Appendix

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Table A.1 Standard Normal Distribution

Let Z be a normal random variable with mean zero and variance 1. For selected values of Z, three values are tabled: (1) the two-sided p-value, or $P[|Z| \geq z]$; (2) the one-sided p-value, or $P[Z \geq z]$; and (3) the cumulative distribution function at Z, or $P[Z \leq z]$.

z	Two-sided	One-sided	Cum-dist.	z	Two-sided	One-sided	Cum-dist.	z	Two-sided	One-sided	Cum-dist.
0.00	1.0000	.5000	.5000	1.30	.1936	.0968	.9032	1.80	.0719	.0359	.9641
0.05	.9601	.4801	.5199	1.31	.1902	.0951	.9049	1.81	.0703	.0351	.9649
0.10	.9203	.4602	.5398	1.32	.1868	.0934	.9066	1.82	.0688	.0344	.9656
0.15	.8808	.4404	.5596	1.33	.1835	.0918	.9082	1.83	.0673	.0336	.9664
0.20	.8415	.4207	.5793	1.34	.1802	.0901	.9099	1.84	.0658	.0329	.9671
0.25	.8026	.4013	.5987	1.35	.1770	.0885	.9115	1.85	.0643	.0322	.9678
0.30	.7642	.3821	.6179	1.36	.1738	.0869	.9131	1.86	.0629	.0314	.9686
0.35	.7263	.3632	.6368	1.37	.1707	.0853	.9147	1.87	.0615	.0307	.9693
0.40	.6892	.3446	.6554	1.38	.1676	.0838	.9162	1.88	.0601	.0301	.9699
0.45	.6527	.3264	.6736	1.39	.1645	.0823	.9177	1.89	.0588	.0294	.9706
0.50	.6171	.3085	.6915	1.40	.1615	.0808	.9192	1.90	.0574	.0287	.9713
0.55	.5823	.2912	.7088	1.41	.1585	.0793	.9207	1.91	.0561	.0281	.9719
0.60	.5485	.2743	.7257	1.42	.1556	.0778	.9222	1.92	.0549	.0274	.9726
0.65	.5157	.2578	.7422	1.43	.1527	.0764	.9236	1.93	.0536	.0268	.9732
0.70	.4839	.2420	.7580	1.44	.1499	.0749	.9251	1.94	.0524	.0262	.9738
0.75	.4533	.2266	.7734	1.45	.1471	.0735	.9265	1.95	.0512	.0256	.9744
0.80	.4237	.2119	.7881	1.46	.1443	.0721	.9279	1.96	.0500	.0250	.9750
0.85	.3953	.1977	.8023	1.47	.1416	.0708	.9292	1.97	.0488	.0244	.9756
0.90	.3681	.1841	.8159	1.48	.1389	.0694	.9306	1.98	.0477	.0239	.9761
0.95	.3421	.1711	.8289	1.49	.1362	.0681	.9319	1.99	.0466	.0233	.9767
1.00	.3173	.1587	.8413	1.50	.1336	.0668	.9332	2.00	.0455	.0228	.9772
1.01	.3125	.1562	.8438	1.51	.1310	.0655	.9345	2.01	.0444	.0222	.9778
