
Contents

Preface	ix
Notation and Acronyms	xi
Chapter 1. Exponential Families	1
1.1. Definition	1
1.2. Mean, variance, and variance function	3
1.3. Examples of exponential families	4
1.4. Maximum likelihood estimation	9
1.5. Technical appendix	18
1.5.1. Some useful results from probability	18
1.5.2. Negative binomial distribution and Poisson-gamma mixtures	19
1.6. Exercises	20
Chapter 2. From Linear Models to GLMs	25
2.1. Reminders on the linear model	27
2.1.1. Matrix form of the linear model	28
2.1.2. Some examples of linear models	29
2.1.3. Least-squares approximation	31
2.1.4. Asymptotics of the LSE	34
2.1.5. Linear Gaussian model	37
2.2. Three components of a generalized linear model	43
2.2.1. The random component	43
2.2.2. The linear predictor	44
2.2.3. The link function	45

2.3. Estimation in generalized linear models	46
2.3.1. Maximum likelihood	46
2.3.2. Asymptotic properties and inference	48
2.3.3. Estimating the dispersion parameter	50
2.4. Some examples	52
2.4.1. Logistic regression model	52
2.4.2. Poisson regression model	59
2.4.3. Gamma regression model	60
2.5. Generalized linear models in R: Poisson regression example	61
2.5.1. Confidence intervals and hypothesis tests	65
2.5.2. AIC and BIC, variable selection	68
2.5.3. Prediction, confidence intervals for a prediction	69
2.6. Technical appendix	71
2.6.1. Some probability distributions	71
2.6.2. Cochran's theorem	72
2.7. Exercises	72
Chapter 3. Censored and Missing Data in GLMs	83
3.1. Censored data	83
3.1.1. Introduction	83
3.1.2. Poisson regression with a right-censored response	85
3.1.3. Gamma regression with a right-censored response	93
3.2. Missing data problems	101
3.2.1. Introduction	101
3.2.2. Missing data typology	102
3.2.3. Methods for treating missing data	103
3.2.4. A missing data problem in the Poisson model	113
3.2.5. A missing data problem in the gamma regression model	127
3.3. Technical appendix	135
3.3.1. Two lemmas	135
3.3.2. Proof of theorem 3.3	140
3.3.3. Proof of theorem 3.4	143
3.3.4. Proof of theorem 3.5	145
3.3.5. Proof of theorem 3.6	149
3.3.6. Elements of empirical processes	150
3.4. Exercises	154
Chapter 4. Zero-Inflated Models	159
4.1. Introduction	159
4.1.1. Overdispersion	159

4.1.2. Excess of zeros	163
4.2. Zero-inflated Poisson models and extensions	166
4.2.1. The zero-inflated Poisson model	166
4.2.2. Semi-parametric ZIP models	170
4.2.3. Zero-inflated generalized Poisson model	174
4.2.4. A zero-inflation test	177
4.3. Zero-inflated negative binomial model	183
4.3.1. Negative binomial model	183
4.3.2. ZINB model	184
4.3.3. The ZIP model versus the ZINB model	186
4.4. Zero-inflated binomial model	187
4.5. Censored and missing data: examples of problems	190
4.5.1. Censored ZIP model	190
4.5.2. Missing covariables in the ZIB model	192
4.5.3. Missing covariables in the ZIP model	195
4.6. Marginal zero-inflated models	200
4.6.1. Introduction	200
4.6.2. MZIP and MZINB models	203
4.7. Exercises	204
References	209
Index	217