribution, 181–188  
     central-limit theorem, 166–168  
     chi-square distribution, 177–179  
     interval, 168–169, 179–181, 184–188, 190–193  
     maximum-likelihood, 182–184  
     mean of distribution, 160–175  
     one-sided confidence intervals, 193–195  
     point, 160–162, 176–177, 181–182, 189–190  
     Poisson distribution, 189–193  
     population, 150–152  
     of power, 303–304  
     randomized clinical trials, 156–160  
 random-number tables, 152–156  
 sample, 150–152  
 standard error of the mean, 162–165  
 t distribution, 169–175  
 variance of distribution, 176–181  
 Estimator, 161  
 ESTRADL.DAT (Data Set), 422, 511  
 ESTROGEN.DAT (Data Set), 716  
 Events, 39  
     complement, 42  
     dependent, 43–44  
     exhaustive, 49  
     independent, 43  
     mutually exclusive, 40, 49  
     simultaneous, 41  
     symbol for, 40  
 Exact binomial probabilities, 811–815  
 Exact methods. *See also* Normal-theory methods  
     comparison of incidence rates, 734–736  
     McNemar's test, 377–380  
     one-sample binomial test (two-sided alternative), 247–249  
 Exact Poisson probabilities, 815–817  
 Excel, 4  
 Excel statistical package procedures  
     BINOMDIST, 87, 132  
     CHIDIST, 244  
     HYPGEOMDIST, 370–371  
     NORMDIST, 122–123  
     NORMINV, 122  
     NORMSINV, 501–502  
     POISSON, 192  
     TDIST, 211–212  
     TINV, 174, 209–210  
 Exchangeable correlation structure, 681–682, 687  
 Exhaustive events, 49  
 Expected mean square, 566  
 Expected table, 359–362, 391–392  
 Expected value  
     for 2 x 2 contingency tables, 360–362  
     of binomial distribution, 88–89  
     of continuous random variable, 110  
     of discrete random variable, 75–76  
     of hypergeometric distribution, 369–370  
     of linear combinations of random variables, 125–126  
     of Poisson distribution, 95–96  
 Exposure variable, 589  
 Exposure-odds ratio, 596–599  
 Externally Studentized residual, 478  
 Extreme outlying value, 28  
 Extreme Studentized Deviate (ESD) statistic, 296–300, 830  
 F distribution, 282–284  
     denominator degrees of freedom, 282  
     lower percentiles of, 284  
     numerator degrees of freedom, 282

- percentage of, 828–830  
 $p$ th percentile, 283  
 $F$  test, 284–287  
 acceptance and rejection regions, 438  
 for fixed-effects one-way ANOVA, 518–521  
 for multiple regression, 472  
 $p$ -value, 438  
 for simple linear regression, 437–441
- Factorial, 80–81  
 False negative, 52  
 False positive, 52  
 False-discovery rate, 536–538  
 FEF (forced mid-expiratory flow), 516  
 FEV.DAT (Data Set), 35, 315–316, 506, 512–513  
 Fisher's exact test, 367–373  
 exact probability of observing table with cells, 369  
 general layout of data, 368  
 general procedure, 371–372  
 hypergeometric distribution, 369–371  
 $p$ -value, 371  
 Fisher's  $z$  test, 463–465  
 acceptance and rejection regions, 464  
 for comparing two correlation coefficients, 464  
 $p$ -value, 465  
 Fisher's  $z$  transformation, 458, 833  
 Fitted regression lines, 448–451  
 assumptions, 448  
 influential points, 450  
 outliers, 450  
 standard deviation of residuals, 448–449  
 Studentized residuals, 448–449  
 Fixed-effects one-way ANOVA (analysis of variance), 516–518, 563. *See also* One-way ANOVA (analysis of variance)  
 acceptance and rejection regions, 521  
 between-group variability, 518–519  
 $F$  test, 520–521  
 $F$  test for group means comparison, 518  
 hypothesis testing, 518–522  
 interpretation of parameters, 517–518  
 $p$ -value, 521  
 within-group variability, 518–519
- Flat distribution, 238  
 Flowcharts  
 categorical data method for statistical inference, 409  
 methods for statistical inference, 503  
 person-time data methods, 803  
 two-sample statistical inference, 308
- Follow-up study, 270  
 Forced mid-expiratory flow (FEF), 516
- Framingham Eye Study, 50  
 Framingham Heart Study, 638–642  
 Frequency definition of probability, 56  
 Frequency distribution, 3, 22–24, 73–75
- Gaussian distribution, 108, 111–114  
 Generalized estimated equations (GEE), 681  
 Geometric mean, 12–13  
 Goodness of fit  
 of logistic-regression models, 643–649  
 regression lines, 435–436, 448–451  
 of Weibull survival model, 794  
 Goodness-of-fit test, 74, 401–404  
 Gossett, William, 169  
 Grand total, 358  
 Graphic methods, 24–29  
 bar graph, 25  
 box plots, 26–29  
 stem-and-leaf plots, 25–26  
 Greene-Touchstone study, 428–429  
 Grouped data, 22–24
- Harvard Medical Study, 415, 425  
 Harvard Pilgrim Health Care, 200  
 Hazard function, 760, 766, 789  
 Hazard rates, 759  
 Hazard ratio, 775  
 Heavy smokers, 516  
 Homogeneity of binomial proportions, 358  
 HORMONE.DAT (Data Set), 315, 349, 413, 506, 580, 716  
 HOSPITAL.DAT (Data Set), 33, 555  
 Hypergeometric distribution, 369–371  
 HYPGEOMDIST function, 370–371  
 Hypothesis testing, 149–150  
 acceptance and rejection regions, 473  
 Bayesian inference, 237–241  
 case study, 256, 293–295  
 chi-square goodness-of-fit test, 401–404  
 clustered binary data, 674–675  
 comparison of means from two paired samples, 275–276  
 and confidence intervals, 235–237  
 critical-value method, 209, 212  
 equality of two variances, 281–287  
 $F$  test, 472  
 Fisher's exact test, 367–373  
 fixed-effects one-way ANOVA, 518–522  
 general concepts, 204–207  
 interval estimation, 280–281  
 multiple logistic regression, 636–642  
 multiple-regression analysis, 472–476  
 null hypothesis, 205–206  
 one-sample  $\chi^2$  test for variance of normal distribution, 241–244  
 one-sample inference for binomial distribution, 244–250  
 one-sample problem, 204  
 one-sample test for mean of normal distribution, 207–221  
 one-sided alternatives, 207–215  
 outliers, 295–301  
 paired  $t$  test, 271–274  
 power estimation for comparing binomial proportions, 381–389  
 power of test, 221–226  
 $p$ -value, 473  
 $R \times C$  contingency tables, 390–400  
 sample-size determination, 228–234  
 sample-size estimation for comparing binomial proportions, 381–389  
 stratified person-time data, 742–745  
 $t$  test, 474  
 true state of nature, 207  
 two-sample inference, 269–307  
 two-sample problem, 204  
 two-sample  $t$  test for independent samples with equal variances, 276–279  
 two-sample  $t$  test for independent samples with unequal variances, 287–293  
 two-sample test for binomial proportions, 353–367  
 two-way ANOVA, 550–553  
 type I error, 206–207  
 type II error, 206–207
- Imputation, 707  
 Incidence, 59  
 Incidence density, 59, 726  
 Incidence rates, 725  
 confidence limits, 729–730  
 and cumulative incidence, 726  
 exact test, 734–736  
 interval estimation, 729–730  
 log-rank test, 768–769  
 normal-theory test, 731–733  
 one-sample inference, 727–729  
 point estimation, 729–730  
 power estimation for, 753–754  
 rate ratio, 736–737  
 sample-size estimation, 750–751  
 trend testing, 755–758  
 two-sample inference, 730–737
- Independent events, 43  
 Independent samples, 381–383, 387–388  
 Independent variable, 429  
 Independent-sample design, 270  
 Inductive reasoning, 149  
 INFANTBP.DAT (Data Set), 199, 315, 465–467, 507  
 Inferential statistics, 3  
 Influential points, 450  
 Interaction effect, 550  
 Internally Studentized residual, 478  
 Interval censoring, 763

- Interval estimation, 150, 168–169, 179–181. *See also* Confidence interval; Estimation; Sample-size estimation  
 for attributable risk, 603  
 comparison of means from two independent samples, 280–281  
 comparison of means from two paired samples, 275–276  
 for correlation coefficients, 460–462  
 exact methods, 186–188, 190  
 for incidence rates, 729–730  
 intraclass correlation coefficient, 569  
 for linear regression, 443–447  
 multiple logistic regression, 642–643  
 normal-theory methods, 184–186  
 for Poisson distribution, 190–193  
 for predictions from regression lines, 445–447  
 rank-correlation coefficients, 499–503  
 of rate ratio, 736–737  
 rate ratio, 746–747  
 for regression parameters, 443–445  
 risk difference, 592–593  
 for risk ratio, 594–595, 599–601  
 of survival probabilities, 764–765
- Interval scale, 327
- Intraclass correlation coefficient, 568–571. *See also* Correlation coefficient  
 definition, 568  
 interpretation of, 569  
 interval estimation, 569  
 as measure of reliability, 571  
 point estimation, 569
- Inverse normal function, 119
- Kaplan-Meier estimator, 760–767  
 estimation of hazard function, 766  
 interval estimation of survival probabilities, 764–765  
 treatment of censored data, 761–763
- Kappa statistic, 404–408  
 acceptance and rejection regions, 406  
 guidelines for evaluating kappa, 408  
*p*-value, 407
- Kruskal-Wallis test, 555–561  
 acceptance and rejection regions, 557  
 comparison of specific groups, 559–560  
 critical values for, 835  
*p*-value, 558  
 procedure, 556–557  
 rank assignment, 558
- Large-sample test, 727–728
- LEAD.DAT (Data Set), 29, 344
- LEAD.DOC (Data Set), 29
- Least significant difference (LSD), 524–528
- Least-squares line, 431, 433
- Left censoring, 763
- Light smokers, 516
- Likelihood, 182
- Linear combinations of random variables, 124–129  
 dependent random variables, 126–129  
 expected value of, 125–126  
 variance of, 125–126, 129
- Linear contrast, 528–531  
 definition, 125  
 multiple-comparisons procedure, 534–536  
*t* test, 529  
 variance of, 129
- Linear regression  
 $F$  test for, 437–441  
 interval estimation for, 443–447  
 simple, 437–445  
 standard deviation of residuals, 448–449  
 standard errors for estimated parameters, 444–445  
*t* test for, 441–443
- Linear-regression methods, 427–451  
 assumptions, 448  
 dependent variable, 429  
 $F$  test for simple linear regression, 437–441  
 independent variable, 429  
 interval estimates for regression parameters, 443–445  
 interval estimation, 443–447  
 interval estimation for predictions, 445–447  
 method of least squares, 431–435  
 overview, 427  
 regression line, 428, 430  
 standard errors for estimated parameters, 444–445  
*t* test for simple linear regression, 441–443
- Logistic regression  
 conditional, 649–651  
 interval estimation, 642–643  
 matched, 649–653  
 ordinal, 656–657  
 point estimation, 642–643  
 polychotomous, 653–656  
 residuals in, 643–647
- Logit transformation logit ( $p$ ), 629
- Log-rank test, 767–773  
 acceptance and rejection regions, 771  
 incidence rates, 768–769  
 procedure, 769–770  
*p*-value, 771
- Longitudinal data analysis, 687–696  
 in clinical trial setting, 688–691  
 interpretation of parameters, 687–688  
 measurement-error methods, 696–706
- Longitudinal study, 270, 304–307
- LSD (least significant difference), 524–528
- Mann-Whitney U test. *See* Wilcoxon rank-sum test
- Mantel extension test, 622–624
- Mantel-Haenszel test, 612–624  
 acceptance and rejection regions, 615  
 effect modification, 618–620  
 estimation in matched-pair studies, 620–621  
 estimation of odds ratio for stratified data, 616–618  
 procedure, 614–615  
*p*-value, 615  
 testing for trends in presence of confounding, 622–624
- Masking problem, 298
- Matched logistic regression, 649–653
- Matched pair, 373–380  
 concordant, 374  
 discordant, 374  
 estimation of odds ratio, 620–621  
 two-sample test for binomial proportions, 373–380  
 type A discordant pair, 374  
 type B discordant pair, 374–375
- Matched-pair design, 79
- Mathematical statistics, 1
- MAXFWT (mean finger-wrist tapping score), 484–491, 538–541
- Maximum-likelihood estimation, 182–184
- McNemar's test, 373–380  
 acceptance and rejection regions, 376  
 for correlated proportions, 375, 377  
 exact test, 377–380  
 normal-theory test, 375–377  
*p*-value, 376, 378
- Mean  
 arithmetic, 7–9, 13–15  
 geometric, 12–13  
 standard error of, 162–165
- Mean deviation, 17
- Mean finger-wrist tapping score (MAXFWT), 484–491, 538–541
- Mean of distribution, 160–175  
 central-limit theorem, 166–168  
 confidence interval, 171–176  
 estimation of, 160–175  
 interval estimation, 168–169  
 one-sample test, 207–215  
 point estimation, 160–162  
 standard error of the mean, 162–165  
 $t$  distribution, 169–175
- Measurement-error methods, 696–706  
 measurement-error correction with gold-standard exposure, 697–701  
 measurement-error correction without gold-standard exposure, 701–703