1.02	.3077	.1539	.8461	1.52	.1285	.0643	.9357	2.02	.0434	.0217	.9783
1.03	.3030	.1515	.8485	1.53	.1260	.0630	.9370	2.03	.0424	.0212	.9788
1.04	.2983	.1492	.8508	1.54	.1236	.0618	.9382	2.04	.0414	.0207	.9793
1.05	.2937	.1469	.8531	1.55	.1211	.0606	.9394	2.05	.0404	.0202	.9798
1.06	.2891	.1446	.8554	1.56	.1188	.0594	.9406	2.06	.0394	.0197	.9803
1.07	.2846	.1423	.8577	1.57	.1164	.0582	.9418	2.07	.0385	.0192	.9808
1.08	.2801	.1401	.8599	1.58	.1141	.0571	.9429	2.08	.0375	.0188	.9812
1.09	.2757	.1379	.8621	1.59	.1118	.0559	.9441	2.09	.0366	.0183	.9817
1.10	.2713	.1357	.8643	1.60	.1096	.0548	.9452	2.10	.0357	.0179	.9821
1.11	.2670	.1335	.8665	1.61	.1074	.0537	.9463	2.11	.0349	.0174	.9826
1.12	.2627	.1314	.8686	1.62	.1052	.0526	.9474	2.12	.0340	.0170	.9830
1.13	.2585	.1292	.8708	1.63	.1031	.0516	.9484	2.13	.0332	.0166	.9834
1.14	.2543	.1271	.8729	1.64	.1010	.0505	.9495	2.14	.0324	.0162	.9838
1.15	.2501	.1251	.8749	1.65	.0989	.0495	.9505	2.15	.0316	.0158	.9842
1.16	.2460	.1230	.8770	1.66	.0969	.0485	.9515	2.16	.0308	.0154	.9846
1.17	.2420	.1210	.8790	1.67	.0949	.0475	.9525	2.17	.0300	.0150	.9850
1.18	.2380	.1190	.8810	1.68	.0930	.0465	.9535	2.18	.0293	.0146	.9854
1.19	.2340	.1170	.8830	1.69	.0910	.0455	.9545	2.19	.0285	.0143	.9857
1.20	.2301	.1151	.8849	1.70	.0891	.0446	.9554	2.20	.0278	.0139	.9861
1.21	.2263	.1131	.8869	1.71	.0873	.0436	.9564	2.21	.0271	.0136	.9864
1.22	.2225	.1112	.8888	1.72	.0854	.0427	.9573	2.22	.0264	.0132	.9868
1.23	.2187	.1093	.8907	1.73	.0836	.0418	.9582	2.23	.0257	.0129	.9871
1.24	.2150	.1075	.8925	1.74	.0819	.0409	.9591	2.24	.0251	.0125	.9875
1.25	.2113	.1056	.8944	1.75	.0801	.0401	.9599	2.25	.0244	.0122	.9878
1.26	.2077	.1038	.8962	1.76	.0784	.0392	.9608	2.26	.0238	.0119	.9881
1.27	.2041	.1020	.8980	1.77	.0767	.0384	.9616	2.27	.0232	.0116	.9884
1.28	.2005	.1003	.8997	1.78	.0751	.0375	.9625	2.28	.0226	.0113	.9887
1.29	.1971	.0985	.9015	1.79	.0735	.0367	.9633	2.29	.0220	.0110	.9890

