



Index

NOTE: Page numbers in *italics* refer to Figures

- absolute risk reduction (ARR) 146–7, 147
- absolute risks 146–7, 147, 148
- adjustment
 - confidence intervals 193–4, 195–6
 - confounders 92, 95
 - goodness-of-fit 284–6
- agreement 260–266, 261
 - association 260–261
 - Bland–Altman charts 265–6
 - Cohen's kappa 262–4, 262
 - limits 265
 - weighted kappa 263, 264
- analysis of variance (ANOVA) 293
- analytic cross-sectional studies 104–6
- Apgar scores 209
- arithmetic mean 67–8, 68
- assessment bias 122
- association
 - agreement 260–261
 - correlation coefficient 252–4
 - linear 251
 - linear regression 270–271
 - negative 249
 - positive 249
 - see also* scatterplots
- automated variable selection 288–9
- backward elimination 289
- backwards selection 288
- bar charts 51–4
 - clustered 35–7, 35–7
 - simple 34, 34–5
 - stacked 37, 38–9
- baseline table 11, 13, 14
- Bayesian probability 141
- beneficial risk factor 156
- bimodal distribution 56, 56
- binary data 224–5, 295
- binary-dependent variables 295–7, 296
- binomial distribution 55, 142–3, 170–171
- Bland–Altman charts 265, 265–6, 266
- blinding
 - assessment bias 122
 - double-blind randomised controlled trial 122
 - parallel group trial 122, 122
 - response/placebo bias 121–2
- block randomisation 120–121
- boxplots 42–3, 43–4, 76–8, 77–8
- case-control studies
 - versus* cohort design 115–16
 - confidence intervals 196–8, 198
 - confounding 113, 114
 - frequency-matched case-control study 114, 114
 - hypothesis tests 213, 228, 243
 - matched 94, 154
 - nested case-control design 114
 - probability 138
 - risk ratio 155
 - structure 111–12, 112
- case report 102–3
- case series studies 103
- categorical data 11
 - agreement 262
 - charts 32–9, 32–9
 - frequency tables 18–22, 19–22
 - hypothesis test 209, 222
 - linear regression 286
 - nominal 6–7
 - ordered 236, 236
 - ordinal 7–8
- causal relationship 271–3
- chance-corrected proportional agreement statistic 262
- charts 32–48
 - bar charts 34–7, 35–9
 - boxplots 42–3, 43–4, 76–8, 77–8
 - categorical data 32–9, 32–9
 - continuous data 40–42, 41–2, 44–6, 45–6