- regression-calibration approach, 699–700, 703–704
- Measures of effect for categorical data, 591–601
- odds ratio, 595–601
  - risk difference, 592–593
  - risk ratio, 593–595
- Measures of location, 5–13
- arithmetic mean, 7–9
  - geometric mean, 12–13
  - median, 9–10
  - mode, 11–12
- Measures of spread, 15–18
- quantiles (percentiles), 16–17
  - range, 15–16
  - standard deviation, 17–20
  - variance, 17–20
- Median, 9–10
- Meta-analysis, 658–663
- models, 662
  - random-effects model, 659–660
  - tests of homogeneity of odds ratios, 661–663
- Method of least squares, 431–435
- corrected sum of cross products, 432
  - corrected sum of squares, 432
  - estimation of least-squares lines, 433
  - least-squares line, 431
  - raw sum of cross products, 432
  - raw sum of squares, 432
- MICE.DAT (Data Set), 582
- Minimum variance unbiased estimator, 161
- MINITAB package, 4, 22–24, 133, 154, 798–799
- Minnesota Heart Study, 151
- Missing data, 706–711
- Mode, 11–12
- Moderate smokers, 516
- Multiple correlation, 493–494
- Multiple imputation, 707
- Multiple linear regression, 468–491.
- See also* Simple linear regression
  - case study, 484–491
  - estimation of regression equation, 468–471
  - goodness of fit, 476–482
  - hypothesis testing, 472–476
  - multiple correlation, 493–494
  - and one-way ANOVA, 541–545
  - partial correlation, 491–493
  - partial F test, 476
  - partial-regression coefficients, 476
  - partial-residual plot, 479–483
  - rank correlation, 494–499
  - standardized regression coefficient, 471
- Multiple logistic regression, 628–649
- acceptance and rejection regions, 637
  - and contingency-table analysis, 632–633
  - estimation of odds ratio for continuous independent variables, 635–636
- estimation of odds ratio for dichotomous independent variables, 631–632
- goodness of fit, 643–649
- hypothesis testing, 636–642
- interval estimation, 642–643
- model, 628–629
- point estimation, 642–643
- prediction with, 642–643
- p-value, 637
- regression parameters, 629–631
- residuals in, 643–647
- Multiplication law of probability, 42–44
- Multisample inference, 516–577
- intraclass correlation coefficient, 568–571
  - Kruskal-Wallis test, 555–561
  - mixed models, 572–576
  - one-way ANOVA, 516–548
  - random-effect one-way ANOVA, 562–568
- Mutually exclusive events, 40, 49
- Negative cofounder, 748
- Negatively skewed distribution, 10–11
- NEPHRO.DAT (Data Set), 658, 714–715
- NIFED.DAT (Data Set), 200, 262, 313
- Nominal scale, 328
- Noninformative prior distribution, 238
- Noninhaling smokers, 516
- Nonparametric statistical methods, 327–345
- case study, 344–345
  - chi-square goodness-of-fit test, 401–404
  - Fisher's exact test, 367–373
  - kappa statistic, 404–408
  - McNemar's test, 373–380
  - R x C contingency tables, 390–400
  - sample size and power, 381–389
  - sign test, 329–333
  - Wilcoxon rank-sum test, 339–343
  - Wilcoxon signed-rank test, 332–339
- Nonsmokers, 516
- Normal approximation
- binomial distribution, 129–135
  - Poisson distribution, 135–137
- Normal distribution, 108, 111–114. *See also* Standard normal distribution
- electronic tables, 118–119
- NORMDIST function of Excel, 122–123
- NORMINV function of Excel, 122
- one-sample test, 207–215
- probability-density function of, 115
- p<sup>th</sup> percentile, 123
- standard, 114–120
- table, 818–821
- Normal range, 118
- Normal variable, standardization of, 121
- Normal-theory methods, 184–186, 244–247. *See also* Exact methods
- McNemar's test, 375–377
- sign test, 329–332
- two-sample test for binomial proportions, 353–356
- Normal-theory test, 731–733
- Normative Aging Study, 63
- NORMDIST function, 122–123
- NORMINV function, 122
- NORMSINV function, 501–502
- Null hypothesis, 205–206
- Numerator degrees of freedom, 282
- Nurses' Health Study, 151, 562, 625
- Observed contingency table, 359
- Odds ratio, 595–601
- chi-square test for homogeneity of, 619–620
  - disease-odds ratio, 596
  - exposure-odds ratio, 596–599
  - interval estimation for, 599–601
  - in meta-analysis, 661–663
  - and multiple logistic regression, 631–632
  - odds in favor of success, 595
  - point estimation for, 600
  - probability of success, 595
  - test of homogeneity, 661–663
- One-sample  $\chi^2$  test for variance of normal distribution, 241–244
- One-sample inference, 204–256
- Bayesian inference, 237–241
  - for binomial distribution, 244–250
  - exact methods, 247–249
  - general concept, 204–207
  - normal-theory methods, 244–247
  - one-sample test for mean of normal distribution, 207–221
  - one-sample test for variance of normal distribution, 241–244
  - for Poisson distribution, 251–256
  - power and sample-size estimation, 249–250
  - power of test, 221–228
  - sample-size determination, 228–234
  - two-sided alternatives, 215–221
- One-sample inference for incidence-rate data, 727–730
- exact test, 728–729
  - large-sample test, 727–728
- One-sample problem, 204
- One-sample *t* test, 455–457
- acceptance and rejection regions, 457
  - for correlation coefficient, 456
  - p-value, 457
- One-sample test
- one-sided alternatives, 207–215
  - two-sided alternatives, 215–221
  - z* test, 220–221
- One-sample *z* test
- acceptance and rejection regions, 459
  - p-value, 460
  - z* transformation of *r*, 458

- One-sided alternatives, 207–215  
power of test, 221–226  
sample-size determination, 228–232
- One-sided confidence intervals, 193–195
- One-tailed test, 208
- One-way ANCOVA (analysis of covariance), 545–548
- One-way ANOVA (analysis of variance), 517, 525. *See also* Two-way ANOVA (analysis of variance)  
acceptance and rejection regions, 521, 525
- Bonferroni multiple-comparisons procedure, 531–534
- case study, 538–548
- comparison of specific groups, 521–538
- dummy variable, 541–542
- F* test, 518–521
- false-discovery rate, 536–538
- linear contrast, 528–531
- LSD procedure, 524–528
- and multiple regression, 541–545
- multiple-comparisons procedure for linear contrasts, 534–536
- pooled estimate of variance, 523–524
- p*-value, 521, 525
- random-effects model, 563–568
- t*-test based on pairs of groups, 522–528
- Ordinal data, 328
- Ordinal logistic regression, 656–657
- OTO.DAT (Data Set), 714–715
- Outliers, 295–300, 450
- Outlying value, 28
- p* (Logit transformation logit), 629
- Paired samples, 383–386
- Paired *t* test, 271–274
- Paired-sample design, 270
- Parametric statistical methods, 327
- Parametric survival analysis, 787–795
- Partial correlation, 491–493
- partial-regression coefficients, 476
- Partial-residual plot, 479–483
- Passive smoking, 516
- PC-SAS TTEST, 294
- Pearson correlation coefficient, 452–455  
definition, 452  
interpretation, 452–453  
vs. population correlation coefficient, 453  
vs. sample regression coefficient, 453–455
- Pearson residual, 643–647
- Percentiles, 16–17, 793–794, 799–802
- Permutations, 79–83
- Person-time data, 725–802  
cumulative incidence, 725–726  
incidence density, 726  
for incidence-rate data, 730–737
- Kaplan-Meier estimator, 760–767  
log-rank test, 767–773
- one-sample inference for incidence-rate data, 727–730
- parametric regression models for survival data, 795–802
- parametric survival analysis, 787–795
- power estimation for, 738–740
- proportional-hazards model, 774–783
- sample-size estimation, 740–742
- stratified, 742–750
- survival analysis, 758–760
- trend testing, 755–758
- Physician's Health Study, 389, 590–591
- Point estimates, 150
- Point estimation. *See also* Estimation; Interval estimation  
binomial distribution, 181–182  
for incidence rates, 729–730  
intraclass correlation coefficient, 569  
mean of distribution, 160–162  
multiple logistic regression, 642–643  
for odds ratio, 600  
Poisson distribution, 189–190  
rate ratio, 736–737, 746–747  
risk difference, 592–593  
for risk ratio, 594–595  
variance of distribution, 176–177
- Poisson approximation, 96–98
- Poisson distribution, 71, 90–93  
electronic tables, 94  
estimation for, 189–193  
expected value of, 95–96  
interval estimation, 190–193  
normal approximation to, 135–137  
one-sample inference, 251–256  
point estimation, 189–190  
Poisson tables, 93–94  
variance of, 95–96
- POISSON function, 192
- Poisson probabilities, 93–94
- Poisson tables, 93–94
- Poisson variable, 827
- Polytomous logistic regression, 653–656
- Population, 150–152
- Population correlation coefficient, 453
- Population variance, 76–77
- Positive confounder, 608
- Positively skewed distribution, 10–11
- Posterior distribution, 237
- Posterior predictive interval, 239
- Posterior probability, 57
- Power estimation. *See also* Estimation  
in clinical trial setting, 386–389  
for clustered binary data, 679–680  
for comparing two binomial proportions, 381–389  
comparing two means, 303–304  
for comparison of two incidence rates, 739–740
- for correlation coefficients, 463
- for incidence rates, 753–754
- for person-time data, 738–742
- for proportional-hazards model, 783–785
- for stratified categorical data, 625–628
- for stratified person-time data, 753–754
- Power of test, 221–226
- Predictive value negative (PV<sup>−</sup>), 51
- Predictive value positive (PV<sup>+</sup>), 51
- Prevalence, 59
- Prevalence study, 589
- Prior distribution, 237
- Prior probability, 56
- Probability, 38–59  
addition law of, 44–46  
Bayes' rule, 53–56  
Bayesian inference, 56–57  
conditional, 46–51  
definition, 39  
event, 39  
frequency definition of, 56–57  
incidence, 59  
multiplication law of, 42–44  
mutually exclusive events, 40  
notation, 40–42  
posterior, 57  
prevalence, 59  
prior, 56  
receiver operating characteristic curve, 57–59  
sample space, 39  
screening tests, 51–52  
total-probability rule, 48–51
- Probability distribution, 73–75
- Probability model, 4
- Probability-density function, 109
- Probability-mass function, 73–75
- PROC GENMOD, 682–686
- PROC MI, 708
- PROC MIANALYZE, 708
- PROC MIXED, 688–691
- PROC TTEST, 291–292
- Product-limit estimator, 761
- Product-limit method, 766
- Proportional Hazards Regression (SAS PHREG), 776
- Proportional odds ordinal logistic regression model, 656
- Proportional-hazards model, 774–783  
assumptions testing, 781–783  
hazard ratio estimation for continuous independent variables, 775  
hazard ratio estimation for dichotomous independent variables, 775  
power estimation for, 781–783  
sample-size estimation for, 786–787
- Weibull survival model, 797
- Proportional-mortality study, 248
- Prospective study, 589