Table A.1 (***continued***)

z	Two-sided	One-sided	Cum-dist.	z	Two-sided	One-sided	Cum-dist.	z	Two-sided	One-sided	Cum-dist.
2.30	.0214	.0107	.9893	2.80	.0051	.0026	.9974	3.30	.0010	.0005	.9995
2.31	.0209	.0104	.9896	2.81	.0050	.0025	.9975	3.31	.0009	.0005	.9995
2.32	.0203	.0102	.9898	2.82	.0048	.0024	.9976	3.32	.0009	.0005	.9995
2.33	.0198	.0099	.9901	2.83	.0047	.0023	.9977	3.33	.0009	.0004	.9996
2.34	.0193	.0096	.9904	2.84	.0045	.0023	.9977	3.34	.0008	.0004	.9996
2.35	.0188	.0094	.9906	2.85	.0044	.0022	.9978	3.35	.0008	.0004	.9996
2.36	.0183	.0091	.9909	2.86	.0042	.0021	.9979	3.36	.0008	.0004	.9996
2.37	.0178	.0089	.9911	2.87	.0041	.0021	.9979	3.37	.0008	.0004	.9996
2.38	.0173	.0087	.9913	2.88	.0040	.0020	.9980	3.38	.0007	.0004	.9996
2.39	.0168	.0084	.9916	2.89	.0039	.0019	.9981	3.39	.0007	.0003	.9997
2.40	.0164	.0082	.9918	2.90	.0037	.0019	.9981	3.40	.0007	.0003	.9997
2.41	.0160	.0080	.9920	2.91	.0036	.0018	.9982	3.41	.0006	.0003	.9997
2.42	.0155	.0078	.9922	2.92	.0035	.0018	.9982	3.42	.0006	.0003	.9997
2.43	.0151	.0075	.9925	2.93	.0034	.0017	.9983	3.43	.0006	.0003	.9997
2.44	.0147	.0073	.9927	2.94	.0033	.0016	.9984	3.44	.0006	.0003	.9997
2.45	.0143	.0071	.9929	2.95	.0032	.0016	.9984	3.45	.0006	.0003	.9997
2.46	.0139	.0069	.9931	2.96	.0031	.0015	.9985	3.46	.0005	.0003	.9997
2.47	.0135	.0068	.9932	2.97	.0030	.0015	.9985	3.47	.0005	.0003	.9997
2.48	.0131	.0066	.9934	2.98	.0029	.0014	.9986	3.48	.0005	.0003	.9997
2.49	.0128	.0064	.9936	2.99	.0028	.0014	.9986	3.49	.0005	.0002	.9998
2.50	.0124	.0062	.9938	3.00	.0027	.0013	.9987	3.50	.0005	.0002	.9998
2.51	.0121	.0060	.9940	3.01	.0026	.0013	.9987	3.51	.0004	.0002	.9998
2.52	.0117	.0059	.9941	3.02	.0025	.0013	.9987	3.52	.0004	.0002	.9998
2.53	.0114	.0057	.9943	3.03	.0024	.0012	.9988	3.53	.0004	.0002	.9998
2.54	.0111	.0055	.9945	3.04	.0024	.0012	.9988	3.54	.0004	.0002	.9998
2.55	.0108	.0054	.9946	3.05	.0023	.0011	.9989	3.55	.0004	.0002	.9998
2.56	.0105	.0052	.9948	3.06	.0022	.0011	.9989	3.56	.0004	.0002	.9998
2.57	.0102	.0051	.9949	3.07	.0021	.0011	.9989	3.57	.0004	.0002	.9998
2.58	.0099	.0049	.9951	3.08	.0021	.0010	.9990	3.58	.0003	.0002	.9998
2.59	.0096	.0048	.9952	3.09	.0020	.0010	.9990	3.59	.0003	.0002	.9998
2.60	.0093	.0047	.9953	3.10	.0019	.0010	.9990	3.60	.0003	.0002	.9998
2.61	.0091	.0045	.9955	3.11	.0019	.0009	.9991	3.61	.0003	.0002	.9998
2.62	.0088	.0044	.9956	3.12	.0018	.0009	.9991	3.62	.0003	.0001	.9999
2.63	.0085	.0043	.9957	3.13	.0017	.0009	.9991	3.63	.0003	.0001	.9999
2.64	.0083	.0041	.9959	3.14	.0017	.0008	.9992	3.64	.0003	.0001	.9999
2.65	.0080	.0040	.9960	3.15	.0016	.0008	.9992	3.65	.0003	.0001	.9999
2.66	.0078	.0039	.9961	3.16	.0016	.0008	.9992	3.66	.0003	.0001	.9999
2.67	.0076	.0038	.9962	3.17	.0015	.0008	.9992	3.67	.0002	.0001	.9999
2.68	.0074	.0037	.9963	3.18	.0015	.0007	.9993	3.68	.0002	.0001	.9999
2.69	.0071	.0036	.9964	3.19	.0014	.0007	.9993	3.69	.0002	.0001	.9999
2.70	.0069	.0035	.9965	3.20	.0014	.0007	.9993	3.70	.0002	.0001	.9999
2.71	.0067	.0034	.9966	3.21	.0013	.0007	.9993	3.71	.0002	.0001	.9999
2.72	.0065	.0033	.9967	3.22	.0013	.0006	.9994	3.72	.0002	.0001	.9999
2.73	.0063	.0032	.9968	3.23	.0012	.0006	.9994	3.73	.0002	.0001	.9999
2.74	.0061	.0031	.9969	3.24	.0012	.0006	.9994	3.74	.0002	.0001	.9999
2.75	.0060	.0030	.9970	3.25	.0012	.0006	.9994	3.75	.0002	.0001	.9999
2.76	.0058	.0029	.9971	3.26	.0011	.0006	.9994	3.76	.0002	.0001	.9999
2.77	.0056	.0028	.9972	3.27	.0011	.0005	.9995	3.77	.0002	.0001	.9999
2.78	.0054	.0027	.9973	3.28	.0010	.0005	.9995	3.78	.0002	.0001	.9999
2.79	.0053	.0026	.9974	3.29	.0010	.0005	.9995	3.79	.0002	.0001	.9999

Table A.2 Critical Values (Percentiles) for the Standard Normal Distribution
The fourth column is the $N(0, 1)$ percentile for the percent given in column one. It is also the upper one-sided $N(0, 1)$ critical value and two-sided $N(0, 1)$ critical value for the significance levels given in columns two and three, respectively.