- charts (*continued*)
 cumulative data 44–7, 45–6
 discrete data 39–40, 39–40, 44, 45
 distribution 51–4
 histogram 40–42, 41–2
 metric data 39–42, 39–42
 nominal data 32–7, 32–7
 ordinal data 32–7, 32–7
 pie chart 32–4, 33–4
 step charts 44, 45
 time-based data 47–8, 47–8
- chi-squared test
 hypothesis tests 209, 222, 226–38
 logistic regression 304
 survival 319
- clinical databases 326
- clinical trials 119–20
- clustered bar chart 35–7, 35–7
- cluster sampling approach 131–2
- coding design 286–7
- coefficient of determination 281
- Cohen's kappa 262, 262–4
- cohort studies
 charts 42
 confounding 110–111
 features 108
 principal structure 107
 prospective cohort study 107–8, 109
 retrospective cohort study 108, 109
 shortcomings 109–10
- conditional probability 141
- confidence intervals
 agreement 262
 difference between population parameters 173–89
 hazard ratios 198–200, 199
 hypothesis tests 173–89, 204, 218–220, 229, 241, 241
 independent populations 174–81, 186–9
 linear regression 291
 logistic regression 302
 Mann-Whitney rank-sums test 187–8, 189
 matched populations 189–90, 190
 mean 164–70, 166, 170
 median 170–173, 173, 187–90, 189–90
 Minitab 175–7, 178
 Normal distribution 165–6, 166
 odds ratio 196–8, 198
 proportions 170–171, 172, 186–7, 187
 ratio of two population parameters 192–200
 risk ratios 193–6, 195–7
 single population parameter 164–74
 SPSS 178, 179
 standard error 165–70
 survival 322
 systematic review 328–9
 two independent population means 192–3, 192–3
- confounders
 data analysis stage
 adjustment 92, 95
 stratification 94–5
- design stage
 matching 94
- randomisation 95
 restriction 94
- detection 93
- Down syndrome babies 91–2, 92
- linear regression 290–291
- logistic regression 304
- myocardial infarctions, causes 90–91, 90–91
- negative 92
- odds ratio 158
- positive 92
- risk ratios 152, 151–2, 194
- study design 110–111, 113, 114
- consecutive samples 132
- constant coefficient 273
- contingency table 28–30, 29–30
 chi-squared test 227–8
 logistic regression 304
 risk 149
- continuous metric data 10
 agreement 264–6
 charts 40–42, 41–2, 44–6, 45–6
 frequency tables 22–4, 23, 26–7
 linear regression 275
 numeric summary values 66, 70
- controlling for confounders 93
- correlation coefficient 252
- counts 9
- Cox's regression model 322–4
- cross-over randomised controlled trial 123–4, 123–4
- cross-sectional studies
 analytic 104–6
 descriptive 103–4
- cross-tabulation 28–30, 29–30
- cumulative data 44–7, 45–6
- cumulative frequency 25–7, 26–8
- data
 definition 3–4
 identification algorithm 11
 metric data 9–10
 sample data 3–4
- databases 326
- deciles 70
- decision rules 206–207
- dependent variables 282, 295–7
- descriptive cross-sectional studies 103–4
- descriptive statistics
 charts 32–48
 definition 17–18
 distribution 49–58
 frequency tables 17–30
- design variables 286–7
- deviance coefficient 306
- diagnostics 292–3
- discrete metric data 9, 11
 charts 39–40, 39–40, 44, 45
 frequency tables 23–4, 23–4
 numeric summary values 70
- dispersion measures 60, 73–86
- distribution
 bimodal 56, 56
 binomial 55, 170–171



INDEX

383

- negative skew 50–51, 51
 Normal distribution 54–5, 54–5
 numeric summary values 66–8, 70, 71, 82–3, 83, 846
 outliers 51
 Poisson 55
 skew 51–3, 52–3, 56–8, 57
 symmetric 50, 53, 53
 transformed data 84, 85, 86
 uniform 50
 double-blind randomised controlled trial 122
 drop-out 125
 dummy variables 286

 ecological fallacy 117
 ecological study 116, 116
 errors
 drop-out 125
 hypothesis test 220–221
 linear regression 276, 277
 sampling 129–130, 165–6, 166
 estimates 128, 130–131 *see also* confidence intervals
 exclusion criteria 326
 expected values 229–30, 262
 experimental studies 101
 clinical trials 119–20
 randomisation 120–126, 122–4

 false negatives 221
 false positives 220
 Fisher's exact test 209, 233, 233–4
 forest plot 328, 328–9, 329
 forward elimination 289
 forward selection 288
 frequency distribution 19, 19–20
 frequency-matched case-control study 114, 114
 frequency matching 94
 frequency tables 17–30
 categorical data 18–22, 19–22
 contingency table 28–30, 29–30
 continuous data 22–4, 23
 cross-tabulation 28–30, 29–30
 cumulative frequency 25–7, 26–8
 discrete data 23–4, 23–4
 grouping data 26–7
 metric data 22–5
 nominal data 18–20, 19–20
 open-ended groups 27, 28
 ordinal data 20–22, 21–2
 ranking data 14, 14
 relative frequency 20, 20
 funnel plots 330–332, 331, 332

