

Content

Preface page xi
Acknowledgements xii

1. **Introduction** 1
 - 1.1 **Introduction** 1
 - 1.2 **Study Design** 1
 - 1.2.1 Observational Longitudinal Studies 2
 - 1.3 **General Approach** 4
 - 1.4 **Prior Knowledge** 4
 - 1.5 **Example** 4
 - 1.6 **Software** 5
 - 1.7 **Data Structure** 6
 - 1.8 **What is New in the Third Edition** 6
2. **Continuous Outcome Variables** 7
 - 2.1 **Two Measurements** 7
 - 2.1.1 Example 7
 - 2.2 **Non-parametric Equivalent of the Paired t-test** 8
 - 2.2.1 Example 9
 - 2.3 **More than Two Measurements** 9
 - 2.3.1 The Univariate Approach: A Numerical Example 12
 - 2.3.2 The Shape of the Relationship between an Outcome Variable and Time 13
 - 2.3.2.1 A Numerical Example 14
 - 2.3.3 Example 15
 - 2.4 **The Univariate or the Multivariate Approach?** 19
 - 2.5 **Comparing Groups** 19
 - 2.5.1 The Univariate Approach: A Numerical Example 20
 - 2.5.2 Example 21
 - 2.6 **Comments** 25
 - 2.7 **Post-hoc Procedures** 25
 - 2.8 **Different Contrasts** 26
 - 2.8.1 Example 26
 - 2.9 **Non-parametric Equivalent of GLM for Repeated Measures** 29
 - 2.9.1 Example 30
3. **Continuous Outcome Variables: Regression-based Methods** 31
 - 3.1 **Introduction** 31
 - 3.2 **Longitudinal Regression Methods** 31
 - 3.3 **Mixed Model Analysis** 32
 - 3.3.1 Introduction 32
 - 3.3.2 Mixed Models for Longitudinal Data Analysis 32
 - 3.3.3 Example 34
 - 3.3.4 Interpretation of the Regression Coefficient 38
 - 3.3.5 Comments 41
 - 3.4 **Generalised Estimating Equations** 42
 - 3.4.1 Introduction 42
 - 3.4.2 Correlation Structures 42
 - 3.4.3 Example 44
 - 3.4.3.1 Different Correlation Structures 46
 - 3.5 **Comparison between Mixed Model Analysis and GEE Analysis** 48
 - 3.6 **The Adjustment for Covariance Method** 49
 - 3.6.1 Example 50
 - 3.6.2 Extension of Mixed Model Analysis 54
 - 3.6.3 Comments 54
 4. **The Modelling of Time** 56
 - 4.1 **Growth Curve Analysis** 56
 - 4.2 **Comparing Groups** 60
 - 4.3 **Adjustment for Time** 64
 - 4.3.1 Time versus Age 68
 - 4.4 **Interaction with Time** 69
 - 4.5 **Classification of Subjects with Different Growth Trajectories** 70
 5. **Models to Disentangle the Between- and Within-subjects Relationship** 76
 - 5.1 **Introduction** 76
 - 5.2 **Hybrid Models** 76
 - 5.2.1 Example 76
 - 5.2.2 Direct Estimation of the Hybrid Model 78
 - 5.2.3 Hybrid Models with Categorical Time-dependent Covariates 80

