

Index

- age-related macular degeneration
 trial, 20, 22, 163–170, 453–460
 SAS, 171–181
- Alzheimer's disease, 53, 237
- anaesthesia, 418
- analgesic trial, 22, 24, 91, 92, 128, 129
- analysis of variance, *see* ANOVA
- ancillary statistic, 147
- ANOVA, 12, 54, 59, 60, 65, 79,
 83, 303
- artificial data, 47, 98, 103, 269–270,
 320, 345, 347
- asymptotic normality, 279
- asymptotic simulation, 137
- available case analysis, 50, 349
- balanced data, 30
- balanced design, 30
- Bayesian inference, xvi, 8, 34, 42, 50,
 78, 79, 105, 107, 108, 146
 Gibbs sampling, 113
 posterior, 106, 110
 proper, 108
- bias, 140
- bootstrap, 305, 308–310
 Bayesian, 114
 parametric, 308
 semi-parametric, 308
- boundary problem, 82, 260, 262
- boundary solution, 208, 323
- Box–Cox transformation, 336
- BRD model, 204, 212, 296–302,
 314, 332, 333,
 341, 344, 347
- breast cancer, 12
- Categorical data, 256, 194–256
 categorical data, 212, 274
 CC, *see* complete case analysis (CC)42
 censoring, 254
 Classification, 440
 clinical trial, 3, 5, 8, 67
 coarsening, 100
 complete case analysis (CC)
 SAS, 171
 complete case analysis (CC), 7, 8, 42–43,
 45–47, 57, 59, 67–74, 77, 83,
 164–167, 281, 297, 349, 453
 SAS, 172
 complete data, 29, 321
 conditional independence, 85
 conditional model
 log-linear model, 137
 transition model, 137
 confidence bound, 424, 426
 confidence interval, 423
 consistency, 256, 264, 279
 contingency table, 52, 194, 197, 256,
 269, 292, 295, 304, 314–327, 331

- contingency table (*Continued*)
 - concordant cell, 320
 - discordant cell, 321
- covariance structure
 - ante-dependence, 66
 - autocorrelation, 355
 - autoregressive AR(1), 56, 63, 80, 174, 381, 398
 - autoregressive AR(2), 138, 139
 - compound symmetry (CS), 60, 63, 67, 72, 80, 174, 358, 373, 428
 - correlation structure, 465
 - exploration, 464–466
 - factor analytic, 187
 - heterogeneous autoregressive ARH(1), 63, 359
 - homogeneous compound symmetry (CSH), 63, 72
 - heterogeneous Toeplitz, 63
 - independence, 60
 - measurement error, 55, 85, 433, 443, 471
 - residual, 472
 - serial correlation, 54, 55, 84, 378
 - Gaussian, 471
 - simple, 174
 - spatial, 187
 - structured, 62
 - Toeplitz, 56, 63
 - unstructured, 60, 62–64, 80, 164
 - variance component, 428
 - variance function, 464, 466
- coverage probability, 152
- Crépeau data, 161

- dairy cattle, 14
- data augmentation, 4, 436
- DATA step, 173
- degrees of freedom, 234, 260, 274, 296, 300, 303, 324, 331, 338, 361, 366, 410, 478
 - Kenward–Roger, 63, 67, 82
 - Satterthwaite, 82
- delta method, 217, 231, 264–267, 270, 273, 282, 381, 384
- depression trials, 15, 67–74, 90, 91, 126, 128, 398, 405, 446, 450
- design matrix, 30, 55, 125, 206, 207
- Diggle–Kenward model, 186, 188, 195, 200, 285, 308, 356, 385, 449
- direct likelihood, 8, 56, 57, 58, 60, 74, 77–92, 99, 116, 119, 145, 158, 164, 167, 173, 174, 453, 454
 - GLIMMIX procedure, 173
 - MIXED procedure, 173
 - NLMIXED procedure, 173
- double robustness, 130, 133
- dropout, 29, 33, *see* pattern, 53, 193, 273, 375, 398
- dropout model, 361, 372, 373, 433, 472
 - direct variables, 393, 395–397
 - increment, 361, 363, 369, 374, 390, 393, 395–473
 - size, 361, 363, 373, 474