- Pseudorandom numbers, 153  
 $PV^-$  (predictive value negative), 51  
 $PV^+$  (predictive value positive), 51  
 $p$ -value, 210–215
  - chi-square goodness-of-fit test, 403
  - chi-square test for trend in binomial proportions, 396–397
  - exact method, 332–333
  - $F$  test for equality of two variances, 284–287
  - $F$  test for one-way ANOVA, 521
  - Fisher's exact test, 371
  - hypothesis testing in multiple linear regression, 473
  - kappa statistic, 407
  - log-rank test, 771
  - Mantel-Haenszel test, 615
  - McNemar's test, 376, 378
  - multiple logistic regression, 637
  - normal-theory method, 329–332
  - normal-theory test, 356
  - one-sample binomial test (exact method), 247
  - one-sample  $t$  test for correlation coefficient, 457
  - one-sample  $t$  test for mean of normal distribution, 218
  - paired  $t$  test, 272
  - $R \times C$  contingency tables, 393
  - sign test (exact method), 332–333
  - sign test (normal-theory method), 330–331
  - Spearman rank-correlation coefficient, 497
  - statistical significance of, 212
  - $t$  test for comparison of pairs of groups in one-way ANOVA, 525
  - two-sample inference for incidence-rate data, 735–736
  - two-sample  $t$  test for independent samples with unequal variances, 289–291
  - two-sample test for binomial proportions, 356
  - two-sample test for incidence rates (normal-theory method), 733
  - Yates-corrected chi-square test, 363
- Quantiles, 16–17
- $R \times C$  contingency tables, 390–400
  - acceptance and rejection regions, 393
  - chi-square test, 392–393
  - chi-square test for trend in binomial proportions, 394–396
  - definition, 390
  - expected table, 391–392
  - $p$ -value, 393
  - test for association, 390–394
  - Wilcoxon rank-sum test, 397–400
- $R^2$ , 439–440
- Random assignment, 154
- Random digits, 822
- Random effects one-way ANOVA (analysis of variance), 562–568
- Random numbers, 152
- Random sample, 150
- Random selection, 153
- Random variables, 72–73
  - continuous, 72
  - correlation coefficient, 127–129
  - cumulative-distribution function, 110
  - dependent, 126–129
  - discrete, 72
  - linear combinations of, 124–129
  - probability-density function, 109
  - standard deviation, 76
- Random-effects one-way ANOVA (analysis of variance)
  - balanced case, 563
  - unbalanced case, 563
- Randomization, 156
- Randomized clinical trials, 156–160
  - design features, 158–159
  - double blind, 159
  - single blind, 159
  - stratification, 159
  - unblinded, 159
- Random-number tables, 152–156
- Range, 15–16
- Rank sum, 336
- Rank-correlation coefficients, 494–499
  - acceptance and rejection regions, 497
  - interval estimation for, 499–503
  - $p$ -value, 498
  - Spearman, 495–499
  - $t$  test for, 496
- Ranking procedure, 335
- Rate ratio, 736–737
  - chi-square test for homogeneity of, 748–749
  - interval estimation, 736–737, 746–747
  - point estimation, 736–737, 746–747
  - stratified person-time data, 745–748
- Ratio scale, 327
- Raw sum of cross products, 432
- Raw sum of squares, 432
- Receiver operating characteristic (ROC) curve, 57–59
- Recidivism rate, 188
- Reference population, 151
- Regression coefficient from first imputed data set, 710
- Regression component, 435
- Regression line, 428–430
  - estimated, 431, 433
  - fitting, 431–435
  - goodness of fit, 435–436, 448–451
  - inferences about parameters from, 435–443
  - interval estimates for regression parameters, 443–445
  - interval estimation for predictions, 445–447
- least-squares line, 431
- method of least squares, 431–435
- predicted value, 434
- predictions for individual observations, 445
- regression component, 435
- regression sum of squares, 436
- residual component, 435
- residual sum of squares, 437
- slope and intercept of, 432
- standard deviation of residuals, 448–449
- total sum of squares, 436
- two-sided 100%  $x (1-\alpha)$  confidence intervals, 444
- Regression mean square, 437
- Regression parameters, interval estimation for, 443–445
- Regression sum of squares, 436
- Regression to the mean, 241
- Rejection region, 208
  - Bonferroni multiple-comparisons procedure, 532
  - chi-square goodness-of-fit test, 403
  - chi-square test for  $R \times C$  contingency tables, 393
  - chi-square test for trend in binomial proportions, 395
  - Dunn procedure, 560
  - $F$  test for one-way ANOVA, 521
  - $F$  test for simple linear regression, 438
  - Fisher's  $z$  test, 464
  - fixed-effects one-way ANOVA (analysis of variance), 521
  - hypothesis testing in multiple linear regression, 473
  - kappa statistic, 406
  - Kruskal-Wallis test, 557
  - log-rank test, 771
  - Mantel-Haenszel test, 615
  - McNemar's test, 376
  - multiple logistic regression, 637
  - one-sample binomial test (normal-theory method), 245
  - one-sample  $\chi^2$  test for variance of normal distribution, 242
  - one-sample  $t$  test for correlation coefficient, 457
  - one-sample  $z$  test for correlation coefficient, 459
  - one-way ANOVA, 521, 525
  - $R \times C$  contingency tables, 393
  - rank-correlation coefficients, 497
  - sign test, 330
  - Spearman rank-correlation coefficient, 497
  - $t$  test for comparison of pairs of groups in one-way ANOVA, 525
  - $t$  test for multiple linear regression, 474
  - $t$  test for simple linear regression, 442
  - two-sample inference for incidence-rate data, 732

- two-sample test for binomial proportions (normal-theory test), 355
- two-sample test for incidence rates (normal-theory method), 732
- Yates-corrected chi-square test, 363
- z* test, one-sample, 459
- z* test, two-sample, 464
- Relative risk (*RR*), 47, 592
- Reliability coefficient, 571
- Reproducibility studies, 566
- Rescaled sample, 14–15
- Residual component, 435
- Residual mean square, 437
- Residual sum of squares, 437
- Retrospective study, 589
- Right censored data, 763
- Risk difference, 592
- interval estimation, 592–593
  - point estimation, 592–593
- Risk ratio, 593–595
- definition, 592
  - delta method, 593–594
  - estimation for case-control studies, 598
  - interval estimation, 594–595
  - point estimation, 594–595
- ROC (receiver operating characteristic) curve, 57–59
- Row effect, 550
- Row margins, 358
- RR* (relative risk), 47, 592
- Sample, 150–152
- independent, 381–383
  - median, 9–10
  - paired, 383–386
  - random, 150
  - regression coefficient, 453–455
  - space, 39
  - standard deviation. *See* Standard deviation
  - variance. *See* Variance
- Sample (Pearson) correlation coefficient, 452–455. *See also* Correlation coefficient
- definition, 452
  - interpretation, 452–453
  - vs. population correlation coefficient, 453
  - vs. sample regression coefficient, 453–455
- Sample-size estimation, 228–234. *See also* Interval estimation
- based on CI width, 233–234
  - in clinical trial setting, 386–389
  - for clustered binary data, 679–680
  - for comparing two binomial proportions, 381–389
  - for comparison of two incidence rates, 740–742
  - for correlation coefficients, 462–463
  - for cross-over design, 672–674
- for equivalence studies, 664–666
- for incidence-rate data, 750–751
- independent samples, 381–383, 387–388
- for longitudinal studies, 304–307
- one-sided alternatives, 228–234
- paired samples, 383–386
- and power, 249–250
- for proportional-hazards model, 786–787
- for stratified categorical data, 628
- for stratified person-time data, 750–753
- two-sample inference, 301–303
- two-sided alternatives, 232–233
- Sampling distribution, 160
- SAS, 4
- SAS General Linear Model procedure, 550–552, 565–566
- SAS PHREG (Proportional Hazards Regression), 776
- SAS PROC GENMOD program, 682–686
- SAS PROC LOGISTIC program, 633–634
- SAS PROC PHREG program, 651–653
- SAS PROC REG program, 469–470
- Satterwaite's method, 288–289
- Scatter plot, 5, 7
- Scheffé's multiple-comparison procedure, 534–536
- Screening tests, 51–52
- false negative, 52
  - false positive, 52
  - predictive value, 51
  - sensitivity of symptom, 51
  - specificity of symptom, 52
- SEER Tumor Registry, 40
- Sensitivity of symptom, 51
- SEXRAT.DAT (Data Set), 103, 199, 262, 418
- SHEP (Systolic Hypertension in the Elderly Program), 156–157
- Sign test, 329–333
- acceptance and rejection regions, 330
  - exact method, 332–333
  - normal-theory method, 329–332
  - p*-value, 330–333
- Significance level, 206
- Simple linear regression. *See also* Multiple linear regression
- F* test for, 437–441
  - standard errors for estimated parameters, 444–445
  - t* test for, 441–443
- Simple random sample, 150
- Single blind, 159
- SMOKE.DAT (Data Set), 102–103, 348, 508, 758–760, 776, 804
- Spearman rank-correlation coefficient, 495–499
- acceptance and rejection regions, 497
- interval estimation for, 500
- p*-value, 498
- t* test for, 496
- two-tailed critical values for, 834
- Specificity of symptom, 52
- Spread, 15
- SPSS, 4
- SPSS<sup>x</sup>/PC CROSSTABS program, 366, 380
- SPSS<sup>x</sup>/PC McNemar's test program, 380
- Standard deviation, 17–20
- properties of, 18–20
  - of random variable, 76
- Standard error of the mean, 162–165
- Standard normal distribution, 114–120.
- See also* Normal distribution
  - (100 *x u*)th percentile, 119
  - cumulative-distribution function, 115–116
  - electronic tables, 118–120
  - normal tables, 115–118
  - p*th percentile, 119
  - symmetry properties, 116–117
- Standardization, 610–612
- age-standardized risk, 611
  - direct, 611–612
  - of normal variable, 121
- Standardized morbidity ratio, 192, 253
- Standardized mortality ratio, 253–254
- Standardized regression coefficient, 471
- Statistics, 1, 3
- Steam-and-leaf plots, 25–26
- Step function, 78
- Strata, 4, 608
- Stratification, 159, 608
- Stratified person-time data
- estimation of rate ratio, 745–748
  - homogeneity of rate ratio, 748–749
  - hypothesis testing, 742–745
  - inference for, 742–750
  - power estimation for, 753–754
  - sample-size determination, 750–753
- Studentized residuals, 448–449, 478–479
- Student's *t* distribution, 169–175
- Study design, 588–591
- case-control study, 589
  - cohort study, 589
  - cross-sectional study, 589
  - prevalence study, 589
  - prospective study, 589
  - retrospective study, 589
- Study population, 151
- Sufficient statistic, 238
- Survival analysis, 758–760
- hazard function, 760
  - hazard rates, 759
- Survival function, 760, 766
- Survival probability, 760
- SWISS.DAT (Data Set), 319, 582, 720, 805
- Symmetric distribution, 10–11
- Systolic Hypertension in the Elderly Program (SHEP), 156–157