Content

5.2.4 Comments 82 5.3 Models to Estimate the Within-subjects Part of the Longitudinal Relationship 82 <ul style="list-style-type: none"> 5.3.1. Introduction 82 5.3.2 Model of Changes 83 <ul style="list-style-type: none"> 5.3.2.1 Example 83 5.3.2.2 Another Example 85 5.3.3 Autoregressive Model 88 <ul style="list-style-type: none"> 5.3.3.1 Example 88 5.3.4 Comments 90 	8.1.1 Two Measurements 134 8.1.2 More than Two Measurements 135 8.1.3 Comparing Groups 135 8.1.4 Example 135 8.1.5 Regression-based Methods 136 <ul style="list-style-type: none"> 8.1.5.1 Example 138
6. Causality in Observational Longitudinal Studies 92 <ul style="list-style-type: none"> 6.1 Time-lag Models 92 <ul style="list-style-type: none"> 6.1.1 Example 92 6.1.2 Comments 92 6.2 Longitudinal Mediation Models 94 <ul style="list-style-type: none"> 6.2.1 Example 96 6.2.2 Comments 103 	8.2 Count Outcome Variables 141 <ul style="list-style-type: none"> 8.2.1 Example 143 <ul style="list-style-type: none"> 8.2.1.1 Introduction 143 8.2.1.2 GEE Analysis 143 8.2.1.3 Mixed Model Analysis 146 8.2.2 Comparison between GEE Analysis and Mixed Model Analysis 147 8.2.3 Negative Binomial Regression Analysis 148 8.2.4 Comments 150
7. Dichotomous Outcome Variables 116 <ul style="list-style-type: none"> 7.1 Two Measurements 116 7.2 More than Two Measurements 117 7.3 Comparing Groups 117 7.4 Example 117 <ul style="list-style-type: none"> 7.4.1 Introduction 117 7.4.2 Development over Time 117 7.4.3 Comparing Groups 119 7.5 Longitudinal Regression Methods 119 <ul style="list-style-type: none"> 7.5.1 Introduction 119 7.5.2 Generalised Estimating Equations 121 7.5.3 Mixed Model Analysis 124 7.5.4 Comparison between GEE Analysis and Mixed Model Analysis 127 7.5.5 The Adjustment for Covariance Method 130 7.5.6 Models to Disentangle the Between-and Within-subjects Relationship 130 7.5.7 Comments 133 	9. Outcome Variables with Floor or Ceiling Effects 152 <ul style="list-style-type: none"> 9.1 Introduction 152 9.2 Tobit Mixed Model Analysis 153 <ul style="list-style-type: none"> 9.2.1 Example 153 9.3 Longitudinal Two-part Models 159 <ul style="list-style-type: none"> 9.3.1 Example 160 9.3.2 Comments 162
8. Categorical and Count Outcome Variables 134 <ul style="list-style-type: none"> 8.1 Categorical Outcome Variables 134 	10. Analysis of Longitudinal Intervention Studies 164 <ul style="list-style-type: none"> 10.1 Introduction 164 10.2 Continuous Outcome Variables 164 <ul style="list-style-type: none"> 10.2.1 Randomised Controlled Trials with One Follow-up Measurement 165 <ul style="list-style-type: none"> 10.2.1.1 Example 168 10.2.2 Randomised Controlled Trials with More than One Follow-up Measurement 172 <ul style="list-style-type: none"> 10.2.2.1 Simple Analysis 175 10.2.2.2 Summary Statistics 177 10.2.2.3 Generalised Linear Model for Repeated Measures 178 10.2.2.4 Generalised Linear Model for Repeated Measures Adjusted for Baseline 178 10.2.2.5 Regression-based Methods 178 10.3 Dichotomous Outcome Variables 187 <ul style="list-style-type: none"> 10.3.1 Introduction 187 10.3.2 Simple Analysis 188 10.3.3 Regression-based Methods 189 10.3.4 Other Methods 191 10.4 Stepped Wedge Designs 195 10.5 Comments 196

10.6 Beyond the Randomised Controlled Trial	197	13. Software for Longitudinal Data Analysis	220
10.6.1 Difference in Difference Method	198	13.1 Introduction	220
10.6.1.1 Example	198	13.2 GEE Analysis with a Continuous Outcome Variable	220
10.6.1.2 Comments	199	13.2.1 STATA	220
11. Missing Data in Longitudinal Studies	201	13.2.2 SAS	220
11.1 Introduction	201	13.2.3 R	221
11.2 Informative or Non-informative Missing Data	201	13.2.4 SPSS	222
11.3 Example	202	13.2.5 Overview	223
11.3.1 Generating Datasets with Missing Data	202	13.3 GEE Analysis with a Dichotomous Outcome Variable	224
11.3.2 Analysis of Determinants for Missing Data	203	13.3.1 STATA	224
11.4 Analysis Performed on Datasets with Missing Data	204	13.3.2 SAS	224
11.5 Imputation Methods	205	13.3.3 R	224
11.5.1 Continuous Variables	205	13.3.4 SPSS	224
11.5.1.1 Cross-sectional Imputation Methods	205	13.3.5 Overview	224
11.5.1.2 Longitudinal Imputation Methods	206	13.4 Mixed Model Analysis with a Continuous Outcome Variable	226
11.5.1.3 Comments	206	13.4.1 Introduction	226
11.5.1.4 Multiple Imputation	206	13.4.2 STATA	226
11.5.2 Dichotomous and Categorical Variables	207	13.4.3 SAS	227
11.5.3 Example	207	13.4.4 R	229
11.5.3.1 Continuous Variables	207	13.4.5 SPSS	231
11.5.3.2 Multiple Imputation in Combination with Mixed Model Analysis?	209	13.4.6 Overview	235
11.5.3.3 Additional Analyses	210	13.5 Mixed Model Analysis with a Dichotomous Outcome Variable	235
11.5.3.4 Dichotomous Variables	210	13.5.1 Introduction	235
11.5.4 Comments	212	13.5.2 STATA	235
11.6 Alternative Methods	213	13.5.3 SAS	236
11.7 GEE Analysis or Mixed Model Analysis for the Analysis of Datasets with Missing Data?	214	13.5.4 R	239
11.8 Conclusions	214	13.5.5 SPSS	240
12. Sample Size Calculations	216	13.5.6 Overview	242
12.1 Introduction	216	 	
12.2 Example	218	 	
12.3 Comment	219	 	
		<i>References</i>	243
		<i>Index</i>	251