- efficiency, 109, 131
- EM, *see* expectation–maximization algorithm (EM)
- empirical Bayes estimation, *see* random effects
- epidemiology, 3
- exchangeability, 166
- expectation–maximization algorithm (EM), xv, xvi, 4, 8, 77, 79, 93–103, 146, 169, 194, 196, 203, 218, 254, 264, 267–269, 273, 282, 436, 439
 - acceleration, 95, 97
 - E step, 94–95, 100, 267, 437
 - EM-aided differentiation, 268
 - information matrix, 95, 98
 - initial step, 94
 - M step, 94–95, 100, 267, 438
 - missing information, 103
 - precision estimation, 94, 95, 98, 102
 - rate matrix, 97
 - rate of convergence, 96, 97
- exploration
 - dropout pattern-specific plot, 470, 475
 - individual profiles plot, 470, 477
 - mean profiles plot, 467
- exponential family, 85

- F* test, 82, 109, 384, 471
 Fisher scoring, 156
 fixed effects, 55, 67, 81, 87,
 421, 475
 fluvoxamine trial, 17, 158, 160,
 196–200, 242, 246, 270–274, 322,
 327, 338, 344, 406–414
 frequentist inference, 32, 50, 51, 60, 79,
 146
 full data, 29

 GAUSS, 157
 generalized estimating equations (GEE),
 34, 79, 83, 86,
 88, 115, 119–143,
 165, 172, 179, 180, 264
 linearization-based method, 124–127,
 168, 174
 working assumption
 unstructured, 129
 working assumptions, 123
 exchangeable, 166
 generalized linear mixed model, 77, 85,
 92, 116, 126, 128,
 168, 172, 179
 Gaussian quadrature, 173
 adaptive, 88–90, 92, 173
 non-adaptive, 88–90
 Laplace approximation, 86
 marginal quasi-likelihood (MQL), 87,
 92
 penalized quasi-likelihood (PQL), 87,
 91, 92, 167, 168, 172
 Taylor series expansion, 86
 generalized linear model
 logistic regression, 128, 405
 GENMOD procedure, xvi, 78, 127,
 172–174, 178
 BY statement, 179
 MODEL statement
 ‘covb’ option, 179
 ‘noint’ option, 179
 ODS statement, 179
 ‘covb=’ option, 179
 ‘parminfo=’ option, 179
 REPEATED statement, 175
 ‘withinsubject=’ option, 174
 SCWGT statement, 175
 WEIGHT statement, 175
 GLIMMIX macro, 85, 126
 GLIMMIX procedure, xvi, 8, 78, 85,
 92, 123, 145,
 156, 157, 172–174
 PROC GLIMMIX statement
 ‘empirical’ option, 126
 WEIGHT statement, 175
 GLM procedure, 78
 global influence, 361
 case deletion, 361, 368, 373, 386
 global satisfaction assessment, 22
 goodness of fit, 9
 growth curve, 12
 GSA, *see* global satisfaction assessment

 halothane, 161
 Hamilton depression rating scale, 14, 67,
 90, 92, 400–405, 446
 hart failure, 188
 hat-matrix diagonal, 370
 hierarchical data, 29
 Hilbert space, 131
 HIV, 330, 335
 hot deck imputation, 45

 identifiability, 218, 219, 285, 320, 321,
 333, 435
 identifiable model, 339–341
 identifiable parameter, 31
 ignorability, 4, 7–9, 27, 29, 33,
 34, 41, 49, 52, 53,
 74, 77–92, 111, 145,
 151, 166, 293, 398, 453
 Bayesian inference, 34
 frequentist inference, 34, 145, 148,
 156
 likelihood inference, 145, 156
 imbalance, 3
 IML procedure, 190
 imprecision, 333, 336
 imputation, 43–45
 multiple
 MCMC method, 113
 propensity score method, 114
 individual-level surrogacy, 249
 influence analysis, 206
 Cook’s distance, 386

