

INDEX

- Access, to healthcare
 - interval scales of, 80
 - logistic regression analysis of, 311
- Accountability, for quality of care, 4
- Acyclical
 - definition, 492
 - directed acyclical graphs (DAGs), 494
- Addition rule, 59, 60
- Adjusted R-squared, 267–269
- Age, as variable
 - countable discrete levels of, 174
 - distribution, 90–92
 - out-of-range, 42
 - as predictor of multiple outcomes, 487–488
 - sequence among variables, 515
 - stratified regression analysis, 430–436
- Agency for Healthcare Research and Quality (AHRQ)
 - chart review recommendations, 43
 - claims data, 2
 - Clinical Classification Software, 265, 312
 - Consumer Assessment of Healthcare Providers and Systems (CAHPS), 158–159
 - Healthcare Costs and Utilization Project, 365
 - time to pain medication measure, 224–225
- Aggregate functions, 22–23
 - maximum, 25
 - minimum, 25
- AHRQ. *See* Agency for Healthcare Research and Quality
- Alemi, F., 392
- American National Standards Institute, 14
- Analysis of variance (ANOVA), 164
- Ancestors of variables, 496
- Anderson-Darling test of normality, 289
- Angular root transformation, 290
- Area under receiver operating curve (AROC), 114–116, 117–118
 - of sequential network learning algorithms, 516
- AROC. *See* Area under receiver operating curve
- Association
 - between cause and effect, 240
 - likelihood ratios and, 110
 - of variables, 7
- Association networks, 459, 468–469
 - construction with Poisson regression, 481–484
 - strata-conditioning relationship and, 463
- Attributable risk, 241–242, 243–244
- Attributes, 78. *See also* Variables
- Aurora Health Care System, 2
- Autocorrelation plots, 285–286, 287
- Average, 82–83
 - dispersion around, 85–87
 - weighted, 84–85
- Avramovic, Ivan, 392
- Back-door path, 507–510
 - blocked, 493, 509–510, 517, 520, 522
 - covariates, 507, 508–509
 - definition, 491, 493

- Backward stepwise selection of independent variables, 281
- “Bad data” file, 24
- Bar charts
 - of binomial distribution, 178, 179
 - as histograms, 92, 93
- Barthel index, 80
- Bayes, Thomas, 63
- Bayesian probability models, 102
- Bayes’s data mining model, 105–106, 111–112
- Bayes’s formula, 68
 - conditional independence applied to, 64–66
 - odds form, 105–106, 110, 111–112
 - posterior odds of mortality, 112
 - prior opinion revision and, 62–63
 - of probability, 62–66
- Bayes’s theorem, 63
- BayseiaLab, 511
- Benchmarking, of physician performance, 2–3, 409–425
 - data balancing in, 409–411
 - distribution switching, 410, 411–413
 - limitations, 420–421
 - multilevel modeling of, 346
 - multiple comorbidities, 409, 413–416
 - overlap in, 416–418
 - patient matching in, 413–416, 421
 - SQL codes, 422–423
 - steps in, 409–410
 - stratified covariate balancing in, 409, 411
 - synthetic controls, 410, 416, 418–420, 421
 - terminology, 411
- Bernoulli, Jacob, 175
- Bernoulli density functions, 205–207
 - geometric distribution and, 206–209
- Bernoulli distribution, 5
- Bernoulli trials, 175, 206–207, 208
- Big data
 - applications, 1
 - definition, 1
- Binary variables, 79, 80, 309
 - common odds ratio, 386–389
 - as indicators, 79
 - logistic regression of, 309
 - main and interaction effects, 274–275
 - rate of occurrence, 174
- Binomial distribution, 5, 90, 175–179
 - bar charts of, 178, 179
 - binomial parameters, 175–176
 - conditions required for, 175
 - definition, 175
 - example, 176–179
 - in Excel, 176, 181
 - normal approximation, 179–181, 182
 - normal distribution, 176, 179–181
 - skewed, 179
- Binominal parameters, 175–176
- Birth, clinical encounters before, 40
- Birthdates, wrong, 40
- Blocking the back-door path, 493, 509–510, 517, 520, 522
- Breusch test, 288
- Budget
 - control of, 310
 - Tukey’s charts of, 234–235
- Bullying, 310
- Bundled prices, 489
- Bupirone, weighted propensity scoring study, 338–342
- CAHPS. *See* Consumer Assessment of Healthcare Providers and Systems
- Case, definition, 385
- Case-control design, 49, 51, 52. *See also* Matched case control studies
 - backward look, 51
 - forward look, 48–51
 - with multiplicative stratified regression, 438
 - retrospective, 48

- stratified, chi-square test of, 386–387
- Case mix index, 83–85
- Casual relationships, display of, 468
- Categorical variables, 69, 79
- Causal analysis, 7, 9. *See also* Causal control charts; Causal networks regression use in, 296–297
- Causal chains, 494, 495
- Causal control charts, 239–254
 - assumptions of causality, 240–241
 - comparison with traditional control charts, 244–245
 - control limits calculations, 246, 247–250
 - lower control limit, 246, 249–250
 - upper control limit, 246, 249–250
 - weighted controls, 246, 249–250, 251
 - counterfactual, 245–251
 - data balancing in, 244, 245–246
- Causal impact, 506–507
 - example, 516–519
- Causal interpretations, 7
- Causal networks, 487–526
 - back-door paths, 507–510
 - blocking of, 493, 509–510, 517
 - covariates, 507, 508–509
 - definition, 491, 493
 - common effect in, 495
 - direct cause in, 494–495
 - as directed acyclical graphs (DAGs), 494
 - directed arcs in, 493–494, 495, 514–516
 - “do operation” manipulation, 507
 - key concepts, 491–497
 - Markov blankets, 492, 493, 510, 513–514, 516–517, 510
 - network parameters specification, 510
 - network structure identification, 510–514
 - constraint-based algorithms, 512–513
 - multivariate methods, 513–514
 - search-and-score methods, 511
 - parameters identification, 516–517
 - parent–child node relationships, 501–502
 - probability calculations, 501–506
 - eliminating steps, 506
 - joining steps, 506
 - relationship with regression, 497–501
 - spurious correlation removal in, 496–497
 - terminology, 496
- Causation
 - principles, 7–8, 489–491
 - relationship with correlation, 7, 476, 489
- Cause and effect, 506
- Centers for Disease Prevention and Control (CDC), Data to Care (D2C) procedures, 4
- Centers for Medicaid & Medicare Services (CMS)
 - bundled payments, 499–501
 - Death Master List, 39
 - healthcare database, 2
 - hierarchical condition category (HCC), 416–419
 - Hospital Compare website, 224–227
 - patient satisfaction scores, 159
- Central limit theorem, 141–144
- Central tendency, 137
- Characteristics, 78. *See also* Variables
- Charlson comorbidity index, 102–103, 119
- Chart reviews, 43
- Children, of Markov blankets, 492, 493, 496, 510