- t* distribution, 169–175, 823  
*t* test  
 acceptance and rejection regions, 442, 474  
 for comparison of pairs of groups, 522–528  
 hypothesis testing in multiple linear regression, 474  
 for linear contrasts in one-way ANOVA, 529  
 for multiple linear regression, 474  
 one-sample, for correlation coefficients, 455–457  
 for simple linear regression, 441–443  
 Spearman rank-correlation coefficient, 496  
**Tables**  
 2 x 2 contingency tables, 360–362  
 binomial, 83–86  
 binomial distribution, 87–88  
 chi-square distribution, 824  
 confidence limits for expectation of Poisson variable, 827  
 critical values for standardized statistic, 836  
 exact binomial probabilities, 811–815  
 exact Poisson probabilities, 815–817  
 expected, 359, 391–392  
 Extreme Studentized Deviate outlier statistic, 830  
 Fisher's *z* transformation, 833  
 Kruskal-Wallis test, 835  
 normal distribution, 115–119, 818–821  
 observed, 359  
 percentage of *F* distribution, 828–830  
 Poisson, 93–94  
 Poisson distribution, 94  
 Poisson variable, 827  
*R* x *C* contingency tables, 390–400  
 random digits, 822  
 random-number, 152–156  
 standard normal distribution, 118–120  
*t* distribution, 823  
 two-tailed critical values for Spearman rank-correlation coefficient, 834  
 two-tailed critical values for Wilcoxon rank-sum test, 831–832  
 two-tailed critical values for Wilcoxon signed-rank test, 830  
 Target population, 151  
 TDIST function, 211–212  
 TEAR.DAT (Data Set), 265, 350, 584  
 TENNIS1.DAT (Data Set), 415, 656, 715  
 TENNIS2.DAT (Data Set), 316, 346, 666, 670, 716  
 Test for homogeneity of binomial proportions, 358  
 Test of association, 359  
 Test of independence, 359  
 Test statistic, 209  
 TINV function, 174, 209–210  
 Total sum of squares, 436, 518  
 Total-probability rule, 48–51  
 Translated sample, 13–14  
 Treatment efficacy, assessment of, 667–670  
 Trend, testing for, 755–758  
 Trimodal distribution, 12  
 True mean difference, 4  
 True state of nature, 207  
 T-TEST program, 273–274  
 Tukey approach, 575  
 Two-sample hypothesis-testing problem, 269  
 Two-sample inference, 269–307  
 case study, 293–295  
 comparison of means from two independent samples, 280–281  
 equality of two variances, 281–287  
 estimation of power, 303–304  
 estimation of sample size, 301–303  
*F* test, 284–287  
 interval estimation, 275–276, 280–281  
 outliers, 295–301  
 paired *t* test, 271–274  
 two-sample *t* test for independent samples with equal variances, 276–279  
 two-sample *t* test for independent samples with unequal variances, 287–293  
 Two-sample inference for incidence-rate data, 730–737  
 acceptance and rejection regions, 732  
 exact test, 734–736  
 hypothesis testing, 730–731  
 normal-theory test, 731–734  
*p*-value, 733, 735–736  
 rate ratio, 736–737  
 Two-sample problem, 204  
 Two-sample test for binomial proportions, 353–367  
 acceptance and rejection regions, 355  
 clustered data, 675–676  
 contingency-table method, 357–367  
 equal number of sites per individual, 679  
 for matched-pair data, 373–380  
 normal-theory method, 353–356  
*p*-value, 356  
 Two-sided alternatives, 215–221  
 confidence interval, 235–237  
 power of test, 226–228  
 sample-size determination, 232–234  
 Two-tailed critical values  
 Spearman rank-correlation coefficient, 834  
 Wilcoxon rank-sum test, 831–832  
 Wilcoxon signed-rank test, 830  
 Two-tailed test, 216  
 Two-way ANCOVA (analysis of covariance), 553–555  
 Two-way ANOVA (analysis of variance), 548–553. *See also* One-way ANOVA (analysis of variance)  
 column effect, 550  
 definition, 548  
 error term, 550  
 fixed effect, 573  
 general model, 549  
 hypothesis testing, 550–553  
 interaction between two variables, 549  
 interaction effect, 550  
 random effect, 573  
 row effect, 550  
 Type I error, 206–207  
 Type II error, 206–207  
 Unbiased estimator, 176  
 Unblinded clinical trial, 159  
 Unimodal distribution, 12  
 Unmatched study design, 81  
 VALID.DAT (Data Set), 36, 199–200, 262, 506, 508  
**Variables**  
 confounding, 607  
 continuous random, 72, 111  
 dependent, 126–129, 429  
 discrete random, 72, 76–77  
 disease, 589  
 dummy, 485, 541–542  
 exposure, 589  
 independent, 429  
 normal, 121  
 Poisson, 827  
 random, 72–73, 76, 109–110, 124–129  
 Variance, 17–20  
 of binomial distribution, 88–89  
 of continuous random variable, 111  
 of discrete random variable, 76–77  
 estimation of, 176–181  
 of hypergeometric distribution, 369–370  
 of linear combinations of random variables, 125–126, 129  
 of Poisson distribution, 95–96  
 population, 77  
 properties of, 18–20  
 Variance of distribution, 176–181  
 chi-square distribution, 177–179  
 interval estimation, 179–181  
 point estimation, 176–177  
 Variance-covariance matrix, 544  
 Variance-stabilizing transformation, 450

- Washout period, 667  
Weibull survival model  
  definition, 789  
  estimation of parameters, 790–793  
  estimation of percentiles, 793–794,  
    799–802  
  goodness of fit, 794  
  hazard functions of Weibull  
    distribution, 789  
  proportional hazards model, 797  
Wilcoxon rank-sum test, 339–343  
  and chi-square test for trend,  
    397–400  
*p*-value, 342  
ranking procedure, 340–341  
two-tailed critical values for,  
  831–832
- Wilcoxon signed-rank test, 333–339  
  *p*-value, 337  
  ranking procedure, 335–336  
  two-tailed critical values for, 830  
Within mean square, 520, 565  
Within sum of squares, 519–520  
Within-group variability, 518–519  
Woburn study, 189–192  
Wolfe's test, 466  
Women's Health Initiative, 742  
Woolf procedure, 600  
 $\chi^2$ . *See* Chi-square test  
Yates-corrected chi-square test,  
  362–367  
  for 2 x 2 contingency tables, 362
- acceptance and rejection  
  regions, 363  
*p*-value, 363  
short computational form, 364–367
- z* test, one-sample, 218  
  acceptance and rejection  
    regions, 459  
  for correlation coefficient, 457–460  
  *p*-value, 460
- z* test, two-sample, 464–465  
  acceptance and rejection regions,  
    464  
  for comparing two correlation  
    coefficients, 464  
  *p*-value, 465
- z* transformation, 458



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## INDEX OF APPLICATIONS (continued)

### **DENTISTRY**

clinical trial of two treatments for periodontal disease: Example 13.63, **680**; Example 13.64, **681**; Example 13.65, **682**; Example 13.66, **684**  
 efficacy of a dental-education program in preventing the progression of periodontal disease: Problems 9.1–9.3, **346**  
 estimation of the frequency of tooth loss among male health professionals: Problems 4.91–4.93, **105**  
 longitudinal study of caries lesions on the exposed roots of teeth: Example 13.62, **676**

### **DERMATOLOGY**

comparison of two ointments in preventing redness on exposure to sunlight: Example 9.7, **329**; Example 9.8, **332**; Example 9.10, **333**; Example 9.11, **335**; Example 9.12, **337**; Example 9.13, **338**  
 comparison of vidabrine vs. placebo in treating recurrent herpes labialis: Example 13.61, **674**

### **DIABETES**

association between ethnicity and diabetes: Review Question 3B.2, **51**  
 association between ethnicity and HgbA1c among diabetes patients: Review Question 12B.3, **548**  
 clinical trial among subjects with impaired glucose tolerance in the Diabetes Prevention Study: Problems 8.133–8.136, **320**  
 effect of compliance with insulin on growth in boys with type I diabetes: Problems 5.86–5.88, **145**; Problems 8.152–8.154, **322**; Problems 9.47–9.50, **349**; Problems 11.88–11.91, **510**; Problems 11.97–11.99, **511**  
 effect of the insulin pump on HgA1c levels among diabetics: Problems 8.163–8.166, **323**  
 genetic profile of patients with type I diabetes: Problems 12.68–12.69, **585**  
 incidence rates of blindness among insulin-dependent diabetics: Problems 4.63–4.67, **103**  
 long-term trends in incidence of type II diabetes in Rochester, Minnesota: Problems 11.85–11.87, **510**  
 plasma-glucose levels in sedentary people: Problems 7.7–7.9, **259**  
 results from a weight loss trial among diabetics: Problems 5.114–5.116, **147**  
 selection of patients for a treatment trial comparing an oral hypoglycemic agent with standard insulin therapy: Example 6.15, **153**  
 side effects of insulin-pump therapy: Problems 10.26–10.27, **412**

### **ENDOCRINOLOGY**

age at onset of spermatozoa in urine samples of pre-adolescent boys: Problems 10.47–10.50, **413**  
 change in bone density over 7 years after treatment with alendronate: Problems 11.75–11.80, **509**  
 clinical trial for the prevention of fractures: Problems 7.99–7.101, **266**  
 comparison of bone loss between alendronate- and placebo-treated patients: Problems 5.65–5.67, **142–143**  
 effect of calcium and estrogen supplementation on bone loss: Problems 12.31–12.34, **580**  
 effect of cod liver oil supplementation in childhood to bone density in middle age: Problems 12.74–12.77, **585–586**  
 effect of low-fat diet on estrogen metabolism: Problems 9.61–9.64, **350–351**  
 effect of low-fat diet on hormone levels in postmenopausal women: Problems 8.107–8.110, **317**  
 effect of obesity on hormonal profile and impact on breast-cancer risk in women: Problems 11.92–11.96, **510–511**  
 effect of raloxifene in preventing fractures among postmenopausal women: Problems 13.85–13.89, **719**  
 effects of tobacco use on bone density in middle-aged women: Figure 2.11, **32**; Problems 2.38–2.46, **37**; Problems 4.79–4.83, **104**; Problems 6.86–6.87, **201**; Review Question 7B.1, **234**; Example 7.58, **256**; Problems 7.73–7.74, **263–264**; Problems 9.41–9.42, **349**; Problems 11.57–11.64, **508**; Review Question 13B.1, **612**  
 hypothyroxinemia as a cause of subsequent motor and cognitive abnormalities in premature infants: Problems 11.48–11.52, **507–508**  
 plasma hormones as risk factors for postmenopausal breast cancer: Example 13.72, **701**; Example 13.73, **704**; Problems 13.78–13.81, **718**  
 relationship between calcium content of drinking water and the rate of fractures: Problems 13.15–13.18, **713**  
 reproducibility of plasma hormones in split blood samples: Examples 12.27–12.30, **562–565**; Example 12.32, **568**; Example 12.33, **569**; Table 12.37, **580**; Problem 12.55, **582**

### **ENVIRONMENTAL HEALTH**

association between selenium level and cognitive function: Problems 10.127–10.130, **423**  
 effect of exposure to anesthetic gases on cancer incidence: Problems 6.33–6.35, **198**  
 effect of nuclear-power plants on birth defects: Problems 4.52–4.54, **102**  
 effect of occupational exposure to 2,4,5-T herbicide on pulmonary function: Problems 7.82–7.84, **264**  
 incidence of childhood leukemia in Woburn, Massachusetts: Examples 6.53–6.55, **189–190**; Examples 6.57–6.58, **191**  
 measurement of exposure to low levels of radiation among shipyard workers: Example 4.5, **72**  
 projected health effects of chronic exposure to low levels of lead in young children: Figures 2.9–2.10, **30**; Problems 2.31–2.32, **36**; Problems 6.67–6.69, **200**; Example 8.20, **293**; Examples 8.23–8.26, **297–299**; Problems 8.93–8.95, **316**; Table 9.5, **345**; Example 11.50, **485**; Problems 11.44–11.47, **507**; Tables 12.7–12.13, **538–548**; Problems 12.44–12.46, **581**; Problems 13.82–13.84, **718**  
 rate of congenital malformations in offspring of Vietnam-veteran fathers: Problem 4.32, **101**  
 relationship between daily particulate air pollution and mortality in Steubenville, Ohio: Problem 5.55, **142**  
 relationship between emergency-room admissions and level of pollution: Problems 4.71–4.74, **104**  
 relationship between pollution levels and heart-attack rates: Problems 5.89–5.91, **145**  
 variation in temperature within a household: Problems 12.37–12.39, **581**; Problem 12.56, **582**

## INDEX OF APPLICATIONS (continued)

### **EPIDEMILOGY**

selection of random samples for serum testing from participants in the Nurses' Health Study: Example 6.10, **151**

### **GASTROENTEROLOGY**

comparison of two treatments for duodenal ulcer: Problems 10.8–10.12, **410**

random assignment of treatments for a clinical trial for duodenal ulcer: Problems 6.1–6.4, **196**

relationship between protein concentration of duodenal secretions and pancreatic function in cystic fibrosis:

Problems 12.42–12.43, **581**

### **GENETICS**

correlation between body weights of fathers and first-born sons: Example 11.29, **458**; Example 11.31, **459**; Example 11.32, **461**

dominant, recessive, and sex-linked mode of inheritance: Problems 3.30–3.47, **61–62**; Problems 4.94–4.96, **105–106**

genetic counseling for families with dominant disease: Problems 3.100–3.103, **67**

genetic effects on cholesterol levels: Table 8.21, **313**

genetic factors modulating the effect of cigarette smoking on renal-cell carcinoma: Problems 10.102–10.104, **421**

genetic marker for coronary heart disease: Review Question 14B.2, **738**

genetic markers for breast cancer: Example 14.4, **727**; Example 14.5–14.6, **728**; Example 14.7, **729**; Example 14.8, **730**

genetic profile of patients with type I diabetes: Problems 12.68–12.69, **585**

genetics of macular degeneration: Table 5.8, **147**

genetics of phenylketonuria: Problems 6.111–6.115, **202–203**

nested case-control study to assess SNPs associated with cardiovascular disease: Examples 12.16–12.17, **536–537**

patterns in sex-ratio data: Problem 4.57, **103**; Problem 6.59, **199**

prevalence of birth defects in a population: Problems 3.111–3.113, **67**

sequencing of ribosomal 5S RNA: Problems 7.19–7.20, **259**

### **GYNECOLOGY**

effect of contraceptive method on fertility: Example 8.6, **274**; Example 8.8, **275**

relationship between IUD use and infertility: Problems 13.1–13.7, **713**

sample of time intervals between successive menstrual periods: Table 2.3, **11**

test of a home pregnancy test-kit: Problems 3.79–3.82, **65**

use of basal body temperature to estimate the exact day of ovulation: Example 6.24, **165**; Example 6.33, **173**; Examples 6.35–6.36, **174**

