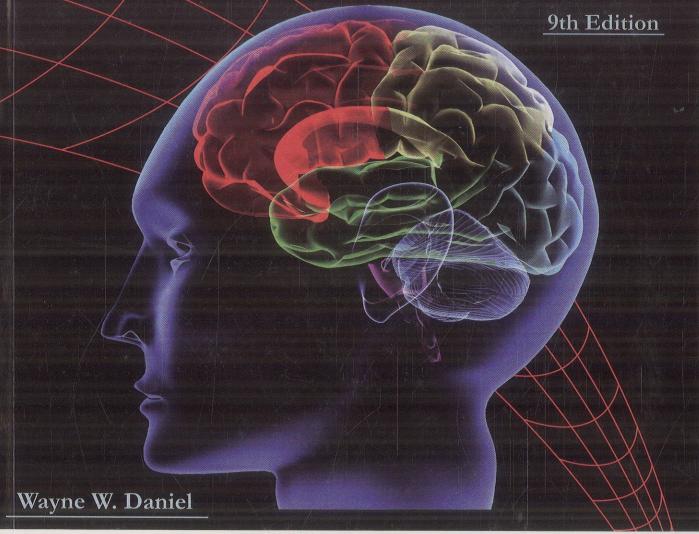
## Biostatistics

Basic Concepts and Methodology for the Health Sciences



International Student Version

|                                               | GETTING ACQUAINTED WITH BIOSTATISTICS 1                                                                                              | 3.5               | Bayes' Theorem, Screening Tests,<br>Sensitivity, Specificity, and Predictive<br>Value Positive and Negative 79 |
|-----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------------------------------------------------------------------------------|
| 1.1<br>1.2<br>1.3                             | Introduction 2 Some Basic Concepts 2 Measurement and Measurement Scales 5                                                            | 3.6               | Summary 84 Review Questions and Exercises 86 References 91                                                     |
| 1.4<br>1.5                                    | Sampling and Statistical Inference 7 The Scientific Method and the Design of Experiments 13 Computers and Biostatistical Analysis 15 |                   | PROBABILISTIC FEATURES OF<br>CERTAIN DATA DISTRIBUTIONS 93                                                     |
| 1.7                                           | Summary 16 Review Questions and Exercises 17 References 18                                                                           | 4.1<br>4.2<br>4.3 | Introduction 94 Probability Distributions of Discrete Variables 94 The Binomial Distribution 100               |
|                                               | STRATEGIES FOR UNDERSTANDING THE MEANINGS OF DATA 19                                                                                 | 4.4<br>4.5<br>4.6 | The Poisson Distribution 109 Continuous Probability Distributions 114 The Normal Distribution 117              |
| 2.1<br>2.2<br>2.3                             | Introduction 20 The Ordered Array 20 Grouped Data: The Frequency Distribution 22                                                     | 4.7<br>4.8        | Normal Distribution Applications 123 Summary 129 Review Questions and Exercises 131 References 134             |
| <ul><li>2.4</li><li>2.5</li><li>2.6</li></ul> | Descriptive Statistics: Measures of Central Tendency 38 Descriptive Statistics: Measures of Dispersion 43 Summary 54                 | 7                 | PROBABILISTIC FEATURES OF<br>THE DISTRIBUTIONS OF CERTAIN<br>SAMPLE STATISTICS 13                              |
|                                               | Review Questions and Exercises 56 References 63                                                                                      | 5.1<br>5.2<br>5.3 | Introduction 136 Sampling Distributions 136 Distribution of the Sample Mean 137                                |
|                                               | PROBABILITY: THE BASIS OF<br>STATISTICAL INFERENCE 65                                                                                | 5.4<br>5.5        | Distribution of the Difference Between Two Sample Means 146 Distribution of the Sample Proportion 151          |
| 3.1<br>3.2                                    | Introduction 66 Two Views of Probability: Objective and Subjective 66                                                                | 5.6<br>5.7        | Distribution of the Difference Between Two Sample Proportions   155 Summary 158                                |
| 3.3<br>3.4                                    | Elementary Properties of Probability 68 Calculating the Probability of an Event 69                                                   | 0.,               | Review Questions and Exercises 159 References 161                                                              |