- Chi-square test, 71–73
 - for goodness of fit, 322
 - for homogeneity of treatment impact, 386–389
 - for Hosmer-Lemshow tests, 324
 - of independence, 467, 478
 - for three variables, 471–475
- Clinical encounters
 - chronology of events in, 47–51
 - erroneous data removal, 38–45
 - absence of encounters, 40–41
 - encounters after death, 38–39
 - encounters before birth, 40
 - patient-reviewed, 212–219, 221
- Clinical practices, Big data-based evaluation of, 4
- Clues, 78. *See also* Variables
- CMS. *See* Centers for Medicaid & Medicare Services
- Coefficient of determination, 277–280
 - maximization, 280
 - in predictive medicine, 281
- Cohen's *d*, 149
- Cohort study, 48–51, 52
- Collider, definition, 492
- Collider test, 515
- Collinearity effects, 291–292
- Common cause, 496
- Common effect, 495
- Community hospitals, survival rate analysis, 349–354
- Community living centers, 520, 522
- Comorbidities, 46, 47
 - causal network analysis, 518–519
 - as lung cancer prognostic factor, 439–447
 - multiple
 - in clinician benchmarking, 409, 413–416
 - risk assessment. *See* Multimorbidity index
 - stratification of, 488
- Comparative effectiveness studies, 4. *See also* Matched case control studies
 - contradictory conclusions, 364
- Compensation, performance-based, 2–3
- Complaints, from patients, 212–219, 221
- Complications, 46–47, 498–499
- Conditioning
 - definition, 385, 493
 - through reduction in strata, 463–464
- Confidence intervals, 5, 150–151
 - 95 percent, 295
 - estimation, 6
 - for odds ratio, 186–189, 374–376
 - of Tukey's charts, 223–224
- Confidence value approach, 150
- Confounding, 1
 - in regression analysis, 498
 - removal
 - automated, 403–406
 - in causal analysis, 498
 - with propensity scoring, 327, 337–343, 384
 - with randomization, 384
- Congestive heart failure, length of stay, 413–416
- Consistency tests, 43–44
- Constant probability *p*, 206
- Constant variance, 161
- Consumer Assessment of Healthcare Providers and Systems (CAHPS), 158–159
- Contingency tables, 57, 66–71, 323
 - definition, 66–67
 - in Excel, 68–71
 - marginal, 473, 474
 - multidimensional, 471–473
 - partial, 473
- Continuous distribution, 136, 138. *See also* Normal distribution
- Continuous interval scale, 160
- Continuous outcomes, stratified
 - covariate balancing
 - difference models, 389–390
 - weighted data, 390–392, 393–395

- Continuous probability density function, 136
- Continuous variables, 80, 309
 average of, 141
 random, 136
 relationships among, 73–74
- Contradictory data, 42–44
- Control, definition, 385
- Control charts, 98–100. *See also*
 Causal control charts; p-charts;
 Tukey's control charts; XmR control charts; X-bar control charts
 control limits calculations,
 154–156
 lower control limits, 98, 99,
 153, 154
 upper control limits, 98, 99
 elements of, 153–156
 lower control limit (UCL), 154
 mix-adjustment of, 210
 with normal distribution
 X-bar charts, 152, 153,
 158–171
 probability, 5
 risk-adjustment of, 194–199, 201,
 210, 244–245
 stratification in, 245
 time-between, 209–212, 236
 of exercise resolutions,
 219–220
 lower control limits, 212
 of patient reviews, 212–219,
 221
 of sentinel events, 203–222
 upper control limits, 212, 216–
 217, 218, 219
 time changes on, 153
 upper control limit (UCL), 153,
 154
 X-axis, 153
 Y-axis, 153
- Control charts, 98–100. *See also*
 Causal control charts; P-charts;
 Tukey's control charts; XmR control charts; X-bar control charts
 applications, 152–153
- Controls, synthetic, 410, 416, 418–
 420, 421
- Co-parents, of Markov blankets, 492,
 496, 510
- Copay, stratified regression analysis,
 430–436, 439–440
- Corner cases, 355
- Corner stratum, 437–440, 442
- Correlation
 causation relationship, 7, 476,
 489
 conditional, 475
 spurious, 475–477, 496–497
- Correlation coefficients, 74–75
- Cost
 as continuous variable, 79, 80
 as interval variable, 79
- Cost data analysis
 of joining insurance plans, 84–85
 log transformation, 97
 with single cost predictor,
 266–271
 statistical evaluation, 264–266
 transformation, 87–88
- Cost-effectiveness analysis
 matched case controls of, 363
 value-based reimbursement and, 4
- Cost overruns, frequency, 57
- Counterfactual assumption, 240, 490,
 498
- Counterfactual causal control charts,
 245–251
- Counterfactual groups, 244
- Covariates, 52. *See also* Stratified
 covariate balancing
 in causal analysis, 240
 combinations, 384, 385–386
 in control charts, 245
 definition, 491, 492
- Cox, Louis Anthony Jr., 203–204
- Cox's hazards regression, 258
- Creating dummy variables, 69
- Critical value approach, 146
- Critical value of the test statistic, 145

- Cross-validation, 292–293
 - of multimorbidity index, 109–110
- c*-statistic, 323
- Cumulative distribution function, 241, 242–243
- Cumulative probability distribution, 139–140
- Data
 - cleaning of. *See* Erroneous data collection, 7
 - on the internet, 2
 - discarding of, 45–47
 - errors in entry, 24
 - filtering, 23–24
 - merging
 - matrix format, 12
 - in SQL, 5–6, 12
 - preparation
 - decision-making in, 12–13
 - errors in, 13
 - importance, 11–13
 - with SQL, 11–12
- Data analysts, clinical roles of, 4
- Data balancing, 244, 245–246. *See also* Propensity scoring
 - in benchmarking, 409–411
 - definition, 410
- Data-driven companies, 2–3
- Data to Care (D2C) procedures, 4
- Dates
 - of birth, wrong, 40
 - conversion from text, 35–36
 - of death, wrong, 39–40
 - out-of-range, 42
- Death, probability of, 80. *See also* Prognosis
- Deceased patient data, 13
 - coding, 25
 - deletion, 38–39
 - erroneous, 38–40
- Decision-making
 - clinical, 4
 - in data preparation, 12–13
- Decision trees, 415
- Definition of the variables method, 515
- Density plots, 290, 293
- Dependent samples, 151
- Dependent samples test, 151–152
- Dependent variables, 68
 - as count of events. *See* Logistic regression
 - in straight line equation, 259
- Descendants of treatment/variables, 492, 496
- Deviance (D), 323
 - expected, 197–199, 200
- Diabetes mellitus
 - as complication of treatment, 47
 - hemoglobin A1C assessment, 163–171
 - multimorbidity index, 117, 118
- Diagnosis
 - association with outcome, 110
 - missing, 13, 41–42
 - post-outcome, 46
 - post-treatment, 46–47
- Diagnosis-related groups (DRGs)
 - case mix index, 83–84
 - in clinician benchmarking, 416, 418, 419
- Diagnostic codes, 365. *See also* International Classification of Diseases (ICD)
 - interaction of, 428
- Dichotomous events, 189
- Directed acyclical graphs (DAGs), 494
- Directional separation of network arcs, 514–516
- Disabilities progression, casual analysis, 511, 512
- Discrete variables, 69, 73, 79
 - histogram of, 90, 91
 - in propensity scoring, 331–332
 - rate of occurrence. *See* Rates, comparison of
- Dispersion, around averages, 85–87