### **HEALTH PROMOTION**

effect of fiber intake on weight gain in women: Review Question 10D.1, **390**

effect of quitting smoking on weight gain in middle-aged women: Problems 8.141–8.145, **320–321**

effect of walking on a treadmill on heart rate: Review Question 8A.2, **275**; Problems 8.167–8.170, **323–324**

gender differences in weight perception among adolescents: Problems 10.100–10.101, **420**

influence of retirement on level of physical activity among elderly women in the ARIC study: Problems 8.137–8.140, **320**

obesity among high school students: Review Question 7C.1, **250**

relationship between education and obesity: Problems 10.82–10.85, **419**

relationship between ethnicity and obesity among women: Problems 10.112–10.113, **422**

relationship between time to quitting smoking and total mortality: Problems 14.48–14.52, **806–807**

risk factors influencing success of smoking-cessation programs: Problems 4.55–4.56, **102**; Problems 9.28–9.32, **348**; Problems 11.65–11.67, **508**; Example 14.26, **758**; Example 14.27, **759**; Example 14.29, **761**; Example 14.34, **768**; Example 14.35, **771**; Example 14.37, **776**; Problems 14.7–14.11, **803**

smoking cessation as a preventive measure for heart disease: Example 6.52, **188**

smoking-cessation strategies for heavy-smoking teenagers: Problems 8.127–8.128, **319**

### **HEALTH SERVICES ADMINISTRATION**

comparison of length of stay in two different hospitals for patients with the same diagnosis: Problems 9.9–9.10, **346**

reproducibility of designation of medical malpractice: Problems 10.51–10.52, **415**

### **HEMATOLOGY**

hematologic data for patients with aplastic anemia: Problems 11.1–11.7, **504**

### **HEPATIC DISEASE**

effect of different hormones on pancreatic and biliary secretions in laying hens: Problems 8.82–8.85, **314–315**;

Problems 9.34–9.37, **348–349**; Problems 10.37–10.41, **413**; Problems 11.35–11.36, **506**; Problems 12.27–12.30, **580**; Problems 13.48–13.51, **716**

relationship of hepatoma to cirrhosis of the liver: Problems 5.50–5.52, **141**

### **HOSPITAL EPIDEMIOLOGY**

association between amount of sleep among medical house staff and medical errors: Problems 7.90–7.92, **265**

distribution of number of admissions to the emergency room: Problems 4.97–4.99, **106**

relationship between adverse events and mortality during hospital stay: Problems 10.59–10.60, **416**

## INDEX OF APPLICATIONS (continued)

### HYPERTENSION

active-control designs for testing new anti-hypertensive agents: Problems 13.41–13.43, **715**  
 assessment of anti-hypertension drug treatment to reduce stroke risk among elderly people with isolated systolic hypertension (SHEP study): Example 6.17, **156**; Example 6.19, **159**  
 association between glaucoma and hypertension: Problems 6.25–6.26, **197**  
 association between left ventricular hypertrophy and hypertension: Review Question 13B.2, **612**  
 cardiovascular-reactivity measures: Table 3.10, **64**; Problems 11.30–11.32, **506**  
 comparison of an arteriosonde blood-pressure machine with the standard cuff: Example 6.39, **177**; Example 6.41, **181**; Example 7.45, **241**; Example 7.46, **243**  
 comparison of blood pressure between Caucasian and African-American girls in the Bogalusa Heart Study: Review Questions 8B.2–8B.3, **293**  
 comparison of the blood-pressure levels of vegetarians and non-vegetarians: Examples 12.20–12.22, **548–553**; Problems 12.58–12.59, **582**  
 comparison of body-mass index between hypertensive and normotensive subjects: Problems 8.78–8.81, **314**  
 comparison of plasma aldosterone levels between black and white children: Problems 5.47–5.49, **141**  
 comparison of the random-zero machine and the standard cuff: Tables 9.11–9.12, **348**  
 contribution of endothelin to blood-pressure regulation: Problems 11.53–11.56, **508**  
 difference in prevalence of hypertension by ethnic group: Problems 5.120–5.122, **148**; Review Question 10E.3, **400**  
 distribution of blood pressure among Samoans: Example 6.5, **150**  
 distribution of diastolic blood pressure in 35 to 44 year old men: Example 5.2, **108**; Example 5.3, **109**; Example 5.6, **111**; Example 5.10, **113**; Example 5.20, **120**; Example 5.24, **124**; Examples 6.3–6.4, **149**  
 distribution of diastolic blood pressure in the HDPP program: Examples 10.39–10.40, **401**; Example 10.41, **403**  
 effect of dietary pattern on blood pressure: Problems 8.129–8.132, **319–320**  
 effect of position on level of blood pressure: Table 2.14, **35**  
 effect of post-menopausal hormones on blood pressure: Example 13.60, **673**; Problems 13.60–13.66, **716–717**  
 effectiveness of hypertension-treatment programs: Problems 4.34–4.36, **101**; Example 6.12, **152**; Problems 6.40–6.46, **198**  
 effectiveness of ingestion of linoleic acid on blood pressure: Table 9.10, **347**  
 effectiveness of stress management in reducing blood pressure: Problems 8.102–8.106, **317**  
 efficacy of treatment for hypertension based on home blood-pressure readings: Table 6.12, **201**; Table 6.13, **202**  
 ethnic differences in rates of hypertension among children: Problems 13.90–13.97, **719–720**  
 evaluation of an automated blood-pressure machine: Table 1.1, **3**; Example 3.26, **54**; Example 10.25, **378**; Problems 12.9–12.11, **578**  
 familial blood-pressure relationships: Problems 5.17–5.20, **138–139**; Example 11.2, **427**; Example 11.35, **463**; Example 11.36, **464**  
 hypertension screening in the home: Example 3.12, **42**  
 inclusion of birthweight and body length in a multiple regression model: Example 11.46, **475**  
 judging the effectiveness of anti-hypertensive medication: Problems 5.62–5.64, **142**  
 non-pharmacologic therapies for hypertension: Problems 12.14–12.17, **579**  
 norms for high blood pressure in children: Problems 5.53–5.54, **141–142**; Problems 11.18–11.23, **505**  
 oscillometric devices for detecting high blood pressure in children: Problems 7.104–7.107, **266–267**  
 prevalence of hypertension in the U.S. population: Example 3.35, **59**  
 relationship between birthweight and infant blood pressure: Example 13.3, **590**  
 relationship between blood lead and blood pressure: Problems 13.31–13.33, **714**  
 relationship between obesity and hypertension: Example 11.47, **475**; Review Question 13A.2, **601**; Problems 13.90–13.92, **719**  
 relationship between salt-taste and sugar-taste response to blood pressure in children: Problems 6.56–6.58, **199**; Problems 8.87–8.88, **315**; Example 11.37, **465**; Problems 11.42–11.43, **507**  
 relationship between the use of oral contraceptives and level of blood pressure in women: Example 8.2, **269**; Table 8.1, **271**; Example 8.5, **272**; Example 8.7, **275**; Example 8.9, **276**; Example 8.10, **278**; Example 8.11, **281**; Example 8.16, **286**; Examples 8.28–8.32, **301–303**  
 reliability of blood-pressure measurements: Example 12.31, **567**; Example 12.34, **570**; Table 12.34, **579**  
 risk factors for newborn blood-pressure measurements: Example 11.38, **468**; Example 11.39, **469**; Examples 11.40–11.41, **470–471**; Examples 11.42–11.44, **471–472**; Example 11.45, **475**; Example 11.48, **476**; Example 11.49, **481**; Example 11.51, **492**; Example 11.52, **493**  
 screening for high-blood pressure in children: Problems 5.53–5.54, **151**  
 screening procedures for detecting hypertension: Example 7.44, **239**; Problems 7.97–7.98, **266**  
 side effects of anti-hypertensive agents: Problems 7.85–7.87, **265**  
 testing of new anti-hypertensive agents: Example 4.4, **72**, Examples 4.6–4.7, **73**; Table 4.2, **74**; Example 4.8, **74**; Example 4.11, **76**; Example 7.23, **219**; Problems 7.26–7.27, **260**; Example 8.33, **304**; Example 8.34, **306**  
 use of both weight and BMI in the same regression model: Example 11.47, **475**

### INFECTIOUS DISEASE

allergic-reaction rates: Problems 14.22–14.24, **804**  
 clustering of gonorrhea cases in central cities: Problem 4.25, **100**  
 comparability of infectious-disease diagnoses as reported by the attending physician and by chart review: Problem 10.17, **410**  
 comparison of efficacy of 2 antibiotics: Problems 3.104–3.106, **67**  
 comparison of vidarabine vs. placebo in treatment of recurrent herpes labialis: Example 13.61, **674**  
 differences in effectiveness and toxicity of aminoglycoside antibiotics: Example 6.18, **158**; Problems 13.34–13.36, **715**

**INDEX OF APPLICATIONS (continued)**

- distribution of annual number of polio deaths: Example 4.37, **95**; Table 4.9, **95**; Example 10.3, **352**  
 distribution of annual number of typhoid-fever deaths: Example 4.31, **90**; Example 4.33, **92**; Figure 4.5, **93**; Example 4.36, **94**  
 distribution of MIC of penicillin G for *N. gonorrhoeae*: Table 2.4, **12**  
 distribution of number of eosinophils in 100 white-blood cells: Problem 5.25, **139**  
 distribution of number of lymphocytes in 100 white-blood cells: Example 4.26, **85**; Example 5.9, **112**; Problems 5.26–5.28, **139**  
 distribution of number of neutrophils in 100 white-blood cells: Example 4.15, **79**; Examples 4.23–4.24, **83**; Example 4.28, **86**; Example 5.1, **108**; Examples 5.34–5.35, **132–133**; Problems 5.29–5.30, **139**; Example 6.1, **149**  
 distribution of time to onset of AIDS following seroconversion among hemophiliacs: Problems 6.64–6.66, **199**  
 effect of aspirin in preventing ototoxicity among patients receiving gentamicin: Problems 10.117–10.120, **422**  
 effectiveness of different smallpox vaccines: Problems 10.89–10.92, **419–420**  
 incidence of H1N1 influenza in Australia and New Zealand: Problems 14.72–14.75, **811**  
 incidence rate of influenza among high-school students: Problems 14.32–14.36, **805**  
 prevalence of HIV-positive people in a low-income census tract: Example 6.6, **150**  
 red wine intake to prevent the common cold: Review Question 13E.2, **649**  
 relationship between the use of oral contraceptives and bacteriuria: Table 13.8, **610**; Example 13.21, **610**; Example 13.22, **611**; Problems 13.9–13.14, **713**  
 reproducibility of assessment of generalized lymphadenopathy among people at high risk for AIDS: Table 8.18, **312**; Problem 9.43, **349**  
 retrospective chart review of patients in a Pennsylvania hospital: Table 2.11, **33**; Examples 8.18–8.19, **291–292**; Problems 8.7–8.11, **309**; Problems 9.11–9.12, **346**; Problems 10.6–10.7, **410**; Review Question 11B.2, **455**; Review Questions 11C.2–3, **467–468**; Review Question 11D.3, **484**; Review Question 12C.4, **555**  
 risk factors for *Chlamydia trachomatis*: Example 13.34, **628**; Example 13.36, **631**; Example 13.38, **636**; Example 13.39, **637**  
 risk factors for HIV infection among intravenous drug users: Problems 4.58–4.62, **103**; Problems 10.53–10.54, **415**  
 sample of admission white-blood counts in a Pennsylvania hospital: Table 2.2, **10**  
 screening of newborns for HIV virus in five Massachusetts hospitals: Table 4.14, **100**  
 side effects of a flu vaccine: Example 4.30, **87**  
 side effects of a polio-immunization campaign in Finland: Example 4.40, **98**; Review Question 10F.2, **404**  
 surveillance methods for detecting infection following caesarean-section birth: Problems 10.93–10.97, **420**  
 validation study of accuracy of assessment of hospital-acquired infection among coronary-bypass patients: Problems 3.107–3.110, **67**