- information matrix, 95, 98
 - expected, 78, 96, 145, 146, 148, 151
 - naive, 150
 - observed, 78, 96, 98, 145, 146, 148, 156
- intention to treat (ITT), 6, 53, 116
- interferon- α , 20
- interval of ignorance, *see* sensitivity analysis
- inverse probability weighting (IPW), 119, 120, 122, 135
- iteratively reweighted least squares, 125
- ITT, *see* intention to treat (ITT)
- jackknife, 254
- kurtosis, 366
- Lagrange multiplier, 294
- last observation carried forward (LOCF), 7, 8, 44–50, 53, 57, 59, 67–74, 77, 164–168, 173, 453
 - SAS, 173
- latent class, 79, 450
- latent-class mixture model, 450
- latent variable, 249, 432
- leverage, 369
- likelihood-based frequentist inference, 156
- likelihood function, 194, 206, 334, 355, 423, 433, 434
 - complete data, 148
 - factorization, 33
 - full data, 33
 - multinomial, 196
 - observed data, 366
 - perturbed, 355
 - profile likelihood, 356
- likelihood inference, xvi, 8, 33, 50, 51, 78, 81
- likelihood ratio, 198, 208, 410, 414
- likelihood ratio test, 82, 145, 148, 203, 208, 239, 302, 305, 310, 363, 371, 387, 421
 - missing data mechanism, 361, 368, 371, 387
- linear mixed model, 8, 55, 59, 65, 67, 72, 73, 77, 79, 81, 84, 85, 157, 187, 192, 223, 238, 306, 359, 377, 387, 419, 462
 - heterogeneity model, 432
 - inference, 81–82
 - marginal model, 86
 - ML, 81, 88
 - REML, 81, 88, 115
- linear predictor, 125
- linear regression, 121
- link function, 194
- local influence
 - perturbation scheme, 373–405
 - selection model, 353–415
 - dropout model, 373
 - mastitis in dairy cattle, 367–373
 - measurement model, 373
 - perturbation scheme, 373–405
- LOCF, *see* last observation carried forward (LOCF)
- log-linear model, 116, 204
- LOGISTIC procedure, 127
- logistic regression, 127, 133, 175, 186, 194, 197, 213, 271, 276, 361, 362, 381, 442, 474
- logit, 125, 337
- longitudinal data, 41, 68, 78, 93, 111, 249
 - major depressive disorder, 403
- MANOVA, 54, 59, 60, 303
- marginal model, 206, 242, 466
 - Bahadur model, 136, 138
 - Dale model, 196
 - MNAR, 194, 203
- Markov model, 158
- mastitis in dairy cattle, 14, 360, 375
 - local influence, 367–373
 - sensitivity analysis, 360, 373
- maximum likelihood, 103, 121, 187
- maximum likelihood estimation, 131, 218, 260, 275, 281, 334
 - unconstrained, 319
- maximum likelihood estimator, 51, 52, 302, 355
- mean squared error, 135, 140, 443
- mean structure, 218, 466
 - exploration, 461, 467
 - preliminary, 381

- measurement error, 55
- measurement model, 361
- measurement process, 29
- mechanism, 30, 149
 - dropout, 257, 260, 268, 331
 - missing at random (MAR), 4, 8, 9, 27, 32–36, 43, 48, 49, 52, 65, 67–74, 77–104, 106, 116, 135, 138, 145, 146, 169, 181, 185, 187, 192, 196, 197, 200, 203, 212–239, 245, 263, 272, 274, 285–312, 368
 - missing completely at random (MCAR), 4, 8, 27, 32, 34, 43–45, 48, 51, 60, 65, 82, 84, 116, 138, 151, 160, 168, 181, 185, 187, 192, 197, 200, 203, 206, 208, 217, 290, 292, 296, 299, 305, 314, 324
 - missing not at random (MNAR), 4, 8, 9, 27, 32–34, 36, 78, 94, 103, 106, 116, 181, 185–213, 215–247, 249–251, 253–282, 285–328, 353–415, 417–430
 - protective, 253–282, 339, 343
- meta-analysis, 79
- method of moments, 124
- MI, *see* multiple imputation (MI)
- MI procedure, xvi, 106, 113, 114, 140, 177–181
 - BY statement, 177
- MI procedure (Continued)
 - CLASS statement, 178
 - MCMC statement, 177
 - 'impute=' option, 181
 - 'initial=' option, 177, 178
 - 'niter=' option, 178
 - 'pmm' option, 177
 - MONOTONE statement, 177
 - 'discrim' option, 178
 - 'logistic' option, 178
 - 'method=' option, 177
 - 'ngroups=' option, 177
 - 'regpmm' option, 178
 - PROC MI statement
 - 'nimpute=' option, 177
 - 'round=' option, 177
 - 'seed=' option, 177
 - 'simple' option, 177
 - VAR statement, 177, 178
- MIANALYZE procedure, xvi, 106, 178, 180–181
 - CLASS statement, 178, 180
 - MODELEFFECTS statement, 180
 - PROC MIANALYZE statement
 - 'bcov' option, 180
 - 'covb=' option, 180
 - 'data=' option, 180
 - 'parminfo=' option, 180
 - 'parms=' option, 180
 - 'tcov' option, 180
 - 'wcov' option, 180
 - 'xpxi=' option, 180
 - TEST statement, 180
- milk protein content trial, 375, 398
 - global influence, 388–390
 - influence analysis, 386–398
 - informal sensitivity analysis, 377–386
 - local influence, 390–393
 - pattern-mixture model, 381–385
 - semi-variogram, 378
- milk yield, 14
- missing at random (MAR), *see* mechanism
- missing completely at random (MCAR), *see* mechanism
- missing data indicators, 29
- missing data pattern, *see* pattern
- missing data process, *see* mechanism
- missing not at random (MNAR), *see* mechanism
- MIXED procedure, xvi, 8, 52, 62, 67, 78, 145, 156, 157, 172–174, 192, 384
 - MODEL statement
 - 'covb' option, 232
 - PROC MIXED statement
 - 'scoring' option, 156
 - REPEATED statement, 62
- MIXOR, 92
- mixture distribution, 79
 - pattern-mixture model, 217, 481
- mixture model, 450
- MLwiN, 92
- model reduction, 475
- model selection, 302, 305
- multinomial distribution, 256, 265