- Distribution, 6, 71, 90-92. *See also*
 Frequency distribution; Normal distribution
 continuous, 136, 138
 definition, 90
 exponential, 142, 143
 parabolic, 142, 143
 switch, 410, 411-413
 uniform, 142, 143
- DNR (do not resuscitate) orders,
 causal analysis of, 503, 505-506
- “Do operation,” 507
- Double-counted data, 13
- DRGs. *See* Diagnosis-related groups
- Dummy variables, 69, 271
- Durbin-Watson statistic, 285-286,
 287
- Eating disabilities-mortality
 relationship
 causal analysis, 507-509, 520, 522
 stratified covariate balancing,
 392-395
- EHRs. *See* Electronic health records
- Electronic health records (EHRs)
 comprehensive, 7
 erroneous data removal, 38-45
 absence of encounters, 40-41
 encounters after death, 38-39
 encounters before birth, 40
 free text, 30-33
 as quality of care measures, 43
 tables
 encounter, 19-21
 foreign keys, 15
 joining of, 25-29
 multiple, 5-6, 12
 patient, 17-21
 patient fields, 15
 primary key, 15
 provider, 19, 20-21
 relationships among, 15, 20-21
- Electronic health records (EHRs) data
 merging, 5-6
 observational nature, 5
 random sampling, 81
- Electronic health records (EHRs)
 systems, matched case controls of,
 363
- Elixhauser index, 102-103, 117-118,
 119
- Elopement, of patients, 206, 207-208
- ElRafey, Amr, 392
- Emergency departments
 patient boarding time analysis,
 247-250, 251, 489
 time to pain medication perfor-
 mance measure, 224-227
- Encounter tables, 19-21
- End nodes, 502
- Erroneous data
 about clinical encounters, 38-45
 absence of encounters, 40-41
 encounters after death, 38-39
 encounters before birth, 40
 missing data, 41-42
- Errors
 in data entry, 24
 Goodman and Kruskal reduction
 of, 515
 medication, 204-205, 206, 232-
 233, 243-244
 medication errors, 43
 normally distributed, 288-289
 in R software, 302
 sum of squares of errors (SSE),
 279
 type I, 145, 146
 type II, 145, 146-147
- Error terms
 heteroscedasticity of, 286-287
 homoscedasticity of, 286
 normal distribution of, 288-289
- Event trees, 413-416, 415-416, 418
- Excel. *See* Microsoft Excel
- Exercise-weight loss relationship,
 Tukey’s chart of, 228-230
- Expected deviance, 197-199, 200
- Exponential distribution, log transfor-
 mation of, 97

- False negative, 146
 False positive, 146
 FDA. *See* Food and Drug Administration
 Administration
 Fee-for-service organizations, logistic regression analysis of, 311
 Finite population correction factor, 141
 Fmax test, 152
 Food and Drug Administration (FDA), 2
 Forecasting, with multilevel modeling, 346
 Forward stepwise selection of variables, 281
 Fourth spread, 223–224, 226, 229, 230–231, 232–233
 Fractures, time to pain medication study, 224–227
 Free text, 30–33
 Frequency distribution, 57, 87, 90–92, 174–175
 cumulative, 90, 91
 with histograms, 92–97
 relative, 90, 91
 F-statistic, 279
 F-test, 145
 F value test, 280

 Gamma distribution, 236–237
 Gender, as variable
 countable discrete levels of, 174
 stratified regression analysis, 430–436
 George Mason University Dataverse, 119
 Goldfeld-Quant test, 288
 Goodman and Kruskal errors reduction, 515
 Goodness of fit
 adjusted R-squared, 267–269
 chi-square test, 322
 G-squared, 481, 482
 in logistic regression, 322–324
 in Poisson regression, 481
 R^2 statistic, 277–278
 Grouping, of data, 22–23, 24–25
 Grow-shrink algorithm, 512–513
 G-squared statistic, 481, 482

 Hartley's Fmax test, 152
 Hazard rate, 241–244
 HCC. *See* Hierarchical condition category
 Healthcare, overuse of, 311
 Healthcare team members, contributions to patient satisfaction
 propensity scoring, 329
 stratified covariate balancing, 387–389
 Health insurance companies
 data analysis use, 3
 risk assessment methods, 3
 start-up, 3
 stock market price analysis, 250, 252
 Health insurance cost, stratified regression analysis, 430–436, 441–450
 Health insurance status, as categorical variable, 79
 Heteroscedasticity, 286–288
 weighed regression and, 294
 Hierarchical condition category (HCC), 416–419
 Hierarchical regression. *See* Multilevel regression
 Histograms, 92–93
 in Excel, 94–97
 HIV. *See* Human immunodeficiency virus (HIV) infection
 Home health care organizations, 4
 Homogeneity of variance, 152
 Homoscedasticity, 286
 Hosmer-Lemshow tests, 324
 Hospice care, effect on hospital readmissions, 48–52, 466–467
 Hospital acquisitions, logistic regression analysis of, 311
 Hospital Compare website, 224–227

- Hospital discharge, number of diagnostic codes in, 428
- Hospital occupancy, 1
- Humana, 250, 252
- Human immunodeficiency virus (HIV) infection, 4
- multimorbidity index of, 117
- Human resources
- logistic regression use, 310–311
- matched case controls use, 364
- Hypothesis testing, 1, 5, 9. *See also*
- Null hypothesis
- chi-square test, 71–73
- comparison of two-sample means, 151–152
- conclusion of, 145
- context-specific, 295–296, 321–322
- definition, 144
- in Excel, 183, 186, 187
- level of significance, 145
- of logistic regression coefficients, 321–322
- one-sample z test of population means, 147–148
- of population proportion, 181–186, 187
- regression coefficients in, 295–296, 321–322
- steps in, 72–73
- test statistic, 145
- critical value, 145
- observed value, 145
- type I errors, 145, 146
- type II errors, 145, 146–147
- for three variables, 471–475
- complete, 470, 474, 475
- concept, 460–461
- conditional, 64–66, 461, 464, 465
- causal network arcs and, 514, 515
- definition, 460
- joint, 470, 473–475
- joint preferential, 437, 442
- marginal probabilities and, 464–467
- of multiple morbidity index, 105–106, 107
- mutual information and, 477–478, 479
- of observation, 52
- order of parsimony, 470
- for three variables, 469–471
- chi-square test, 471–475
- visual network display of, 467–469
- Independence assumption, 152
- Independence samples tests, 151–152
- Independent events, 160–161
- Independent variables
- backward stepwise selection, 281
- in chi-square test, 72
- collinearity, 291–292
- with interactions, 428–429
- monotone relationships, 437
- in ordinary regression, 271
- binary variables, 271–273
- categorical variables, 271, 273
- continuous variables, 271
- interaction variables, 271
- preparation, 271–274
- squaring, 290
- unconfounded impact estimation, 433–436
- Inferential statistics, 141–142
- Influenza outbreaks, prediction of, 281
- Interaction effect, 274–277
- Interaction terms, 276–277, 428
- higher order, 428
- pair-wise, 428
- in propensity scoring, 331
- ICC. *See* Interclass correlation
- Identity theft, 39
- Improvements, risk-adjusted P-charts of, 194–199, 201
- Incongruous data, 13
- Inconsistency, of data, 13, 42–44
- Inconsistent data form, 44–45
- Independence
- chi-square test of, 73, 467, 478