**MENTAL HEALTH**

- Alzheimer's-disease prevalence: Table 3.5, **61**; Problems 3.16–3.27, **61**  
 association between selenium levels and cognitive function: Problems 10.127–10.130, **423**  
 comparison of physician and spouse reports for diagnosing schizophrenia: Problems 10.108–10.111, **421–422**  
 effect of widowhood on mortality: Problems 10.33–10.36, **412**; Problems 13.29–13.30, **714**; Problem 13.108, **720**  
 evaluation of a Mental Function Index to identify people with early signs of senile dementia: Problems 12.12–12.13, **578**  
 matched pair study for schizophrenia: Examples 4.16–4.17, **79–80**  
 use of APOE gene to diagnose Alzheimer's disease: Table 3.15, **66**  
 use of Chinese Mini-Mental Status Test to identify people with dementia in China: Table 3.12, **65**  
 use of vitamin E supplementation to prevent Alzheimer's disease: Review Question 9B.2, **344**

**MICROBIOLOGY**

- pod weight of plants inoculated with nitrogen-fixing bacteria vs. uninoculated plants: Table 2.18, **37**; Problems 8.116–8.120, **318**; Problems 9.44–9.46, **349**  
 quality control for susceptibility testing: Table 6.10, **197**

**NEUROLOGY**

- changes in symptoms in clinical trial of Parkinson's disease patients: Problems 8.175–8.177, **324**  
 risk of cancer among cystic-fibrosis patients: Problems 5.59–5.61, **142**

**NUTRITION**

- association between high salt intake and cause of death: Example 10.16–10.17, **367**; Example 10.19, **370**; Example 10.20, **372**  
 calcium intake in low-income populations: Problems 8.2–8.6, **309**; Problems 8.12–8.18, **309**  
 comparison of blood-pressure levels between vegetarians and non-vegetarians: Examples 12.20–12.22, **548–553**  
 comparison of dietary vitamin C intake between smokers and non-smokers: Problems 8.182–8.186, **325**  
 comparison of protein intake among vegetarians and non-vegetarians: Problems 12.1–12.5, **577**  
 distribution of total carbohydrate intake in children: Problems 5.6–5.9, **138**  
 effect of cod liver oil supplementation in childhood on bone density in middle age: Problems 12.74–12.77, **585–586**  
 effect of oat bran intake on cholesterol levels: Problems 7.54–7.58, **262**  
 effectiveness of dietary counseling in achieving sodium restriction: Table 8.20, **313**; Problem 9.33, **348**  
 iron-deficiency anemia in low-income populations: Problems 7.33–7.40, **260–261**  
 measuring compliance with a sodium-restricted diet: Problem 9.33, **348**  
 prevalence of bladder cancer in rats fed a high-saccharin diet: Example 6.50, **186**; Example 6.51, **187**  
 protective effect of vitamins A and E vs. cancer: Example 2.1, **5**; Example 10.26–10.27, **381**  
 recall of pre-school diet of their children by 70–79 year-old women: Problems 11.118–11.121, **574–575**

## INDEX OF APPLICATIONS (continued)

relationship between breast-cancer incidence and dietary-fat intake: Example 13.70, **697**; Example 13.71, **701**; Problems 13.73–13.77, **717–718**  
 relationship between dietary and plasma vitamin C in the EPIC-Norfolk Study: Problems 11.109–11.112, **512**  
 relationship of dietary intake assessed by food-frequency questionnaire vs. the diet record: Table 2.16, **36**; Problems 5.56–5.58, **142**; Problems 7.59–7.60, **262**; Problem 11.33, **506**; Problems 11.68–11.72, **509–510**  
 reproducibility of a food-frequency questionnaire: Example 10.9, **359**; Example 10.15, **365**; Example 10.42–10.44, **404–406**  
 serum cholesterol levels in vegetarians: Problems 7.26–7.28, **260**  
 validation of a dietary questionnaire administered over the Internet: Example 11.33, **462**; Example 11.34, **463**

### OBSTETRICS -----

accuracy of daughter's report of maternal smoking during pregnancy: Table 3.19, **69**  
 Apgar score: Examples 11.53–11.55, **494–496**; Example 11.57, **501**  
 association between socioeconomic status and birth defects: Problems 4.100–4.103, **106**  
 cigarette smoking and low-birthweight deliveries: Table 5.5, **146**  
 distribution of birthweights in the general population: Example 5.5, **110**; Example 6.8, **150**  
 drug therapy for preventing low-birthweight deliveries: Problem 7.22, **260**; Problems 8.37–8.40, **311**; Problems 9.7–9.8, **346**  
 estriol levels in pregnant women as an indicator of a low-birthweight fetus: Example 11.1, **427**; Example 11.3, **428**; Examples 11.4–11.5, **429**; Example 11.8–11.11, **433–434**; Example 11.12, **439**; Example 11.15, **443**; Example 11.16, **444**; Example 11.24, **453**; Example 11.26, **455**  
 infant-mortality rates in the U.S., 1960–2005: Problems 11.13–11.17, **505**  
 probability of a male live childbirth: Example 3.2, **39**  
 rate of congenital malformations in offspring of Vietnam-veteran fathers: Problem 4.32, **101**  
 relationship between birthweight and gestational age: Problems 3.48–3.50, **62**  
 relationship between low socioeconomic status and low birthweight: Examples 7.2–7.3, **204–205**; Example 7.4, **206**; Example 7.6, **206**; Examples 7.10–7.11, **209–210**; Example 7.12, **211**; Example 7.14, **212**; Example 7.16–7.17, **213**; Example 7.19, **215**; Example 7.29, **225**; Example 7.31, **226**; Example 7.33–7.34, **230**; Example 7.36, **231**; Example 8.1, **269**  
 sample of birthweights from 100 consecutive deliveries: Table 2.7, **22**  
 sample of birthweights from 1000 consecutive deliveries: Table 6.2, **155**; Example 6.16, **154**; Example 6.22, **163**; Example 6.23, **164**; Problems 6.52–6.55, **198**  
 sample of birthweights from a San Diego hospital: Table 2.1, **8**  
 screening tests for Down's syndrome: Problems 10.121–10.123, **422–423**  
 surveillance methods for detecting infection following caesarean-section birth: Problems 10.93–10.97, **420**  
 variability of an assay for *M. hominis* mycoplasma: Problems 6.36–6.39, **198**

### OCCUPATIONAL HEALTH -----

excess cancer deaths in nuclear-power-plant workers: Example 7.49, **248**  
 incidence of bladder cancer and Hodgkin's disease among rubber workers: Examples 7.52–7.53, **251–252**; Example 7.54–7.57, **252–255**  
 incidence of bladder cancer among workers in the tire industry: Problems 4.23, **100**; Problem 6.75, **200**  
 incidence of stomach cancer among workers in the tire industry: Problem 4.24, **100**; Problem 6.76, **200**  
 mortality experience of workers exposed to waste disposal during the Manhattan Project: Problems 7.43–7.46, **261**  
 mortality experience of workers in a chemical plant: Problems 3.28–3.29, **61**  
 mortality experience of workers with exposure to EDB: Example 4.38, **95**; Example 6.59, **192**  
 proportion of lung-cancer deaths in chemical-plant workers: Problems 7.28–7.32, **260**

### OPHTHALMOLOGY -----

association between body mass index and AMD: Problems 13.111–13.112, **721**  
 association between cigarette smoking and glaucoma: Review Question 14C.1, **749**; Review Question 14D.12, **754–755**  
 association between ethnic origin and genetic type in retinitis pigmentosa: Problem 10.15, **410**  
 association between glaucoma and hypertension: Problems 6.25–6.26, **197**  
 change in electroretinogram (ERG) amplitude following surgery for patients with retinitis pigmentosa: Review Question 9A.5, **339**  
 change in serum retinol and serum triglycerides after taking high doses of vitamin A among retinitis-pigmentosa patients: Problems 10.64–10.69, **416–417**  
 change in visual field in retinitis pigmentosa patients: Problems 11.100–11.103, **511–512**; Problems 14.68–14.71, **810–811**  
 comparison of eye drops in preventing redness and itching in people with hay fever: Example 9.9, **333**  
 comparison of lens photographs of cataractous and normal eyes: Table 8.16, **310**  
 comparison of mean ERG amplitude among patients with different genetic types of retinitis pigmentosa: Problems 8.97–8.101, **316**  
 comparison of Sorbinil vs. placebo for the prevention of diabetic retinopathy: Problems 10.143–10.146, **424–425**  
 comparison of the ocular anti-inflammatory properties of four different drugs in albino rabbits: Example 12.23, **556**; Example 12.24, **557**; Example 12.26, **560**  
 comparison of visual acuity in people with the dominant and sex-linked forms of retinitis pigmentosa: Example 9.15, **339**; Example 9.16, **341**; Example 9.17, **342**; Example 10.38, **399**  
 compliance with lutein supplement tablets among macular-degeneration patients: Problems 5.92–5.95, **145–146**; Problems 11.81–11.84, **509–510**

# Index of Applications

## ACCIDENT EPIDEMIOLOGY

cumulative incidence of automobile accidents among medical interns: Problems 5.99–5.102, **146**

## AGING

risk factors predicting survival among subjects in the EPESE study: Example 13.74, **706**; Example 13.75, **707**; Example 13.76, **710**  
use of vitamin E supplementation to prevent Alzheimer's disease: Review Question 9B.2, **344**

## BACTERIOLOGY

distribution of the number of bacterial colonies on a petri or agar plate: Example 4.32, **91**; Example 4.34, **92**; Example 5.36, **136**; Example 6.2, **149**; Example 6.60, **193**

## BIOAVAILABILITY

comparison of bioavailability of four different beta-carotene preparations: Problems 12.20–12.26, **579–580**; Problems 12.52–12.54, **582**; Problems 14.12–14.15, **803**

## BLOOD CHEMISTRY

monitoring clinical-chemistry measurements in pharmacologic research: Problems 5.31–5.35, **139**

## BOTANY

distribution of tree diameters: Example 5.21, **122**

## CANCER

abortion as a risk factor for breast cancer: Problems 10.61–10.63, **416**

age at first birth as a risk factor for breast cancer: Example 3.1, **38**; Example 10.4, **353**; Example 10.5, **355**; Example 10.7, **357**; Example 10.10, **360**; Example 10.13, **363**; Example 10.33, **390**; Example 10.35, **393**; Example 10.36, **394**; Example 10.37, **396**; Example 13.2, **590**; Example 13.10, **598**; Example 13.11, **600**; Example 13.33, **673**

age at menarche as a risk factor for breast cancer: Problems 7.66–7.68, **263**

age at menarche as a risk factor for ovarian cancer: Problems 13.120–13.123, **721–722**

age at surgery for undescended testis as a risk factor for testicular cancer: Problems 7.112–7.116, **267**

arsenic exposure as a risk for non-melanoma skin cancer: Review Question 13C.2, **624**; Review Question 13D.1, **628**

association between age at menarche and ovarian cancer: Review Question 10A.2, **367**

association between aspirin intake and colon cancer: Problems 14.43–14.47, **806**; Problems 14.61–14.62, **807–808**

association between oral-contraceptive use and breast cancer: Example 13.32, **625**; Example 13.33, **626**; Example 14.1, **725**; Example 14.2, **726**; Example 14.9, **731**; Example 14.10, **732**; Example 14.11, **734**; Example 14.13, **737**; Problems 14.1–14.6, **802–803**

association between oral-contraceptive use and endometrial cancer: Problem 10.14, **410**

association between oral-contraceptive use and ovarian cancer: Example 10.1–10.2, **352**; Problems 13.109–13.110, **721**

association between parity and ovarian-cancer incidence: Review Question 7A.3, **215**

association between postmenopausal hormone use and breast cancer: Problems 10.105–10.107, **421**; Example 14.17, **742**; Example 14.18, **745**; Example 14.19, **747**; Example 14.20, **749**; Example 14.21, **750**; Example 14.22, **752**; Example 14.23, **754**; Problems 14.53–14.56, **807**; Problems 14.63–14.67, **808–809**

cardiovascular disease mortality among women with breast cancer: Problems 7.102–7.103, **266**

cigarette smoking as a risk factor for lung cancer: Example 3.24, **52**; Problems 11.24–11.29, **505–506**; Review Question 13A.3, **601**; Examples 13.12–13.13, **602–603**; Examples 13.14–13.15, **604–605**; Review Question 14H.4, **783**

clinical trial of efficacy of maintenance chemotherapy for leukemia patients: Example 14.45, **787**; Example 14.46, **793**; Example 14.47, **794**; Example 14.48, **797**; Example 14.49, **799**