 GCS *see* Glasgow Coma Scale
 generalised linear model 293
 Glasgow-Blatchford Bleeding Scale (GBS), 340
 Glasgow Coma Scale (GCS), 7
 goodness-of-fit 280–281, 284–6, 306, 307
 grouped data 26–7, 26–7, 40–42, 41–2
 grouped frequency distributions 26–7, 26–7

 hazard ratios 198–200, 199, 244, 244, 320–321, 323, 324
 histograms 40–42, 41–2

 confidence intervals 175
 distribution 51–2, 68, 68, 85
 numeric summary values 68, 68, 85
 Hoehn scale scores 22, 22
 homoskedasticity 278
 Hosmer-Lemeshow statistic 306
 hypothesis tests
 chi-squared test 209, 222
 confidence intervals 173–89, 204, 218–20, 229, 241,
 241
 versus. confidence intervals 218–20
 decision rules 206–7
 difference between population parameters 210–213
 equality of population proportions 214, 227–30
 errors 220–221
 Fisher's exact test 209
 independent population 227
 independent populations 210–211, 223–5
 Kruskal-Wallis test 209
 Mann-Whitney rank sums test 209, 215, 215–18, 217
 matched-pairs t test 209, 213–14, 214
 McNemar's test 209
 mean 208–11
 median 214–15, 218
 Minitab 211–12
 Normal distribution 208, 213, 217
 null hypothesis 205
 paired populations 213–14
 power 221–2
 procedure 206
 proportions 227–30
 p values 206–8, 210, 210, 211, 230, 242, 242
 ratio of two population parameters 204–25, 239–44
 research questions 204–5
 rules of thumb 223–5
 significance level 207, 223–4
 SPSS 212–13, 218
 trend 209, 236–8, 238
 two-sample t test 185, 188, 209–13, 211–12
 Wilcoxon signed-ranks test 173, 189, 190, 209, 218
 see also null hypothesis

 inclusion criteria 326
 independent populations
 difference 187–8, 189
 hypothesis test 210–211, 223–5, 227
 ratios 192–3, 192–3
 Whitney rank sums method 187–8, 189
 independent variables
 linear regression 282
 logistic regression 298, 303–4
 inferences 128–30
 Injury Severity Score (ISS) 263, 264
 intention-to-treat analysis 125–6
 interquartile range (IQR) 73–6, 74–6, 317
 inter-rater agreement 260

 journals 329

 Kaplan-Meier curve 315–17, 316–17
 Kaplan-Meier table 313–15
 Kendall's rank-order correlation coefficient 258–9

linear regression
 analysis of variance 293
 association 270–271
 assumptions 277–8
 causal relationship 271–3, 272
 coding design 286–7
 confounders 290–291
 design variables 286–7
 diagnostics 292–3
 goodness-of-fit 280–281, 284–6
 Minitab 279–80
 model building 273–6, 287–8
 multiple 282, 282–4
 nominal independent variables 286–7
 ordinary least squares 277–8
 population regression equation 278
 sample regression equation 275
 SPSS 278–9, 279
 statistical significance 278–80
 variable selection 288–290
 variation 271–3
 location measures 64–71
 logistic regression 294–307
 binary-dependent variables 295–7, 296
 goodness-of-fit 306
 maximum likelihood estimation 298–300
 Minitab 303
 model building 297–8, 303–6
 odds ratios 300–301
 Poisson 306–7
 regression coefficient 301, 302
 SPSS 298
 statistical inference 301–2
 log–log plot 324
 log-rank test 319–20, 320

Mann-Whitney rank sums test 187–8, 189, 209
 Minitab output 216–18, 217
 ranking procedure 215, 215–16
 SPSS output 218
 Wilcoxon signed-ranks test 218

Mann-Whitney test 227
 manual variable selection 289–90
 matched case-control studies 94, 154
 matched-pairs *t* test 209, 213–14, 214
 matched populations 189–90, 190, 218
 maximum likelihood estimation 298–300
 McNemar's test 209

mean
 confidence intervals 164–70, 166, 170
 hypothesis test 208–11
 linear regression 275
 numeric summary values 67–8, 68
 standard error 165–70
 statistical inference 129

measurements 8, 10

median
 confidence intervals 172–3, 173, 189, 190
 hypothesis test 214–15, 218
 numeric summary values 66–7
 survival 316–17

meta-analysis 332–5

charts 39–42, 39–42
 frequency tables 22–4
 metric data 10
 agreement 264–6
 continuous 10
 discrete 9
 mode 65, 65–6
 model building 273–6, 287–8
 mound-shaped distributions 50, 53, 53
 multicollinearity 283
 multiple linear regression 282, 282–4, 283