- Interaction variables, 271
- Intercept coefficient, 295
- Interclass correlation (ICC) coefficient, 348
- International Classification of Diseases (ICD)
 - codes, 24
 - use in case identification, 365
- International Classification of Diseases (ICD-9), 103–104, 106, 108, 109
- International Classification of Diseases (ICD-10), 106, 108–109
- Internet
 - data collection on, 2
 - patient reviews posted to, 82–83
 - of things, 2
- Interrelated variables, 493–494
- Interval scales, of healthcare access, 80
- Interval variables, 79, 87
- Intuition, 98, 152–153
- Inverse probability of treatment weighing (IPTW), 337–342
- IPTW. *See* Inverse probability of treatment weighing
- Item set, 403–404

- Jarque-Bera test of normality, 289
- Joint events, probability of, 464, 467
- Joint preferential independence condition, 437, 442

- Kaiser Permanente, 2
- Kaplan-Meier estimator, 377–378
 - k binary covariates, 385
 - k constant, 439, 442, 444
- k -fold cross-validation, 293
- Kolmogorov-Smirnov test of normality, 289

- Landmark time, 47–48
- LASSO regression. *See* Least absolute shrinkage and selection operator (LASSO) regression
- Law of large numbers, 142–144
- Lean, definition, 3

- Least absolute shrinkage and selection operator (LASSO) regression, 294–295, 399, 513–514, 518
- Leave-one-out cross-validation, 293
- Length of stay
 - case mix index, 83–84
 - casual network analysis, 494–496
 - clinician benchmarking, 413–416, 419–420
 - as continuous variable, 80
 - patient comorbidities effect, 413–416
- Levene's test, 152
- Likelihood ratios, 63
 - as association measurement, 110
 - conditional independence-based calculation, 64–66
 - contingency table-based, 69–71
 - definition, 68
 - of multimorbidity index, 102, 106–109
 - combination of diseases adjustment, 107
 - confounding, 111–112
 - detection applications, 110
 - diseases with no or complete mortality, 107–108
 - predictive applications, 110–111
 - rare diseases, 108
 - repeated diseases adjustments, 106–107
 - of zero value, 111
- Linear equations, 259–260
- Linear regression, 105
 - assumptions, 282–289
 - correctness of model form, 282–285
 - data transformations, 290–291, 292, 293
 - heteroscedasticity, 286–288
 - homoscedasticity, 286
 - independence of error terms, 285–286

- normally distributed errors, 288–289
- ordinary
 - logit transformation in, 315–317
 - R software for, 305–307
- Linear transformation, of variables, 87–90
- Link functions, 314
- Logarithm transformation, 290–291, 292, 293
- Logistic regression, 309–325
 - applications, 310–311
 - calculation, 313–315
 - case study, 312–315
 - coefficients, 320–321
 - hypothesis testing of, 321–322
 - estimation of parameters, 320–321
 - goodness of fit, 322–324
 - natural logarithm function, 313–314
 - propensity scoring with, 313–319, 331, 338, 339
 - R code, 318–319
 - SQL code, 315–316
- Logit function of π , 314
- Logit transformation, in ordinary regression, 315–317
- Log transformation
 - of cost data, 290–292
 - of skewed distribution, 97
- Longitudinal data, multilevel modeling of, 358
- Lung cancer prognosis, stratified regression analysis, 439–458
 - SQL codes, 447–450
 - strata, 452–458
- Main effect, 274–277
- Marital status, as categorical variable, 79
- Marketing
 - logistic regression use in, 311
 - matched case control use in, 362
- Markov blankets, 399, 401–403
- children, 492, 493, 496, 510
- co-parents, 492, 496, 510
- definition, 493
- parents, 492, 493, 496, 499–501, 510, 513–514
- Matched case control studies, 361–382
 - applications, 362–364
 - case definition, 364
 - controls definition, 364
 - enrollment period, 366
 - exposure to treatment measurement, 365–366
 - identification of cases, 364–365
 - matching controls to cases, 368–371
 - observation period, 366–368
 - outcomes analysis, 373–377
 - outcomes measurement, 371–373
 - overlap in, 378
 - person-time, 366, 377
 - time-to-event analysis, 377–378
 - verification of matching, 373
- Matching, adequate, 343
- Matrix format, of data merging, 12
- Maximum–minimum hill-climbing algorithm, 511
- Maximum values, 22
- Mean, 82
 - arithmetic, 82
 - sampling distribution, 141–144
 - weighted, 82–83
 - comparison of, 135–172
 - in propensity scoring, 331–332
 - dispersion of data around. *See* Standard deviation
 - of normal distribution, 137
 - population (μ), 82
 - sample (X), 82
- Median
 - fourth spread, 223–224, 226–227
 - of normal distribution, 137
 - Tukey’s control limits, 224, 226–227