| E           | ISING SAMPLE DATA TO MAKE STIMATES ABOUT POPULATION PARAMETERS 162            | 7.10<br>7.11 | Determining Sample Size to Control Type II Errors 278 Summary 281         |     |
|-------------|-------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------------|-----|
| 6.1         | Introduction 163                                                              |              | Review Questions and Exercises 283 References 301                         |     |
| 6.2         | Confidence Interval for a Population<br>Mean 166                              | _            | TOTAL SALES                                                               |     |
| 6.3         | The t Distribution 172                                                        |              | TATISTICAL INFERENCE AND THE                                              |     |
| 6.4         | Confidence Interval for the Difference                                        | A            | NALYSIS OF DATA VARIABILITY                                               | 305 |
|             | Between Two Population Means 178                                              | 8.1          | Introduction 306                                                          |     |
| 6.5         | Confidence Interval for a Population Proportion 185                           | 8.2          | The Completely Randomized Design 308                                      | 8   |
| 6.6         | Confidence Interval for the Difference                                        | 8.3          | The Randomized Complete Block                                             |     |
|             | Between Two Population Proportions 187                                        |              | Design 334                                                                |     |
| 6.7         | Determination of Sample Size for                                              | 8.4          | The Repeated Measures Design 346                                          |     |
|             | Estimating Means 189                                                          | 8.5          | The Factorial Experiment 353                                              |     |
| 6.8         | Determination of Sample Size for                                              | 8.6          | Summary 368 Review Questions and Exercises 371                            |     |
| 6.0         | Estimating Proportions 192                                                    |              | References 404                                                            |     |
| 6.9         | Confidence Interval for the Variance of a Normally Distributed Population 194 |              | Rejercites, 404                                                           |     |
| 6.10        | Confidence Interval for the Ratio                                             | 9 s          | TATISTICAL INFERENCE AND                                                  |     |
|             | of the Variances of Two Normally                                              |              | HE RELATIONSHIP BETWEEN                                                   |     |
| <i>(</i> 11 | Distributed Populations 199                                                   | 7            | WO VARIABLES                                                              | 409 |
| 6.11        | Summary 203 Review Questions and Exercises 206                                |              |                                                                           | -   |
|             | References 212                                                                | 9.1          | Introduction 410                                                          |     |
|             | Neteronous 212                                                                | 9.2<br>9.3   | The Regression Model 410                                                  |     |
|             |                                                                               | 9.3<br>9.4   | The Sample Regression Equation 413 Evaluating the Regression Equation 423 |     |
| 7 u         | ISING SAMPLE STATISTICS TO                                                    | 9.5          | Using the Regression Equation 437                                         |     |
|             | EST HYPOTHESES ABOUT                                                          | 9.6          | The Correlation Model 441                                                 |     |
| P           | OPULATION PARAMETERS 215                                                      | 9.7          | The Correlation Coefficient 442                                           |     |
| 7.1         | Introduction 216                                                              | 9.8          | Some Precautions 455                                                      |     |
| 7.1         | Hypothesis Testing: A Single Population                                       | 9.9          | Summary 456                                                               |     |
| 1.2         | Mean 223                                                                      |              | Review Questions and Exercises 460                                        |     |
| 7.3         | Hypothesis Testing: The Difference Between                                    |              | References 482                                                            |     |
|             | Two Population Means 237                                                      |              |                                                                           |     |
| 7.4         | Paired Comparisons 250                                                        | 10           | STATISTICAL INFERENCE AND                                                 |     |
| 7.5         | Hypothesis Testing: A Single Population                                       | ,,           | THE RELATIONSHIPS AMONG                                                   |     |
|             | Proportion 258                                                                |              | THREE OR MORE VARIABLES                                                   | 485 |
| 7.6         | Hypothesis Testing: The Difference Between                                    | ==           |                                                                           |     |
|             | Two Population Proportions 262                                                | 10.1         | Introduction 486                                                          |     |
| 7.7         | Hypothesis Testing: A Single Population<br>Variance 265                       | 10.2         | The Multiple Linear Regression                                            |     |
| 7.8         | Hypothesis Testing: The Ratio of Two                                          | 10.3         | Model 486 Obtaining the Multiple Regression                               |     |
| 7.0         | Population Variances 268                                                      | 10.5         | Obtaining the Multiple Regression Equation 488                            |     |
| 7.9         | The Type II Error and the                                                     | 10.4         | Evaluating the Multiple Regression                                        |     |
|             | Power of a Test 273                                                           | ,,,          | Equation 497                                                              |     |