cluster of leukemia cases in Woburn, Massachusetts: Example 4.2, **71**

## INDEX OF APPLICATIONS (continued)

comparison of exemestane versus tamoxifen for treatment of women with breast cancer: Review Question 14F.3, **767**; Review Question 14G.2, **774**  
 comparison of 5-year survival for breast cancer between two different chemotherapy regimens: Example 10.21, **373**; Example 10.24, **376**; Example 10.29, **384**; Example 10.30, **385**; Example 13.29, **621**  
 comparison of a new treatment and a standard treatment for cancer – the case for a one-sided confidence interval: Example 6.61, **193**; Example 6.63, **194**  
 comparison of incidence rates of breast cancer between Chinese and American women: Problems 5.110–5.113, **147**  
 comparison of risk factors for different types of breast cancer according to ER/PR status: Example 13.46, **654**  
 comparison of stage of breast cancer by ethnic group: Problems 10.22–10.23, **411**  
 comparison of two active treatments for early-stage breast cancer: Example 13.53, **663**; Example 13.54, **664**; Example 13.55, **665**  
 cumulative incidence of breast cancer: Example 14.3, **727**  
 effect of beta-carotene on cancer incidence: Problems 10.74–10.76, **418**  
 effect of ethnicity on serum estradiol and body-mass index in premenopausal women: Table 9.14, **350**  
 effect of obesity on hormonal profile and impact on breast-cancer risk in women: Problems 11.92–11.96, **510–511**  
 effect of passive smoking on cancer risk: Example 13.23, **612**; Example 13.24, **616**; Examples 13.25–13.26, **617**; Example 13.27, **619**  
 effect of PUVA treatment for psoriasis on malignant melanoma: Problems 7.63–7.65, **262–263**  
 excess cancer deaths in nuclear-power-plant workers: Example 7.49, **248**  
 family history of breast cancer as a risk factor for breast cancer: Example 3.25, **52**; Example 4.39, **96**; Example 6.48, **184**; Example 6.49, **186**; Example 7.47, **244**; Example 7.48, **247**; Example 7.50, **249**; Example 7.51, **250**; Problem 7.21, **260**; Example 14.12, **736**  
 genetic factors modulating the effect of cigarette smoking on renal-cell carcinoma: Problems 10.102–10.104, **421**  
 genetic markers for breast cancer: Example 14.4, **727**; Examples 14.5–14.6, **728**; Example 14.7, **729**; Example 14.8, **730**  
 incidence of breast cancer: Example 3.4, **39**; Example 3.36, **59**  
 incidence of childhood leukemia in Woburn, Massachusetts: Examples 6.53–6.55, **189–190**; Examples 6.57–6.58, **191**  
 incidence of colon cancer based on SEER rates: Problems 7.117–7.119, **267–268**  
 incidence of ovarian cancer: Review Question 14A.2–3, **730**  
 incidence of stomach cancer: Example 3.5, **40**  
 influence of social class on age at menarche and impact on breast-cancer risk: Problems 8.149–8.151, **322**  
 lifetime risk of breast cancer: Review Question 4C.1, **89**  
 lung-cancer incidence for men vs. women: Review Question 10B.3, **373**  
 mammography as a screening test for breast cancer: Example 3.18, **47**; Example 3.21, **49**; Problems 6.77–6.80, **200**  
 neuroblastoma screening in young children: Problems 7.79–7.81, **264**  
 plasma hormones as risk factors for postmenopausal breast cancer: Example 13.44, **650**; Example 13.45, **651**; Example 13.72, **701**; Example 13.73, **704**; Problems 13.78–13.81, **718**; Problems 13.117–13.119, **721**  
 prevalence of bladder cancer in rats fed a high-saccharin diet: Example 6.50, **186**; Example 6.51, **187**  
 prevalence of malignant melanoma among 45- to 54-year-old women in the U.S.: Example 6.42, **181**; Example 6.43, **182**  
 prostate-specific antigen (PSA) test as a screening test for prostate cancer: Review Question 3C.3, **52**  
 protective effect of vitamin A or vitamin E vs. cancer: Example 2.1, **5**; Examples 10.26–10.27, **381**  
 randomized clinical trial testing the effect of estrogen-replacement therapy vs. placebo on breast-cancer incidence: Example 14.14, **738**; Example 14.15, **740**; Example 14.16, **742**; Example 14.44, **787**  
 relationship between breast-cancer incidence and dietary-fat intake: Example 13.70, **697**; Example 13.71, **700**; Problems 13.73–13.77, **717–718**  
 relationship between breast-cancer incidence and menopausal status: Problems 14.25–14.26, **805**  
 relationship between breast-cancer incidence and parity: Example 14.24, **755**; Example 14.25, **757**  
 relationship between lung-cancer incidence and heavy drinking: Example 13.16, **607**; Example 13.17, **608**; Example 13.18, **609**  
 relationship between plasma vitamin-A concentration and stomach-cancer risk: Problems 7.51–7.53, **261–262**  
 relationship of dietary factors to colon cancer: Example 13.9, **598**  
 risk of cancer among patients with cystic fibrosis: Problems 5.59–5.61, **142**  
 screening techniques for esophageal cancer: Problems 6.109–6.110, **202**  
 serum estradiol as a screening test for breast cancer: Table 3.17, **68**  
 survival of women with breast cancer undergoing radical mastectomy: Example 6.11, **152**  
 two-stage model of breast-cancer carcinogenesis: Problems 4.87–4.90, **105**  
 vitamin E as a preventive agent for cancer: Table 5.2, **139**

### CARDIOLOGY

association between coronary flow reserve and myocardial velocity ratio in hypertensive patients: Problems 11.104–11.108, **512**  
 comparison of angioplasty (PTCA) with medical therapy for treating single-vessel coronary disease: Problems 13.37–13.38, **715**  
 comparison of duration of exercise for coronary-artery disease patients randomized to medical therapy or PTCA: Table 8.24, **314**; Problems 13.45–13.46, **736**  
 effect of calcium-channel blockers on heart rate and blood pressure for patients with unstable angina: Problems 6.70–6.74, **200**; Example 7.32, **228**; Example 7.37, **233**; Examples 7.38–7.39, **234**; Problem 7.62, **262**  
 glucose level as a risk factor for carotid-artery stenosis: Problems 8.111–8.112, **317**  
 reduction of infarct size in patients with myocardial infarction: Example 7.13, **211**; Example 7.15, **212**; Example 7.30, **225**

### CARDIOVASCULAR DISEASE

association between ankle-arm index and S-T segment depression: Table 3.18, **69**  
 association between childhood SES and subclinical markers of atherosclerosis: Problems 8.146–8.148, **321–322**

## INDEX OF APPLICATIONS (continued)

association between cholesterol levels in spouse pairs: Example 11.22, **452**; Example 11.26, **455**; Example 11.27, **455**; Example 11.28, **456**  
 association between high salt intake and cause of death: Examples 10.16–10.17, **367**; Example 10.19, **370**; Example 10.20, **372**  
 association between obesity and coronary disease: Example 13.20, **609**  
 baldness pattern as a risk factor for MI: Problems 13.98–13.101, **720**  
 change in hematocrit in a patient with intermittent claudication: Review Question 11A.2, **447**  
 changes in the incidence and case-fatality rate of myocardial infarction 1990–2000: Problems 7.10–7.14, **259**  
 cholesterol levels before and after adopting a vegetarian diet: Table 2.13, **34**  
 cigarette smoking as a risk factor for MI in women: Problems 10.18–10.21, **410–411**  
 clinical trial of lipid-lowering agents and antioxidants to prevent progression of atherosclerosis among patients with clinical coronary disease: Problems 12.60–12.62, **583**  
 comparison between antithrombotic drug regimens after coronary stenting to prevent stent thrombosis: Problems 10.131–10.134, **423–424**  
 comparison between treatment groups in a study of in-hospital mortality among CABG patients: Problems 8.172–8.175, **324**  
 comparison of aspirin vs. placebo in the Physicians' Health Study: Example 6.21, **160**; Example 10.31, **386**; Example 10.32, **388**; Problems 10.1–10.5, **409–410**; Example 12.14, **534**; Example 13.4, **590**; Example 14.40, **781**  
 comparison of aspirin vs. placebo in the Women's Health Study: Problems 13.113–13.116, **721**  
 comparison of drugs for easing pain in unstable angina: Problems 5.45–5.46, **140**  
 comparison of HDL cholesterol levels between Caucasian and African-American adults in the ARIC study: Problems 8.159–8.162, **323**  
 deaths due to heart failure: Review Question 5C.4, **137**  
 different methods of measuring cholesterol: Figure 2.4, **15**  
 distribution of duration of cigarette smoking: Problems 5.12–5.13, **138**  
 distribution of serum cholesterol: Review Question 5B.3, **124**; Problems 5.1–5.5, **138**; Problems 5.14–5.16, **138**  
 distribution of serum triglycerides: Example 5.4, **109**; Example 5.8, **111**; Example 6.26, **166**  
 effect of calcium-channel blockers on blood pressure and heart rate: Problem 7.72, **290**  
 effect of oat bran on serum cholesterol: Problems 7.54–7.58, **262**  
 effect of obesity on hypertension: Problems 5.68–5.71, **143**  
 excess cardiac deaths attributable to an earthquake: Problems 4.68–4.70, **104**  
 genetic markers for coronary heart disease: Review Question 14B.2, **738**  
 Hispanic paradox: Problems 3.97–3.99, **66**  
 hyperinsulinemia as an independent risk factor for ischemic heart disease: Problems 8.121–8.124, **318–319**  
 microenzymatic vs. autoanalyzer method of cholesterol measurement: Figure 2.4, **15**  
 nested case-control study to assess SNPs associated with cardiovascular disease: Examples 12.16–12.17, **536–537**  
 predicting the incidence of coronary heart disease as a function of several risk factors: the Framingham Heart Study: Example 13.40, **638**; Example 13.41, **643**; Example 13.42, **645**; Example 13.43, **648**  
 prevalence and incidence of different types of cardiovascular morbidity in Minnesota: Example 6.9, **151**  
 racial trends in heart rate among children: Problems 8.23–8.24, **309–310**  
 relationship between LDL cholesterol and obesity in children: Problems 11.37–11.41, **506**  
 relationship between the use of oral contraceptives and heart disease in women: Example 10.6, **356**; Example 10.8, **358**; Example 10.11, **361**; Example 10.14, **364**; Example 13.1, **589**; Example 13.5, **593**; Examples 13.7–13.8, **595–596**; Review Question 13A.1, **601**; Example 13.15, **647**; Problems 13.104–13.107, **720**  
 reproducibility of activated Protein C (APC), a serum marker of thrombosis: Table 2.17, **36**; Review Question 12E.2, **567–568**; Review Question 12F.2, **571**  
 reproducibility of cardiovascular risk factors in children: Table 2.6, **21**  
 risk factors for sudden death in the Framingham, Massachusetts population: Problems 13.44–13.47, **716**  
 secondary prevention trial of lipid lowering in patients with previous MI: Problems 10.42–10.46, **413**  
 serum-cholesterol levels in children of men with heart disease: Example 6.37, **175**; Example 7.1, **204**; Example 7.5, **206**; Example 7.9, **208**; Example 7.18, **214**; Examples 7.27–7.28, **224–225**; Example 7.35, **230**; Examples 7.40–7.41, **236**; Example 7.42, **237**; Example 7.43, **239**; Example 8.12, **282**; Example 8.15, **285**; Example 8.17, **289**  
 serum-cholesterol levels in recent Asian immigrants to the U.S.: Example 7.20, **216**; Example 7.21, **217**; Example 7.22, **218**; Example 7.24, **220**  
 serum-cholesterol levels in vegetarians: Problems 7.23–7.25, **260**  
 testing for genes associated with cardiovascular disease: Review Question 14B.2, **758**  
 trends in coronary heart disease mortality in Olmstead County, Minnesota, over 20 years: Problems 3.121–3.123, **68**  
 validation study of accuracy of assessment of hospital-acquired infection among coronary-bypass patients: Problems 3.107–3.110, **67**  
 variability of cholesterol measurements in children: Problems 6.84–6.85, **200–201**

### CEREBROVASCULAR DISEASE

clinical trial of Warfarin to prevent stroke in patients with atrial fibrillation: Example 6.20, **159**  
 distribution of cerebral blood flow (CBF) in normals: Example 5.22, **122**

### DEMOGRAPHY

mortality among Americans of Chinese descent: Problems 7.41–7.42, **261**  
 relationship of fertility rates to survival outcomes of previous births in Norway: Table 3.13, **66**  
 sex-ratio data in humans: Problem 7.61, **262**; Problems 10.77–10.79, **418**