- Medical centers, cancer survival rates, 355–358
- Medical errors
 - cumulative distribution function, 204
 - gradation, 206
 - hazard rate, 243–244
 - probability density function, 204, 205
 - time to, 204–205
 - Tukey’s charts of, 232–233
- Medical foster homes (MFHs)
 - case identification, 365
 - cost-of-care analysis, 264–271
 - logarithm transformation, 290–291, 292, 293
 - with single cost predictor, 266–271
 - definition, 264–265
 - matched case control study, 365–366
 - normal probability plots, 289
 - propensity scoring, 333–337
 - logistic regression analysis with, 313–319
- Medicare, 310
 - health maintenance organizations (HMOs), 311
- Medication errors, 43
 - conditional probabilities, 463–464, 465
 - EHR-related decrease, 3
- Medications
 - advertising of, 311
 - comparative effectiveness studies, 4
 - data analysis, 2
 - as diagnostic indicators, 42
 - EHR test fields for, 30
 - generic, 346
 - pharmacovigilance of, 488
 - postlaunch effectiveness of, 2
 - propensity scoring, 328
- Metformin, 42
- MFHs. *See* Medical foster homes
- Michigan Medicine, 328
- Microsoft Excel
 - Analysis ToolPak Histogram tool, 96–97
 - binomial probability distribution, 176, 177–178, 181
 - central limit theorem simulation, 142–143
 - contingency tables, 68–71
 - correlation calculations, 74–75, 475
 - histograms, 94–97
 - hypothesis testing, 183, 186, 187
 - law of large numbers simulation, 142–143
 - linear transformation of variables, 89–90
 - logarithm transformation with, 290, 292
 - median function, 226
 - pivot table feature, 69–71
 - regression analysis, 266–271, 300
 - scatter plots, 74, 260–262
- Microsoft SQL Server Management Studio, 21
- Minimum values, 22
- Missing data, 13, 41–42
- Mode, of normal distribution, 137
- Moffitt Cancer Center, Personalized Medicine Institute, 2
- Monotone relationships, 437
- Morbidity scales, 80. *See also* Multimorbidity (MM) index
- Mortality, as binary event, 80
- Mortality risk. *See also* Multimorbidity (MM) index
 - definition, 102
 - six-month, countable discrete levels of, 174
- Multicollinearity, 294–295
- Multilevel regression, 345–360
 - applications, 345–346
 - assumptions, 348
 - coefficient models, 347
 - corner cases, 355
 - examples, 349–354

- intercept regression, 347–348, 352–358
 - SQL code, 354–358
- interclass correlation (ICC) coefficient, 348
- of longitudinal data, 358
- macrolevel (practice level), 346–347, 348, 353–354
- measurement issues, 358–359
- microlevel (patient level), 346–347, 348, 349–353
- stratification in, 354–358
- Multimorbidity (MM) index
 - accuracy, 105, 112–118, 119
 - adjustment for ICD-10, 108–109
 - alternatives, 102–105, 117–118, 119
 - Bayes data mining model, 105–106, 111–112
 - comparison to other diagnosis-based indexes, 117–118, 119
 - comparison to physiological markers, 117, 118
 - cross-validation, 109–110
 - estimation of parameters, 106
 - example of use, 119, 120
 - likelihood ratios, 106–108, 111
 - combination of diseases adjustment, 107
 - confounding, 111–112
 - detection applications, 110
 - diseases with no or complete mortality, 107–108
 - multimorbidity score, 119
 - posterior odds, 119, 120
 - predictive applications, 110–111
 - rare diseases, 108
 - repeated diseases adjustments, 106–107
 - of zero value, 111
 - recommendations for improvement, 120–121
 - sample size, 109
 - sensitivity, 112–114
 - specificity, 112–114
 - SQL coding, 125–131
 - theoretical basis, 105–106
 - time interval calculations, 112
- Multiple regression, 266–271
 - causal networks as, 499–501
 - definition, 258
 - equations, 261
 - interaction effect, 274–277
 - main effect, 274–277
 - terminology, 491, 492–493
- Multiplication rule, 59–60
- Multivariate regression, 6, 9
 - independent variables in, 110
 - multilinearity, 476
 - terminology, 491, 492–493
- Mutual information, 477–478, 479
 - conditional, 478
- Mutually exclusive events, 189
- Myocardial infarction, length of stay, 413–416
- National Institute of Mental Health, 338–339
- Natural logarithm function, 313–314
- Near-miss events, logistic regression of, 310–311
- Network modeling, 487–488. *See also* Association networks; Causal networks
 - as extension of regression, 488
 - stratification in, 385
- Never events, 3
- Noise, random, 109
- Nonlinear equations, 260
 - transformation, 260–261
- Normal distribution, 90, 136–144
 - bell-shaped, 136, 137
 - in control charts, 152
 - definition, 136
 - examples, 136–139
 - properties, 136–137
 - standard, 138–139
 - examples, 139–140
- Normality assumption, 152

- Normal probability plots, 289
- Null hypothesis, 73, 144–145
 - alternative hypotheses, 144–145
 - confidence intervals, 150–151
 - critical value approach, 150
 - definition, 144
 - failure to reject, 146, 147–148
 - p*-value approach, 150
 - rejection, 146, 279
 - in matched case control studies, 373
 - statistical significance of, 149
- Null model, 481
- Null values, 21
- Numbers
 - conversion from text, 44–45
 - conversion to text, 31
- Nurse retention/turnover, 310, 345–346
- Nursing Home Compare website, 311
- Nursing homes, propensity scoring, 328–329, 333–337
- Obama, Barack, 250
- Observational data, propensity scoring, 327–344
- Observation per person, 52
- Observations
 - independence of, 52
 - over-time periods. *See* Tukey's charts
 - single, 223
 - weight of, 82
- Observed variables, in weighed regression, 294
- Odds
 - Bayes's formula, 62–66
 - of mortality, 112
 - posterior, 63, 65–66, 112
 - as ratios, 62–63
 - relationship to probability, 62
- Odds ratio
 - common, 386–389
 - confidence intervals, 188–189, 374–376
 - definition, 186
 - of mortality, 104–105
 - of observed outcomes, 373–377
 - in stratified covariate balancing, 386–389
- One-sample tests, 152
- One-sample *t* test, 148, 149
- One-sample *z* test, 147–148
- One-sided tests, 139
- Operating room fires
 - geometric distribution, 206
 - hazard rate, 242–243
- Order, of records, 36–38
- Ordinal variables, 79, 80
- Outcome
 - association with diagnosis, 110
 - causal relationship with treatment
 - back-door path, 507–510
 - numerical example, 503–506
 - probability prediction, 501–503
 - regression and, 497–501
 - control charts of, 98–99, 153
 - definition, 492
 - diagnosis after, 46
 - impact of treatment on, 48
 - in matched case control studies
 - analysis, 373–377
 - measurement, 371–373
 - multiple, 487–488. *See also* Causal networks
 - patient-reported, 43–44
 - predicted and actual, 323
 - therapeutic ranges, 371–373
 - trend analysis of, 98–99
 - variables for measurement of, 80
 - in Veterans Health Administration system, 3
- Outliers, detection of, 144
- Out-of-range data, 42
- Overfitting, of data, 281
- Overlap, case-control
 - in benchmarking, 416–418
 - in matched case control studies, 378
 - in propensity scoring, 343