| 10.5 | Using the Multiple Regression                                      |     | 13.4 The Wilcoxon Signed-Rank Test for                         |        |
|------|--------------------------------------------------------------------|-----|----------------------------------------------------------------|--------|
| 10.6 | Equation 503 The Multiple Correlation Model 506                    |     | Location 694 13.5 The Median Test 699                          |        |
| 10.6 |                                                                    |     |                                                                |        |
| 10.7 | Summary 519                                                        |     | 13.6 The Mann–Whitney Test 703                                 | C 771. |
|      | Review Questions and Exercises 521<br>References 533               |     | 13.7 The Kolmogorov–Smirnov Goodness-C<br>Test 711             |        |
| 44   | 4 D D (T (A) 4 4 T T A) 1 1 (A) 1 5 A B B                          |     | 13.8 The Kruskal–Wallis One-Way Analysis Variance by Ranks 717 | s of   |
| 11   | ADDITIONAL TECHNIQUES FOR THE ANALYSIS OF RELATIONSHIPS            |     | 13.9 The Friedman Two-Way Analysis of Variance by Ranks 725    |        |
|      | AMONG VARIABLES                                                    | 535 | 13.10 The Spearman Rank Correlation                            |        |
| 11.1 | Introduction 536                                                   |     | Coefficient 731                                                |        |
| 11.2 | Qualitative Independent Variables 539                              |     | 13.11 Nonparametric Regression Analysis                        | 740    |
| 11.3 | Variable Selection Procedures 556                                  |     | 13.12 Summary 743                                              |        |
| 11.4 | Logistic Regression 565                                            |     | Review Questions and Exercises 7-                              | 45     |
| 11.5 | Summary 575                                                        |     | References 760                                                 |        |
|      | Review Questions and Exercises 576                                 |     |                                                                |        |
|      | References 590                                                     |     | 14                                                             |        |
|      |                                                                    |     | 14 EVALUATING THE HEALTH                                       |        |
|      |                                                                    |     | OF HUMAN GROUPS: VITAL<br>STATISTICS                           | 763    |
| 12   | ANALYSIS OF FREQUENCY DATA:                                        |     | SIAHSHCS                                                       | /03    |
|      | AN INTRODUCTION TO THE CHI-                                        | E02 | 14.1 Introduction 764                                          |        |
|      | SQUARE DISTRIBUTION                                                | 593 | 14.2 Death Rates and Ratios 765                                |        |
| 12.1 | Introduction 594                                                   |     | 14.3 Measures of Fertility 772                                 |        |
| 12.2 | The Mathematical Properties of the                                 |     | 14.4 Measures of Morbidity 776                                 |        |
|      | Chi-Square Distribution 594                                        |     | 14.5 Summary 777                                               |        |
| 12.3 | Tests of Goodness-of-Fit 597                                       |     | Review Questions and Exercises 7'                              | 79     |
| 12.4 | Tests of Independence 612                                          |     | References 782                                                 |        |
| 12.5 | Tests of Homogeneity 623                                           |     |                                                                |        |
| 12.6 | The Fisher Exact Test 629                                          |     |                                                                |        |
| 12.7 | Relative Risk, Odds Ratio, and the                                 |     | APPENDIX: STATISTICAL TABLES                                   | A-1    |
|      | Mantel-Haenszel Statistic 634                                      |     |                                                                |        |
| 12.8 | Survival Analysis 648                                              |     | ANSWERS TO ODD-NUMBERED                                        |        |
| 12.9 | Summary 664                                                        |     | EXERCISES                                                      | A-106  |
|      | Review Questions and Exercises 666                                 |     |                                                                |        |
|      | References 678                                                     |     | INDEX                                                          | 1-1    |
| 13   | SPECIAL TECHNIQUES FOR<br>USE WHEN POPULATION<br>PARAMETERS AND/OR |     |                                                                |        |

683

**POPULATION DISTRIBUTIONS** 

684

686

685

ARE UNKNOWN

Measurement Scales

The Sign Test

13.1 Introduction

13.2

13.3