Contents

Preface xiii

CHAPTER 1

Why Statistics? 1

Variability 2
Populations and Samples 4
Descriptive and Inferential Statistical Procedures 6
Measurement 8
Using Computers to Learn From Data 15
Summary 16
Exercises 17

PART I

Descriptive Statistics 19

CHAPTER 2

Frequency Distributions and Percentiles 21

Frequency Distributions 22
Grouped Frequency Distributions 25
Graphing Frequency Distributions 30
Characteristics of Distributions 33
Percentiles 38
Computations Using Excel 39
Summary 41
Exercises 42

CHAPTER **3**

Central Tendency and Variability 47

Sigma Notation 47
Measures of Central Tendency 50
Measures of Variability 56
Summary 64
Exercises 65

CHAPTER **4**

z Scores and Normal Distributions 69

Standard Scores (*z* Scores) 69
Characteristics of *z* Scores 74
Normal Distributions 76
Using the Standard Normal Distribution 80
Other Standardized Scores 87
Summary 88
Exercises 88

PART **II**

Introduction to Inferential Statistics *91*

CHAPTER **5**

Overview of Inferential Statistics 93

Why Inferential Procedures Are Needed 93
Varieties of Inferential Procedures 95
Random Sampling 96
Biased Sampling 100
Overgeneralizing 101
Summary 102
Exercises 103

CHAPTER **6**

Probability 105

Probabilities of Events 106
Probability and Relative Frequency 107
Discrete Probability Distributions 109

The Or-rule for Mutually Exclusive Events 112
Conditional Probabilities 113
Probability and Continuous Variables 114
Summary 116
Exercises 117

CHAPTER 7

Sampling Distributions 119

Constructing a Sampling Distribution 119
Two Sampling Distributions 123
Sampling Distributions Used in Statistical Inference 127
Sampling Distribution of the Sample Mean 128
Review of Symbols and Concepts 133
z Scores and the Sampling Distribution of the Sample Mean 133
A Preview of Inferential Statistics 136
Summary 138
Exercises 139

CHAPTER 8

Logic of Hypothesis Testing 141

Step 1: Check the Assumptions of the Statistical Procedure 143
Step 2: Generate the Null and Alternative Hypotheses 145
Step 3: Sampling Distribution of the Test Statistic 147
Step 4: Set the Significance Level and Formulate the Decision Rule 150
Step 5: Randomly Sample From the Population and Compute the Test Statistic 152
Step 6: Apply the Decision Rule and Draw Conclusions 153
When H_0 Is Not Rejected 154
Brief Review 155
Errors in Hypothesis Testing: Type I Errors 157
Type II Errors 158
Outcomes of a Statistical Test 161
Directional Alternative Hypotheses 162
A Second Example 166
A Third Example 169
Summary 172
Exercises 174

CHAPTER 9

Power 177

Calculating Power Using z Scores 178
Factors Affecting Power 182

Effect Size 189
Computing Procedures for Power and Sample Size Determination 193
When to Use Power Analyses 195
Summary 197
Exercises 198

CHAPTER 10

Logic of Parameter Estimation 199

Point Estimation 200
Interval Estimation 200
Constructing Confidence Limits for μ When σ Is Known 201
Why the Formula Works 204
Factors That Affect the Width of the Confidence Interval 206
Comparison of Interval Estimation and Hypothesis Testing 209
Summary 210
Exercises 211

PART III

Applications of Inferential Statistics 213

CHAPTER 11

Inferences About Population Proportions Using the z Statistic 215

The Binomial Experiment 216
Testing Hypotheses About π 219
Testing a Directional Alternative Hypothesis About π 225
Power and Sample Size Analyses 228
Estimating π 232
Related Statistical Procedures 235
Summary 236
Exercises 238

CHAPTER 12

Inferences About μ When σ Is Unknown: The Single-sample t Test 241

Why s Cannot Be Used to Compute z 242
The t Statistic 243

Using t to Test Hypotheses About μ 245
Example Using a Directional Alternative 252
Power and Sample Size Analyses 253
Estimating μ When σ Is Not Known 256
Summary 258
Exercises 258