## INDEX OF APPLICATIONS (continued)

contralateral design for assessing the effect of an eye drop in lowering intraocular pressure in glaucoma patients: Review Question 10D.3, **390**

contralateral design for evaluation of effectiveness of an eye drop in preventing itching: Problems 7.69–7.72, **263**; Problems 9.38–9.40, **349**

distribution of astigmatism in 1033 Army recruits: Table 2.12, **34**

distribution of intraocular pressure: Example 5.23, **123**; Problems 7.110–7.111, **267**

effect of an eye drop in increasing tear break-up time among patients with dry eye: Problems 7.88–7.89, **265**; Problems 9.55–9.60, **350**; Example 12.35, **572**; Example 12.36, **574**; Problems 12.63–12.67, **584–585**

effect of different fluoroquinolones on corneal sensitivity: Problems 12.82–12.84, **586–587**

effect of diflunisal on intraocular pressure: Problems 8.19–8.22, **309**

effect of dose of Botox on eye pain: Problems 8.178–8.181, **324–325**

effect of medication regimen on intraocular pressure among glaucoma patients: Table 7.9, **266**

effect of sunlight on mice with retinitis pigmentosa: Problem 12.57, **582**

effectiveness of an eye drop in preventing dry eye symptoms: Problems 10.124–10.126, **423**

effectiveness of a topical antiallergic eye drop in preventing the signs and symptoms of allergic conjunctivitis: Problems 8.113–8.115, **317–318**

genetic forms of retinitis pigmentosa: Example 4.1, **71**; Problems 4.94–4.96, **105–106**

genetics of macular degeneration: Table 5.8, **147**; Problems 10.135–10.138, **424**

incidence of cataract among people 65+ years of age: Example 3.22, **50**

incidence rates of blindness among insulin-dependent diabetics: Problems 4.63–4.67, **103**

incidence rates of cataract among people with excessive exposure to sunlight: Problems 7.47–7.50, **261**

prevalence of glaucoma among the elderly as determined by Eyemobile screening: Review Question 5C.3, **137**

prevalence of low vision among the elderly: Example 6.7, **150**

rate of field loss in retinitis-pigmentosa patients: Problems 5.83–5.85, **144–145**

reproducibility of tear break up time among dry eye patients: Problems 12.70–12.73, **585**

testing of a drug on ocular-hypertensive patients to prevent glaucoma: Example 7.25, **221**

treatment trial of vitamin supplements for retinitis pigmentosa: Review Question 12D.3, **561**; Example 13.67, **687**; Example 13.68, **688**; Example 13.69, **691**; Example 14.30, **762**; Example 14.31, **764**; Example 14.32, **765**; Example 14.33, **766**; Example 14.36, **772**; Example 14.38, **776**; Example 14.39, **778**; Example 14.41, **783**; Example 14.42, **785**; Example 14.43, **786**; Problems 14.16–14.21, **803–804**

twin study design for macular degeneration: Review Question 10C.3, **380**

visual acuity as an ordinal variable: Example 9.4, **328**

### **ORNITHOLOGY**

comparison of wing length of different species of stonechats: Problems 12.78–12.81, **586**

### **ORTHOPEDICS**

accuracy of the FAIR test in diagnosing piriformis syndrome: Problems 5.78–5.82, **144**

comparison of the FAIR test with patients' self-report for assessment of severity of piriformis syndrome: Table 3.16, **68**

treatment trial for piriformis syndrome: Problems 14.37–14.42, **806**

### **OTOLARYNGOLOGY**

comparison of antibiotics for treating acute otitis media: Problems 3.75–3.78, **64**; Problems 10.56–10.58, **416**; Problems 10.86–10.88, **419**; Problems 13.52–13.53, **716**; Problems 13.70–13.72, **717**

comparison of medical and surgical treatment for children with chronic otitis media: Example 10.28, **383**

comparison of the ototoxicity of different aminoglycosides: Problem 13.35, **715**

duration of middle-ear effusion in breast-fed and bottle-fed babies: Table 9.9, **347**

number of episodes of otitis media in the first 2 years of life: Example 4.3, **72**; Table 4.3, **75**; Example 4.10, **75**; Examples 4.12–4.13, **76**; Example 4.14, **78**; Problems 4.26–4.31, **100–101**

sibling history of ear infection as a risk factor for otitis media in the first year of life: Problems 13.67–13.69, **717**

### **PEDIATRICS**

age at onset of night-time bladder control: Problems 10.80–10.81, **418**

age at onset of spermatozoa in urine samples of pre-adolescent boys: Problems 10.47–10.50, **413**

age trends in pulse rates in children: Example 11.6, **430**

association between climate conditions in infancy and adult height: Problems 8.155–8.158, **322–323**

duration of middle ear effusion in breast and bottle fed babies: Table 9.9, **347**

effect of in-vitro fertilization on birth defects: Problems 5.96–5.98, **146**

hypothyroxinemia as a cause of subsequent motor and cognitive abnormalities in premature infants: Problems 11.48–11.52, **507–508**

inclusion of birthweight and body length in a multiple regression model: Example 11.46, **475**

number of episodes of otitis media in the first 2 years of life: Example 4.3, **72**; Table 4.3, **75**; Example 4.10, **75**; Examples 4.12–4.13, **76**; Problems 4.42–4.45, **101–102**

projected health effects of chronic exposure to low levels of lead in young children: Figures 2.9–2.10, **30**; Problems 2.31–2.32, **36**; Problems 6.67–6.69, **200**; Example 8.20, **293**; Examples 8.23–8.26, **297–299**; Problems 8.93–8.95, **316**; Table 9.5, **345**; Example 11.50, **485**; Problems 11.44–11.47, **507**; Tables 12.7–12.13, **538–548**; Problems 12.44–12.46, **581**; Problems 13.82–13.84, **718**

## INDEX OF APPLICATIONS (continued)

- racial trends in heart rate among children: Problems 8.23–8.24, **309–310**  
 relationship between LDL cholesterol and obesity in children: Problems 11.37–11.41, **506**  
 relationship between salt-taste and sugar-taste response to blood pressure in children: Problems 6.56–6.58, **199**; Problems 11.42–11.43, **507**  
 risk factors for newborn blood-pressure measurements: Example 11.38, **468**; Example 11.39, **469**; Examples 11.40–11.41, **470–471**; Examples 11.42–11.44, **471–472**; Example 11.45, **475**; Example 11.48, **476**; Example 11.49, **481**; Example 11.51, **492**; Example 11.52, **493**  
 serum-cholesterol levels in children of men with heart disease: Example 6.37, **175**; Example 7.1, **204**; Example 7.5, **206**; Example 7.9, **208**; Example 7.18, **214**; Examples 7.27–7.28, **224–225**; Example 7.35, **230**; Example 8.12, **282**; Example 8.15, **285**; Example 8.17, **289**

### **PHARMACOLOGY**

- clinical pharmacology of ampicillin: Problems 6.30–6.32, **197**  
 concentration of aspirin in urine samples: Table 8.15, **310**

### **PULMONARY DISEASE**

- asthma incidence in children: Problems 7.15–7.18, **259**  
 comparison of triceps skin-fold thickness in normal men and men with chronic airflow limitation: Table 6.8, **196**  
 decline in pulmonary function over time: Problems 5.21–5.24, **139**  
 differential diagnosis for lung cancer vs. sarcoidosis: Example 3.27, **55**  
 distribution of duration of cigarette smoking: Problems 5.12–5.13, **138**  
 distribution of forced vital capacity in grade-school children: Examples 5.14–5.15, **117–118**  
 effect of occupational exposure to 2,4,5-T herbicide on pulmonary function: Problems 7.82–7.84, **264**  
 effect of ozone exposure on pulmonary function: Table 8.22, **313**  
 establishing standards for FEV for children in Tecumseh, Michigan: Example 11.14, **440**; Examples 11.17–11.18, **445**; Example 11.19, **446**; Examples 11.20–11.21, **447**; Example 11.25, **454**; Example 11.26, **455**  
 familial aggregation of chronic bronchitis: Example 4.27, **85**; Example 4.29, **87**  
 genetic determinants of FEV: Problems 11.9–11.12, **505**  
 influence of passive smoking and parental phlegm on pneumonia and bronchitis in early childhood: Problems 13.19–13.28, **713–714**  
 interventions to improve compliance with asthma medication among inner-city children: Problems 10.139–10.142, **424**  
 parental smoking as a determinant of lung function in children: Problems 8.41–8.48, **311**  
 relationship between asbestos exposure and death due to chronic obstructive pulmonary disease: Problems 5.10–5.11, **138**  
 relationship between parental smoking and respiratory disease in childhood: Problems 3.51–3.61, **62–63**  
 relationship of age, sex, height, and smoking to pulmonary function in children: Table 2.15, **35**; Problems 5.42–5.44, **140**; Problems 8.85–8.86, **315**; Problem 8.96, **316**; Problem 11.34, **506**; Problems 11.113–11.117, **513–514**  
 reproducibility of dyspnea diagnoses: Problem 10.16, **410**  
 risk factors for COPD death in a Chinese population: Problems 14.57–14.60, **807**  
 short-term effects of sulfur-dioxide exposure in young asthmatics: Problems 12.6–12.8, **577–578**  
 temporal trends in smoking-cessation rates: Table 3.8, **63**  
 tuberculin skin test as a screening test for tuberculosis: Example 3.3, **39**  
 use of saliva thiocyanate as an objective indicator of cigarette smoking: Table 3.9, **63**  
 working environment of passive smokers and relationship to pulmonary function: Example 2.2, **5**; Problems 8.31–8.33, **310**; Examples 12.1–12.13, **516–532**; Example 12.15, **535**

### **RADIOLOGY**

- evaluation of accuracy of ratings in CT images by a radiologist: Example 3.32, **57**  
 screening techniques for esophageal cancer: Problems 6.109–6.110, **202**

### **RENAL DISEASE**

- analgesic abuse and kidney disorder: Problems 8.125–8.126, **319**; Problems 10.28–10.31, **412**; Problems 12.47–12.51, **582**; Problem 13.8, **713**; Problems 13.102–13.103, **720**; Problems 14.27–14.31, **805**  
 cause of death among patients with analgesic abuse: Example 9.6, **328**  
 comparison of nephrotoxicity of different aminoglycosides: Example 13.50, **658**; Example 13.51, **660**; Example 13.52, **661**; Problem 13.34, **715**  
 effect of protein on course of kidney disease among diabetic patients: Example 5.29, **126**; Example 5.31, **128**  
 physiological and psychological changes in patients with end-stage renal disease: Table 6.10, **197**  
 prevalence of bacteriuria over 2 surveys: Problems 4.37–4.41, **101**  
 serum-creatinine levels: Examples 5.25–5.28, **125–126**; Problem 7.1, **259**  
 treatment of patients with diabetic nephropathy with captopril: Table 8.19, **312**

### **RHEUMATOLOGY**

- comparison of muscle function between patients with rheumatoid arthritis and osteoarthritis: Table 8.23, **314**  
 effectiveness of ibuprofen in preventing inflammation among osteoarthritis patients: Review Question 13G.2, **666**  
 testing a new drug for relief of pain from osteoarthritis: Example 7.7, **207**

## INDEX OF APPLICATIONS (continued)

### SEROLOGY

variability of an assay for *M. hominis* mycoplasma: Problems 6.36–6.39, **198**

### SEXUALLY TRANSMITTED DISEASE

association between type of STD and previous episodes of urethritis: Problem 10.13, **410**

comparison of spectinomycin and penicillin G in treating patients with gonorrhea: Problems 6.27–6.29, **197**; Problems 10.24–10.25, **412**  
diagnosing patients for syphilis: Example 3.15, **44**; Example 3.20, **48**

### SLEEP DISORDERS

change in prevalence of sleep-disordered breathing by age and sex: Example 13.30, **622**; Example 13.31, **623**

### SPORTS MEDICINE

comparison of Motrin and placebo in the treatment of tennis elbow: Problems 8.89–8.92, **316**; Problems 9.13–9.14, **346**; Example 13.56, **666**; Example 13.57, **669**; Examples 13.58–13.59, **671**; Problems 13.54–13.59, **716**

effect of playing surface on the rate of Canadian football injuries: Problems 6.102–6.103, **201–202**

risk factors for tennis elbow: Problem 10.55, **416**; Examples 13.48–13.49, **656**; Problems 13.39–13.40, **715**

### UROLOGY

age at onset of night-time bladder control: Problems 10.80–10.81, **418**

### WOMEN'S HEALTH

relationship between abortion and breast cancer: Problems 4.75–4.77, **104**

### ZOOLOGY

preference of different bird species for different types of sunflower seeds: Problems 10.70–10.73, **417–418**