n-tiles 70

negative
 confounding 92
 outcomes 329
 skew 50–51, 51

negative predictive value (NPV) 337

nested case-control design 114

nominal categorical data 6–7, 10
 charts 32–7, 32–7
 frequency tables 18–20, 19–20
 linear regression 286–7
 numeric summary values 64, 70

non-parametric tests 187–8, 208, 209, 218

Normal distribution 54–5, 54–5
 confidence intervals 165–6, 166
 linear regression 277
 probability 144
 standard deviation 82–3, 83, 84

null hypothesis 205
 difference between population parameters 204–25
 ratio of two population parameters 231, 232, 240–241
 survival 319

number needed to treat 149–50

numeric summary values
 dispersion measures 60, 73–86
 distribution 66–8, 70, 71, 82–3, 83, 84
 interquartile range (IQR) 73–6, 74–6
 location measures 64–71
 numbers 60–61
 outliers 73
 percentages 60–64
 percentiles 68–70
 proportions 60–61
 quantitation 60
 range 73
 skew 67, 71, 86
 standard deviation 79–84
 transformed data 84, 85, 86

observational study designs
 case-control studies 111–16, 112, 114
 case report 102–3
 case series studies 103
 cohort studies 108–11, 109
 cross-sectional studies 103–6
 ecological fallacy 117
 ecological study 116, 116
 issues 101
 portfolio 101, 102
 research questions and methods 100



INDEX

385

observed values 231
odds ratios
 calculation 157–8, 158
 confidence intervals 196–8, 198
confounding 158
hypothesis tests 242–3
logistic regression 300–301
risk ratio approximating 159
stroke and exercise study 156–7, 157
systematic review 329
one-to-one matching 94
open-ended groups 27, 28
open trials 122
ordered categorical data 236, 236
ordering of data 7–8, 20–22, 21–2
ordinal categorical data 7–8, 10
 charts 32–7, 32–7
 confidence intervals 188, 189
 frequency tables 20–22, 21–2
 hypothesis test 208
 numeric summary values 64, 67, 70, 71
ordinary least squares (OLS) 277–8
outliers
 distribution 51
 frequency tables 27
 numeric summary values 73
p values
 hypothesis tests 206–8, 210, 210, 211, 230, 242, 242
 linear regression 284
 logistic regression 305
 survival 323
Palliative Care Outcome Scale (POS) 263, 264
parallel design 122
parametric tests 187, 208, 209, 222
parsimony 290
Pearson's correlation coefficient 256, 256
percentages
 cumulative frequency 44–7, 45
 frequency 20, 20
 numeric summary values 60–64
percentiles 68–70
perfect agreement 261
pie charts 32–4, 33–4
placebo bias 121–2
Poisson distribution 55, 143–4
Poisson regression 306–7
population
 correlation coefficient 254
 difference between parameters 173–89
 logistic regression 297
 mean 164–70, 166, 170, 208–11
 median 172–3, 173, 189, 190, 214–15, 218
 odds ratios 196–8, 198, 243, 243
 parameters 128
 proportions 170–171, 172
 ratio of two parameters 192–200, 239–44
 regression equation 278
 risk ratios 193–6, 195–7, 240, 240–241
 single parameter 164–74
 statistical inference 128–130
 survival 314