- in stratified covariate balancing, 398–403
 - calculation, 398
 - definition, 398
 - Markov blanket of treatment, 399, 401–403
 - partial matches, 398–403
 - synthetic controls, 400
- Pain levels, patient-reported, 43–44
- Pain medications, 224–227
- Paired samples test, 151–152
- Paired *t*-test, 333, 373
- Parabola, equation for, 260
- Parametric distribution, 90
- Parents, of Markov blankets, 492, 493, 496, 499–501
- Path, definition, 492
- Patient-centered medical homes (PCMHs), 328
- Patient online review analysis, 82–83, 212–219, 221
- Patient satisfaction
 - network models of, 488–489
 - with nursing home care, 329
 - as ordinal variable, 80
 - patient online review analysis, 82–83, 212–219, 221
 - propensity scoring, 328, 329
 - stratified covariate balancing of, 387–389
 - X-bar control chart measurement, 158–162
- Patient tables, creation of, 17–21
- Paxil, 4
- Pay-for-performance schemes, propensity scoring of, 328–329
- PCMHs. *See* Patient-centered medical homes
- P (probability) control charts, 5, 189–194
 - control limits calculations, 190–194, 210
 - errors in display of, 194
 - lower control limits, 192–193, 194
 - observations per period, 236
 - observed rates, 193–194
 - risk-adjusted, 194–199, 201
 - expected deviance, 195, 197–199, 200
 - expected rate, 198, 199, 200
 - lower control limit, 195
 - t*-statistic, 198, 199
 - upper control limit, 195
 - upper control limits, 192–193, 194
 - x-y* plots, 190–191, 194
- Pearl, Judea, 507
- Pearl's collider test, 515
- Pearson correlation, 74
- Pharmacovigilance, 488
- Physician performance. *See* Benchmarking, of physician performance
- Physiological markers, as prognostic indicators, 117, 118
- Plots, 153
- Poisson distribution, 90
- Poisson regression, 258, 478–484
 - for association network construction, 481–484
 - response variables in, 480
- Population mean, one-sample *z* test of, 147–148
- Population of interest, 80–81
- Pravastatin, 4
- Prediction, causal, 501–506
- Predictive medicine
 - matched case controls of, 363
 - variables of, 281
- Predictive models
 - evaluation, 46
 - training-data set, 46
 - validation-data set, 46
- Predictors
 - discarding of, 45
 - in multimorbidity models, 110–112
 - obvious, 45
 - rare, 45
 - relationship to outcomes, 46
 - single cost, 266–271

- Presidential election (2016), 250, 252
 Price, Richard, 63
 Pricing violations, 209
 Probability, 55–62
 addition rule, 59, 60
 calculus of, 58–61
 causal network-based calculation, 501–506
 conditional, 61–62, 67–68
 Bayes's formula for, 62–66
 independence and, 64–66, 461, 464, 465, 514, 515
 joint probability-based calculation, 464–467
 marginal probability-based calculation, 466–467
 of death, 80
 decimal expression of, 56, 62
 definition, 56, 58, 461
 empirical, 56, 57
 expected values in, 84–85
 frequency distribution, 58
 graphical representation, 59–61
 of joint events, 464, 467
 marginal, 64–66, 466–467
 multiplication rule, 59–60
 odds-based calculations, 66
 posterior, 105
 predicted, comparison with events, 43–44
 random variations, 71–73
 relationship to odds, 62
 subjective or personal, 56, 57
 theoretical, 56–57
 Probability control charts. *See* P (probability) control charts
 Probability density functions, 241, 242–243
 Bernoulli, 205–207
 binomial, 205
 geometric, 205, 206–208
 Poisson, 205
 Probability functions, 57–58
 Probability networks, strata-conditioning and, 463
 Process control, 9
 Process improvement, matched case control use in, 362–363
 Productivity, of data-driven organizations, 1, 3
 Prognosis
 applications, 102
 definition, 80, 102
 in multiple morbidity. *See* Multiple morbidity index
 Propensity scoring, 7, 384, 410–411
 applications, 328–329
 comparison with stratified covariate balancing, 392–397
 data balancing in, 330–332
 double regression in, 338
 extreme weights in, 343
 interaction terms, 331
 inverse probability of treatment weighing (IPTW), 337–342
 logistic regression with, 313–319, 338–339
 of medical foster homes, 333–337
 with logistic regression analysis, 313–319
 overlap in, 343
 quintile matching, 332–333 343
 as a simulation, 329–331
 steps, 330–331
 verification of propensity scores, 342–343
 Propensity to participate in treatment, 329
 Provider networks, 489
 Provider tables, 19, 20–21
 Pseudo- R^2 , 323
 p -value, 149, 295
 p -value approach, 149, 150
 Q–Q plots, 283–285, 288, 289
 Quality control, 136
 matched case control use in, 362–363
 Quality improvement, 153
 Quality of care

- accountability for, 4
 - of data-driven organizations, 2–3
 - measures, 3
- Quality of life, multilevel modeling of, 346
- Quartiles, fourth spread, 223–224, 226
- Quintiles, in propensity score matching, 332–337, 343
- R (software)
 - anova function, 279–280
 - correlation calculations, 475
 - cost data log transformation, 290–291
 - definition, 300
 - downloading of, 300
 - errors in, 302
 - heteroscedasticity, 287
 - linear Poisson distribution models, 481–485
 - logit transformation, 318–319
 - propensity score matching, 333–336
 - regression analysis tools, 300–307
 - Shapiro-Wilk test of normality, 289
 - stratified covariate balancing, 406
 - weighted propensity scoring, 339–343
 - weighted regression performance, 294
- R^2 coefficient, 277–278, 281
- Race, as variable
 - as categorical variable, 79
 - countable discrete levels, 174
- Randomization, for removal of confounding, 384
- Random noise, 109
- Random sampling, 81
- Random seed values, 110
- Rank order functions, 36–38
- Rare events. *See also* Sentinel events analysis
 - geometric distribution-based probability, 208
- Rates, comparison of, 173–201
 - Bernoulli distribution, 175–179
 - binomial probability distribution, 175–179
 - comparison of two rates, 183–186
 - confidence interval for odds ratio, 186–189
 - discrete variables summarization, 174–175
 - inference for a single rate, 183–186
 - normal approximation, 179–181
 - p- (probability) control charts, 189–201
 - control limits calculations, 190–194
 - errors in display of, 194
 - lower control limits, 192–193, 194
 - observed rates, 193–194
 - risk-adjusted, 194–199, 201
 - upper control limits, 192–193, 194
 - x - y plots, 190–191, 194
 - statistical significance, 181–183
- Ratios, odds as, 62–63
- Readmission
 - effect of hospice care on, 48–52, 466–467
 - rates, 4
- Reasoning, causal, 515
- Receiver operating curve (ROC), 114, 323
- Regression, 255–307. *See also* Multiple regression; Multivariate regression; Stratified regression applications, 256–258
 - cause-or-effect interpretation, 296–297
 - collinearity effects, 291–292
 - confounding in, 498
 - Cox’s hazards, 258
 - cross-validation of, 292–293
 - definition, 256, 261
 - error terms