- multiple imputation (MI), xv, xvi, 8,
 - 77–79, 104–117, 119, 135–143,
 - 163, 169, 181, 221, 244, 254,
 - 268–269, 274, 282
- analysis task, 138, 178–180
- GEE, 137, 143
- hypothesis testing, 108–109
- imputation task, 136, 138, 177–178
- inference, 108
- inference task, 180–181
- local, 106
- MCMC method, 169
- proper, 110, 169
- SAS, 176, 181
- semi-parametric, 106
- transition, 143
- uncongenial, 115, 116, 137
- multivariate analysis of variance, *see*
 - MANOVA
- multivariate regression, 80
- Muscatine coronary risk factor study, 160
- muscatine coronary risk factor study, 161

- Newton–Raphson, 91, 101, 149, 191,
 - 310, 439
- NLMIXED procedure, xvi, 8, 78, 85, 92,
 - 145, 156, 158, 173, 178
- BY statement, 179
- ODS statement, 179
 - ‘additional estimates=’ option, 179
 - ‘covmataddest=’ option, 180
 - ‘covmatparmest=’ option, 179
 - ‘parameter estimates=’ option, 179
- PROC NLMIXED statement
 - ‘cov’ option, 180
 - ‘ecov’ option, 180
- RANDOM statement, 174
- non-compliance, 116
- non-ignorability, 33
- non-linear model, 85
- normal distribution
 - bivariate, 50, 52, 149, 361
 - multivariate, 54, 59, 94, 111, 115,
 - 125, 133, 164, 186, 187, 253,
 - 256, 282, 356
 - trivariate, 216–218, 359
- numerical integration, 86, 88–90, 167,
 - 168, 373
- obesity, 160
- observed data, 29, 286, 288, 325, 331,
 - 333, 344
- obsessive-compulsive disorder, 17
- odds ratio, 201, 242, 244, 324, 326
- onychomycosis, 18
- ophthalmology, 20, 163, 453
- optimization
 - constrained, 191
- ordinal data, 92, 194
- ordinary least squares, 34, 50, 51, 67,
 - 83, 85, 121, 254, 277
 - residual profiles, 462, 465
- orthodontic growth data, 12, 55–66,
 - 115, 304
- orthogonal projection, 131
- outcome-based model, 218, 364
- outliers, 364
- overdispersion, 167
- overspecified model, 34, 318, 332, 335,
 - 341, 344, 347, 349

- paradox, 219, 290
- partial regression, 255
- pattern, 30, 37, 147, 286, 378
 - attrition, 4, 30, 237
 - dropout, 4–6, 9, 22, 30, 35, 45, 53,
 - 82, 84, 137, 150, 161, 186, 194,
 - 198, 216, 218, 220, 244,
 - 289–291, 326, 339, 354, 355,
 - 358, 359, 361, 370, 381, 385,
 - 398, 420, 474
 - intermittent, 45
 - intermittent missingness, 166
 - monotone, 22, 30, 35, 45, 111, 181,
 - 289, 332, 339, 341
 - non-monotone, 5, 6, 30, 45, 111, 212,
 - 289, 291–292, 332, 339, 341,
 - 344
- pattern-mixture model, 4, 29, 30, 33, 34,
 - 37, 106, 215–247, 250, 253, 257,
 - 286–289, 291, 313, 377, 381–385,
 - 412, 434, 475
- ACMV, 34, 36, 217, 221, 227, 239,
 - 288, 290, 291, 458, 480
- CCMV, 35, 36, 217, 221, 226, 234,
 - 239, 458, 480