positive
 confounding 92
 outcomes 329
 skew 51–3, 52–3
positive predictive value (PPV) 337
power of a test 221–2
prediction 280
probability
 binomial probability distribution 142–3
 calculation 138, 139
 case-control studies 138
 conditional and Bayesian statistics 141
 definition 138
 dice rolling experiment 141, 141–2
 discrete *versus.* continuous 142
 logistic regression 298, 299
 Normal distribution 144
 number needed to treat 149–50
 odds 156
 Poisson distribution 55, 143–4
 proportional frequency 138–9
 simple probability
 addition rule 140
 multiplication rule 139
 survival 314
proportional agreement 261
proportional frequency 138–9
proportional hazards 324
proportions
 confidence intervals 170–171, 172, 186–7, 187
 hypothesis test 227–30
 numeric summary values 60–61
 populations 227
publication bias 329–30
quintiles 70
randomised controlled trial (RCT)
 hypothesis tests 211, 220
 study design 120, 123–5
random number tables 120
range 73
ranked data
 frequency tables 14, 14
 log-rank test 319–20
 Mann-Whitney rank-sums test 209, 214–19
 Spearman's rank correlation coefficient 256–9
 Wilcoxon signed-rank test 173, 189, 190, 209, 218
receiver operating characteristic curve (ROC) 339, 340
reference value 149–51, 150, 151
regression coefficient 301, 302
relative frequency 20, 20, 45, 76
relative risk reduction 148–9
residuals 276–7
response bias 121–2
risk 298
risk ratios 147–8
 case-control study 155
 confidence intervals 193–6, 195–7
 confounding 152, 151–2
 formula 149
 hypothesis tests 240–241



risk ratios (*continued*)
 relative risk reduction 148–9
 survival 322
 systematic review 331
 rules of thumb 223–5

sample
 consecutive 132
 logistic regression 297
 mean 165–6, 166
 percentage 129–30
 regression equation 275
 simple random 130
 statistics 128, 129
 stratified random 130–131
 survival 314
 systematic random 130

sampling
 errors 129–30, 165
 inclusion and exclusion criteria 133
 sample size 132–3
 sampling error 129–30
 statistical inference 128–30
 target population 128–9, 130–131
 types 129–32

scatterplots
 limitations 250
 linear regression 276
 logistic regression 295–6

sensitivity 337

significance level 207, 223–4

simple bar chart 34, 34–5

simple random sample 130

skew 51–3, 52–3, 67, 71, 86

slope coefficient 273

Spearman's rank correlation coefficient 256–9, 257, 259

specificity 337

spread measures 60, 73–86

stacked bar chart 37, 38–9

standard deviation 79–84, 81, 83–4
 agreement 266
 confidence intervals 174, 184

standard error 165–70

statistical inference 128–9, 301–2

step charts 44, 45

stepwise selection 288–9

straight line model see linear regression

stratified random sample 130–131

study design
 blinding 121–2, 122
 case-control studies 111–16, 112, 114
 case series studies 103
 clinical trials 119–20
 cohort studies 108–11, 109
 confounders 94–5
 cross-sectional studies 103–6
 experimental studies 119–26
 intention-to-treat analysis 125–6
 matching 94
 randomisation 120–126, 122–4
 randomised controlled trial 120, 123–5
 study populations 128–130

sum of squares 80

survival
 censored data 312–13
 comparison between groups 317–18
 Cox's regression model 322–4
 hazard ratio 320–321
 Kaplan–Meier curve 315–17, 316–17
 Kaplan–Meier table 313–15
 log–log plot 324
 log-rank test 318–20
 median 316–17
 probability 314
 proportional hazards 324
 single groups 312–13, 313

symmetric distribution 50, 53, 53

systematic random sample 130

systematic review
 exclusion criteria 326
 forest plot 328, 328–9, 329
 funnel plot 330–332
 inclusion criteria 326
 meta-analysis 332–5
 methods 327
 publication bias 329–30
 search strategy 327
 selection criteria 327

t distribution 168, 174, 187–8

target population 128–9

test statistic 236

time series chart 47–8, 47–8

transformed data 84, 85, 86

treatment bias 122

treatment group 122

trend 209, 236–8, 238

two-sample *t* test 209–11, 304
 Minitab output 211, 211–12
 SPSS output 212, 212–13

typeI/II errors 220–221

uniform distributions 50

units 11

univariate logistic regression 304

variables
 characteristics 11–14
 definition 3–4
 selection 289–90
 types 6, 6
see also categorical; continuous; discrete metric;
 nominal; ordinal data

variation 271–3

visual analogue scale (VAS) 11

Wald statistic 298

weighted kappa 263, 264

Whitney rank sums method 187–8, 189

Wilcoxon signed-rank test 173, 189–90, 190, 209, 218

Yahr scale scores 22, 22

Yate's correction 233

z distribution 298