- Regression (*continued*)
- heteroscedasticity of, 286–287
 - homoscedasticity of, 286
 - normal distribution of, 288–289
 - Excel use, 266–271
 - forward, 280–281
 - hierarchical, 280–281
 - logistic, 258
 - model building, 280–281
 - multicollinearity of, 294–295
 - ordinary/standard, 258
 - log transformation in, 315–317
 - parameters
 - effect of interaction terms on, 276
 - estimation, 295
 - tests of, 255
 - for prognostic predictive models, 102
 - relationship between causal networks, 497–501
 - residuals, 262–264
 - autocorrelation, 285–286, 287
 - diagnostic plots, 282–283
 - squared, 264
 - tests of parameters of, 256
 - types, 258
 - weighted, 294, 337–343
- Regression coefficients, 262
- collinearity and, 291–292
 - in cost data evaluation, 268–270
 - definition, 262
 - in hypothesis testing, 295–296
 - interaction terms and, 276–277
 - multiple variables and, 428–429
 - stratified covariate balancing, 427–428
 - in stratified regression, 427–458
 - impact of correction factors, 434–435
 - impact of independent variables, 433–434
 - stratified regression equation, 436
 - unconfounded impact, 427–458
 - units of measurement, 296
- Regression equations, 256–258, 259–264
- multilinear form, 429
 - network representation, 497, 498
- Repeated measures test, 151–152
- Resampling, 390–391
- Reserved words, 22
- Residuals, 262–264
- autocorrelation, 285–286, 287
 - diagnostic plots, 282–283
 - squared, 264
- Restricted maximization algorithm, 511
- Rise, definition, 259
- Risk adjustment, of control charts, 194–199, 201
- Risk assessment, 8–9
- with binary data, 203–204
 - of health insurance companies, 3
 - of mortality. *See also* Multimorbidity (MM) index
 - differential point systems, 103–104
 - selective methods, 104
- ROC. *See* Receiver operating curve
- Rosenbaum, Paul R., 329–330, 384
- Rubin, Donald B., 245, 329–330, 384
- Run, definition, 259
- Samples and sampling
- adaptive, 81
 - complete, 81
 - convenience, 81
 - not representative, 82–83
 - random, 81
 - representative, 80–81
- Sample size, 466
- distribution of mean and, 141–144
 - in sentinel event analysis, 203
- Scatter plots, 73–74
- creation with Excel, 260–262

- creation with R, 304–305
- Seed values, 110
- Sentinel events analysis, 203–222
 - Bernoulli distribution function, 205–209
 - cumulative distribution function, 204
 - days to event, 208–209
 - expected value, 204–205
 - geometric distribution function, 206–209
 - probability density function, 204
 - with time-between control charts, 209–212
 - exercise resolution example, 219–220
 - patient reviews example, 212–219, 221
- Severity of illness, 80, 102
- Shapiro-Wilk test of normality, 289
- Shewart, Walter A., 156
- Shewart charts, 156
- Significance, statistical, 149
- Simdata, 294
- Skewed distribution
 - binomial probability distribution, 179
 - log transformation, 97
 - Tukey's chart sensitivity to, 236–237
- Slope
 - calculation of, 259–260
 - definition, 259
- Slope coefficient, 295
- Southeast Alabama Medical Center, 225–227
- SQL (Structured query language)
 - definition, 14
 - versions of, 14
 - web-based searching of, 14
- SQL (Structured query language)
 - codes, commands, and functions, 6, 8–9, 11–53
 - BY, 13
 - FROM, 16–17
 - INTO, 39–40
 - BETWEEN, 42
 - for benchmarking, 422–424
 - CAST, 44–45
 - CONCAT, 30–31
 - for conditional probability calculations, 462–463
 - CONVERT, 35–36, 44–45
 - CREATE TABLE, 17–21
 - data control language, 14
 - data definition language, 14
 - data functions, 33–36
 - data manipulation functions, 32–33
 - data manipulation portion, 14
 - data merging function, 5–6, 12
 - DATEADD, 33–34
 - DATEDIFF, 33, 34–35
 - DATEPART, 33, 34
 - FROM dbo.data, 16
 - referencing temporary tables, 16–17
 - for deletion of erroneous data, 38–45
 - GETDATE, 33
 - GROUP, 13
 - GROUP BY, 22–23, 24, 37, 38
 - HAVING, 24–25, 39
 - IIF manipulation functions, 33
 - INSERT VALUE, 17, 21–23
 - for intercept regression modeling, 353–358
 - JOIN, 13
 - for joining of tables, 25–29
 - full join, 25, 28–29
 - inner join, 25–27
 - join statements, 26–27
 - left or right join, 25, 27–28
 - no join (cross join), 25, 29
 - for logit transformation, 315–316
 - manipulation functions, 13
 - Microsoft SQL Server Management Studio, 21

SQL (*continued*)

- for multimorbidity index, 106, 125–131
 - ICD-9-based, 106, 108, 109
 - ICD-10-based, 106, 108–109
 - likelihood ratio calculations, 106, 107–108, 111
 - sensitivity and specificity measures, 112–114
- for mutual information calculation, 479
- NULL VALUES, 21
- ORDER BY, 22, 38
- for prognostic predictive models, 102
- random seed values, 110
- RANK, 36–38
- RANK_DENSE, 36–38
- rank order functions, 36–38
- risk measurement, 195
- SELECT, 13, 15–23
 - field name deletion with, 16
 - purpose, 15
 - reserve words, 15
 - TOP 20* FROM #temp, 16–17
- SELECT ID, 39–40
- standardized functions, 14
- for stratified covariate balancing, 395–397, 403–406
- for stratified regression, 439
 - confounded impact of variables, 433–434
 - correction factor estimation, 434–435, 446
 - k constant, 439, 450
- STUFF, 32–33
- text functions, 30–33
- time to pain medication, 225–227
- USE Database 1, 16
- WHEN, 13
- WHERE, 22, 23–25, 37, 39–40, 47
- Square root transformation, 290
- Squiggly symbol, 387