- extrapolation, 228, 231
- global hypothesis, 384, 478
- identifying restrictions, 34–37, 216, 220, 222, 458, 480
- marginal hypothesis, 478
- MNFD, 36
- NCMV, 36, 217, 221, 227, 239, 458
- NFD, 222, 239
- NFMV, 36
- strategy 3, 383
- pessimistic–optimistic interval, 297, 298, 301, 346, 349, 351
- pivot, 108
- PMM, *see* pattern-mixture model
- posterior probability, 437, 440
- power, 62, 64
- presence or absence of colds data, 274
- prevalence of HIV in Kenya data, 330, 333, 335, 337, 351
- principal components, 389
- profile, 58, 471
- profile likelihood, 244
- propensity score, 177
- proportional odds, 197
- protective estimator, *see* mechanism
- pseudo-likelihood, 254, 263–264, 270
 - sandwich estimator, 264
- QQ plot, 155
- quality of life, 12
- quasi-likelihood, 125
- random effects, 54, 55, 79–81, 85, 87, 136, 224, 250, 471
 - empirical Bayes estimation, 82, 87, 88
- random intercept, 56, 81, 167, 169
- random slope, 81
- random-coefficient-based model, 218
- random-effects model, 90, 92
- randomization, 6, 53
- rats data, 418, 422
- residuals
 - ordinary least squares, 462, 465
- restricted maximum likelihood (REML), *see* linear mixed model
- ridge, 439
- ridge optimization, 191
- sample size, 423
- sampling framework
 - naive, 147, 150, 152, 159
 - unconditional, 147, 152
- sampling zero, 208, 316, 318
- SAS, 62, 78, 171–181, 188–193, 223
- SAS macro, 171
 - DROPOUT, 175
 - DROPWGT, 175
 - LOCF, 173
 - NLPNRR, 191
- saturated model, 302, 324, 343
- score equation, 124, 294, 305
- score function, 100
- score test, 82, 148, 198
- selection model, 4, 30, 31, 36, 84, 138, 185–213, 215, 216, 218, 219, 242–247, 250, 253, 257, 286, 289, 291, 310, 353–415, 434, 453
- SEM, *see* selection model
- semi-variogram, 472
 - random intercepts, 378, 381
- sensitivity analysis, 8, 9, 28, 65, 188, 215, 216, 218, 237, 281, 285–312, 313, 328, 481
 - global influence, 353–415
 - influence graph, 408, 412
 - informal, 361, 377
 - interval of ignorance, 295, 352
 - interval of uncertainty, 343, 344, 348, 352
 - latent-class mixture model, 449–450
 - local influence, 353–415, 417–430, 453, 455
 - direct variables model, 369–373
 - incremental variables model, 369–373
 - influence graph, 355
 - likelihood displacement, 355
 - normal curvature, 356, 360
 - region of ignorance, 350
 - selection model, 353–415
- sensitivity parameter, 333, 335, 337, 338, 341, 343, 344
- separability, 147
- separability condition, 34
- serotonin reuptake inhibitor, 17

- shared-parameter model, 4, 31, 36, 249–251, 286, 450
- side effects, 6, 17, 160, 198, 242, 273, 322, 324, 339
- single imputation, 43
- six cities study, 279–282
- Slovenian public opinion survey, 25, 295, 302, 303, 348, 351
- subject-specific profiles
 - alignment, 377–381
 - exploration, 470, 477
- survival analysis, 249

- t* test, 65, 72, 79, 82
- t* distribution, 361, 365, 366
 - degrees of freedom, 365
- Taylor series, 125
- therapeutic effect, 17, 158, 200, 273, 322, 324, 339
- tinea pedis study, 202–203
- tobit regression, 122
- toenail data, 18, 19, 82, 85
 - MAR analysis, 84–85
 - MCAR analysis, 82, 84

- uncertainty, 330

- vision chart, 20, 453
- visual acuity, 21, 454
- vorozole study, 12, 224–237, 461–481
 - correlation structure, 465
 - mean structure, 462
 - selection model, 474, 475
 - variance function, 464

- Wald test, 67, 82, 83, 148, 152, 155, 160, 198, 362
- weighted generalized estimating equations (WGEE), xvi, 8, 77, 119–143, 163, 165, 167, 168, 174, 175, 195
 - SAS, 175
- weights, 125, 175, 355
- WGEE, *see* weighted generalized estimating equations (WGEE)
- Wistar rat, 418
- working assumption, *see* generalized estimating equations

- zero cell, 316
- zero count, 325