CHAPTER **13**

Comparing Two Populations: Independent Samples 263

Comparing Naturally Occurring and Hypothetical Populations 264
Independent and Dependent Sampling From Populations 266
Sampling Distribution of the Difference Between Sample Means (Independent Samples) 267
The t Distribution for Independent Samples 269
Hypothesis Testing 271
A Second Example of Hypothesis Testing 279
Power and Sample Size Analyses 281
Estimating the Difference Between Two Population Means 283
The Rank-sum Test for Independent Samples 286
Summary 292
Exercises 292

CHAPTER **14**

Random Sampling, Random Assignment, and Causality 299

Random Sampling 299
Experiments in the Behavioral Sciences 300
Random Assignment Can (Sometimes) Be Used Instead of Random Sampling 303
Interpreting the Results Based on Random Assignment 305
Review 306
A Second Example 306
Summary 307
Exercises 308

CHAPTER **15**

Comparing Two Populations: Dependent Samples 311

Dependent Sampling 312
Sampling Distributions of the Dependent-sample t Statistic 318
Hypothesis Testing Using the Dependent-sample t Statistic 320

A Second Example 326
Power and Sample Size Analyses 328
Estimating the Difference Between Two Population Means 330
The Wilcoxon T_m Test 332
Hypothesis Testing Using the Wilcoxon T_m Statistic 334
Summary 337
Exercises 338

CHAPTER **16**

Comparing Two Population Variances: The F Statistic 345

The F Statistic 346
Testing Hypotheses About Population Variances 348
A Second Example 353
Estimating the Ratio of Two Population Variances 354
Summary 355
Exercises 355

CHAPTER **17**

Comparing Multiple Population Means: One-factor ANOVA 359

Factors and Treatments 361
How the Independent-sample One-factor ANOVA Works 361
Testing Hypotheses Using the Independent-sample ANOVA 367
Comparisons Between Selected Population Means: The Protected t Test 372
A Second Example of the Independent-sample One-factor ANOVA 374
One-factor ANOVA for Dependent Samples 376
A Second Dependent-sample One-factor ANOVA 381
Kruskal–Wallis H Test: Nonparametric Analogue for the Independent-sample One-factor ANOVA 384
Friedman F_r Test: Nonparametric Analogue for the Dependent-sample One-factor ANOVA 387
Summary 390
Exercises 391

CHAPTER **18**

Introduction to Factorial Designs 399

The Two-factor Factorial Experiment: Combining Two Experiments Into One 400
Learning From a Factorial Experiment 402
A Second Example of a Factorial Experiment 407

Graphing the Results of a Factorial Experiment 408
Design of Factorial Experiments 410
Three-factor Factorial Experiment 412
Summary 421
Exercises 422

CHAPTER **19**

Computational Methods for the Factorial ANOVA 425

Two-factor Factorial ANOVA 425
Comparing Pairs of Means: The Protected *t* Test 433
A Second Example of the Factorial ANOVA 436
Summary 437
Exercises 438

CHAPTER **20**

Describing Linear Relationships: Regression 441

Dependent Samples 443
Mathematics of Straight Lines 445
Describing Linear Relationships: The Least-squares Regression Line 448
Precautions in Regression (and Correlation) Analysis 454
Inferences About the Slope of the Regression Line 457
Using the Regression Line for Prediction 464
Multiple Regression 469
Summary 470
Exercises 470

CHAPTER **21**

Measuring the Strength of Linear Relationships: Correlation 477

Correlation: Describing the Strength of a Linear Relationship 478
Factors That Affect the Size of *r* 482
Testing Hypotheses About ρ 482
Correlation Does Not Prove Causation 489
The Spearman Rank-order Correlation 491
Other Correlation Coefficients 495
Power and Sample Size Analyses 496
Summary 498
Exercises 498

CHAPTER **22**

Inferences From Nominal Data: The χ^2 Statistic 505

Nominal, Categorical, Enumerative Data 506
χ^2 Goodness-of-fit Test 507
A Second Example of the χ^2 Goodness-of-fit Test 511
Comparison of Multiple Population Distributions 513
Second Example of Using χ^2 to Compare Multiple Distributions 517
An Alternative Conceptualization: Analysis of Contingency 519
Summary 522
Exercises 523

Glossary of Symbols 527

Tables 531

Appendix A. Variables From the Stop Smoking Study 545

Appendix B. Variables From the Wisconsin Maternity Leave and Health Project and the Wisconsin Study of Families and Work 547

Answers to Selected Exercises 549

Index 555