SSE. *See* Sum of squares of errorsSST. *See* Sum of squares total

Standard deviation

calculation, 86–87

definition, 85–87

weighted, 87

Standardized normal distributions, 5

Statistical analysis, steps in, 78

Statistical process control, 3, 5

Statistical significance, 145, 149

Stock market prices, causal control

chart analysis, 250, 252

Straight line equation, 259–260

Strata/stratum, definition, 355, 386

Strategic planning, matched case control use in, 362

Strategy, logistic regression analysis of, 311

Stratification, 81

in control chart construction, 245

definition, 386, 492, 493

history, 385

in multilevel modeling, 354–358

in network modeling, 385

relationship to conditioning, 463–464

as subgroup analysis, 386

Stratified covariate balancing, 383–407, 463

in benchmarking, 409, 411

case-control overlap, 398–403

calculation, 398

definition, 398

Markov blanket of treatment, 399, 401–403

partial matches, 398–403

synthetic controls, 400

of causal networks, 517

comparison with propensity scoring, 392–397

of continuous outcomes

difference models, 389–390

weighted data, 390–392, 393–395

definition, 384

- examples, 392–395, 392–397
- of patient satisfaction, 387–389
- in propensity scoring, 332
- SQL code, 403–406
- SQL codes, 395–397
- Stratified regression, 427–458
 - multilinear form, 429–430
 - calculation of parameters, 430–436
 - comparison with multiplicative form, 436–437
 - correction factors, 429–430, 434–435
 - definition, 429
 - example, 430–436
 - impact of independent variables, 434–436
 - multiplicative form, 446–447
 - case and control strata, 438–440
 - comparison with multilinear form, 436–437
 - corner stratum, 437–440, 442
 - correction factors, 446
 - estimation of parameters, 437–439, 447–450
 - examples (health insurance cost), 430–436, 441–450
 - examples (lung cancer prognosis), 439–458
 - joint preferential independence condition, 437, 442
 - k constant, 439, 442, 444
 - SQL (lung cancer prognosis), 447–450, 452–458
- Structured query language. *See* SQL (structured query language)
- Student's t -distribution, 148, 236
 - with four degrees of freedom, 236
 - for mortality risk, 195, 199
 - tables, 195
 - for treatment effects, 390
- Study design, 6, 48–51
 - case-control design, 48, 49, 51, 52
 - cohort design, 48–51, 52
 - observation per person, 52
 - unit of analysis, 52
- Sturges formula, 92–93
- Subsets, selection of, 23–25
- Substrings, 30
- Suicide risk model, 490
- Sum of squares, R anova function, 279–280
- Sum of squares of errors (SSE), 279
- Sum of squares total (SST), 278–279
- Surgery
 - robotic, propensity scoring of, 328
 - wrong-side, 203, 208, 250
- Survival function, 242–243
- Switching distribution, 410, 411–413
- Synthetic controls, 410, 416, 418–420, 421
- Synthetic minority oversampling technique, 416, 418
- Tables, of EHRs
 - encounter, 19–21
 - foreign keys, 15
 - joining of, 25–29
 - full join, 25, 28–29
 - inner join, 25–27
 - join statements, 26–27
 - left or right join, 25, 27–28
 - no join (cross join), 25, 29
 - multiple, 5–6, 12
 - patient, 17–21
 - patient fields, 15
 - primary key, 15
 - provider, 19, 20–21
 - relationships among, 15, 20–21
- Taboo algorithm, 511
- Tercero-Gomez, Victor, 236–237
- Tertiary care centers, survival rate analysis, 349–354
- Text, conversion to dates, 35–36
- Text fields, combing of, 30–31
- Text processing, 2
- Therapeutic ranges, of outcomes, 371–373

- Tilde symbol, 387
 - Time periods, for observations, 223–227
 - Time-stamped data, 47–51
 - Time to pain medication (OP_21) measure, 224–227
 - Training-data set, 46
 - Treatment, definition, 491, 492
 - Treatment impact on outcome
 - back-door path, 507–510
 - blocked, 493, 509–510, 517
 - covariates, 507, 508–509
 - definition, 491, 493
 - stratified covariate balancing
 - binary outcomes, 386–389
 - continuous outcomes, 389–395
 - difference models, 389–390
 - weighted data, 390–392, 393–395
 - Treatment participation. *See* Propensity scoring
 - Trend line regression, 260–262
 - Trump, Donald, 250, 252
 - t*-statistic, 148, 295, 373, 390
 - t*-tests, 152
 - t*-tests
 - one-sample, 148, 149
 - paired, 333, 373
 - Tukey, John, 223–224
 - Tukey's control charts, 210, 223–228
 - comparison with other charts, 236–237
 - confidence interval limits, 223–224
 - control limits calculations
 - with fourth spread, 224, 226
 - lower control limits, 224, 231, 233, 234, 235, 236
 - with post-intervention period data, 229, 230
 - with pre-intervention period data, 229, 230, 231
 - tightness of, 229
 - upper control limits, 224, 226, 229, 230, 231, 233, 234, 236
 - without post-intervention period data, 232–233, 234
 - without pre-intervention period data, 232–233, 234, 235
 - examples
 - budget variations, 233–235
 - exercise time/weight control, 227–232
 - medical errors, 232–233
 - time to pain medication, 224–227
 - fourth spread calculations, 223–224, 226, 229, 230–231, 232–233
 - gamma distribution sensitivity, 236–237
 - observed to expected values comparison, 233–235
 - reference point, 234
- Two-sided tests, 139
 - Type I errors, 145, 146
 - Type II errors, 145, 146–147
- Uniform distribution, 90
 - US Department of Veterans Affairs
 - cancer comorbidities analysis, 518–519
 - eating disabilities–mortality analyses
 - causal analysis, 507–509, 520, 522
 - stratified covariate balancing, 392–395
 - patient outcomes, 3
 - performance measurement in, 3
 - progression of disabilities analysis, 511–512
 - suicide risk model, 490

- Veterans Affairs Informatics and Computing Infrastructure (VINCI), 2
- US Food and Drug Administration (FDA), 2
- Unit of analysis, 52
- Units of measurement, 296
- Univariate data analysis, 78
- Univariate methods of inference, 6
- Universe of possibilities, 461–463, 461–464, 466, 467
- University of California, medical centers' database, 2
- Validation-data set, 46, 293
- Value-based reimbursement, 4, 186, 188
 - propensity scoring of, 329
- Values, expected, 83–85
- Variable character data type, 35
- Variables. *See also* Binary variables; Dependent variables; Discrete variables; Independent variables
 - association of, 7
 - constant, 78
 - contingency table–based relationships, 66–71
 - correlation between, 74–75
 - counterfactual effects of, 7
 - definition, 78
 - dummy, 69, 271
 - examples, 78
 - expected values, 83–85
 - fluctuations of, 135–136
 - forward stepwise selection, 281
 - interval, 79, 87
 - levels of, 78–80
 - probability of observation, 90–92
 - linear transformation of, 87–90
 - mechanism of, 7
 - multicollinearity, 294–295
 - from multiple tables, 12
 - new, calculation of value, 30–33
 - nominal, 80
 - optimal class interval size, 92–93, 94
 - ordinal, 79, 80
 - ratio, 79–80, 87
 - restriction of number of, 294–295
 - sequence of, 7, 514–516
 - standard deviation of, 85–87
 - values over time, 98–99
 - X, 81
- Variance, 86, 87
 - of sum, 88
- Variation
 - random, 244
 - with special or assignable causes, 244
- Veterans Affairs Informatics and Computing Infrastructure (VINCI), 2, 441
- Veterans Health Administration. *See* US Department of Veterans Affairs
- Wald test, 320–321
- Weighted covariates, 390–392, 393–395
- Weight loss, Tukey's charts of, 228–232
- White test, 288
- Wilcoxon signed-rank test, 373
- X^2 test, 145
- X-bar control charts, 152, 153, 158–171
 - assumptions of, 160–161
 - comparison with Tukey's charts, 236
 - distribution of findings, 171
 - example, 158–162
 - lower control limit, 159–162, 168, 170
 - risk-adjusted, 162–171
 - upper control limit, 159–162, 168, 170–171

- XmR control charts, 152, 153, 156–158, 210
 - comparison with Tukey’s charts, 236–237
 - lower control limit, 158
 - outliers, 236
- Shewart charts, 156
 - upper control limit, 157–158
- z statistic, 148
- z tests, 147–148, 152
 - one-sample, 147–148