Percent	One-sided	Two-sided	z	Percent	One-sided	Two-sided	z
50	.50	1.00	0.00	99.59	.0041	.0082	2.64
55	.45	.90	0.13	99.60	.0040	.0080	2.65
60	.40	.80	0.25	99.61	.0039	.0078	2.66
65	.35	.70	0.39	99.62	.0038	.0076	2.67
70	.30	.60	0.52	99.63	.0037	.0074	2.68
75	.25	.50	0.67	99.64	.0036	.0072	2.69
80	.20	.40	0.84	99.65	.0035	.0070	2.70
85	.15	.30	1.04	99.66	.0034	.0068	2.71
90	.10	.20	1.28	99.67	.0033	.0066	2.72
91	.09	.18	1.34	99.68	.0032	.0064	2.73
92	.08	.16	1.41	99.69	.0031	.0062	2.74
93	.07	.14	1.48	99.70	.0030	.0060	2.75
94	.06	.12	1.55	99.71	.0029	.0058	2.76
95	.05	.10	1.64	99.72	.0028	.0056	2.77
95.5	.045	.090	1.70	99.73	.0027	.0054	2.78
96.0	.040	.080	1.75	99.74	.0026	.0052	2.79
96.5	.035	.070	1.81	99.75	.0025	.0050	2.81
97.0	.030	.060	1.88	99.76	.0024	.0048	2.82
97.5	.025	.050	1.96	99.77	.0023	.0046	2.83
98.0	.020	.040	2.05	99.78	.0022	.0044	2.85
98.5	.015	.030	2.17	99.79	.0021	.0042	2.86
99.0	.010	.020	2.33	99.80	.0020	.0040	2.88
99.05	.0095	.0190	2.35	99.81	.0019	.0038	2.89
99.10	.0090	.0180	2.37	99.82	.0018	.0036	2.91
99.15	.0085	.0170	2.39	99.83	.0017	.0034	2.93
99.20	.0080	.0160	2.41	99.84	.0016	.0032	2.95
99.25	.0075	.0150	2.43	99.85	.0015	.0030	2.97
99.30	.0070	.0140	2.46	99.86	.0014	.0028	2.99
99.35	.0065	.0130	2.48	99.87	.0013	.0026	3.01
99.40	.0060	.0120	2.51	99.88	.0012	.0024	3.04
99.45	.0055	.0110	2.54	99.89	.0011	.0022	3.06
99.50	.0050	.0100	2.58	99.90	.0010	.0020	3.09
99.51	.0049	.0098	2.58	99.91	.0009	.0018	3.12
99.52	.0048	.0096	2.59	99.92	.0008	.0016	3.16
99.53	.0047	.0094	2.60	99.93	.0007	.0014	3.19
99.54	.0046	.0092	2.60	99.94	.0006	.0012	3.24
99.55	.0045	.0090	2.61	99.95	.0005	.0010	3.29
99.56	.0044	.0088	2.62	99.96	.0004	.0008	3.35
99.57	.0043	.0086	2.63	99.97	.0003	.0006	3.43
99.58	.0042	.0084	2.64	99.98	.0002	.0004	3.54
				99.99	.0001	.0002	3.72

Table A.3 Critical Values (Percentiles) for the Chi-Square Distribution

For each degree of freedom (d.f.) in the first column, the table entries are the critical values for the upper one-sided significance levels in the column headings or, equivalently, the percentiles for the corresponding percentages.

	Percentage								
	2.5	5	50	75	90	95	97.5	99	99.9
	Upper One-Sided α								
d.f.	.975	.95	.50	.25	.10	.05	.025	.01	.001
1	.001	.004	.455	1.32	2.71	3.84	5.02	6.63	10.83
2	.051	.103	1.39	2.77	4.61	5.99	7.38	9.21	13.82
3	.216	.352	2.37	4.11	6.25	7.82	9.35	11.34	16.27
4	.484	.711	3.36	5.39	7.78	9.49	11.14	13.28	18.47
5	.831	1.15	4.35	6.63	9.24	11.07	12.83	15.09	20.52
6	1.24	1.64	5.35	7.84	10.64	12.59	14.45	16.81	22.46
7	1.69	2.17	6.35	9.04	12.02	14.07	16.01	18.47	24.32
8	2.18	2.73	7.34	10.22	13.36	15.51	17.53	20.09	26.12
9	2.70	3.33	8.34	11.39	14.68	16.92	19.02	21.67	27.88
10	3.25	3.94	9.34	12.55	15.99	18.31	20.48	23.21	29.59
11	3.82	4.57	10.34	13.70	17.27	19.68	21.92	24.72	31.26
12	4.40	5.23	11.34	14.85	18.55	21.03	23.34	26.22	32.91
13	5.01	5.89	12.34	15.98	19.81	22.36	24.74	27.69	34.53
14	5.63	6.57	13.34	17.12	21.06	23.68	26.12	29.14	36.12
15	6.26	7.26	14.34	18.25	22.31	25.00	27.49	30.58	37.70
16	6.91	7.96	15.34	19.37	23.54	26.30	28.85	32.00	39.25
17	7.56	8.67	16.34	20.49	24.77	27.59	30.19	33.41	40.79
18	8.23	9.39	17.34	21.60	25.99	28.87	31.53	34.81	42.31
19	8.91	10.12	18.34	22.72	27.20	30.14	32.85	36.19	43.82
20	9.59	10.85	19.34	23.83	28.41	31.41	34.17	37.57	45.31
21	10.28	11.59	20.34	24.93	29.62	32.67	35.48	38.93	46.80
22	10.98	12.34	21.34	26.04	30.81	33.92	36.78	40.29	48.27
23	11.69	13.09	22.34	27.14	32.01	35.17	38.08	41.64	49.73
24	12.40	13.85	23.34	28.24	33.20	36.42	39.36	42.98	51.18
25	13.12	14.61	24.34	29.34	34.38	37.65	40.65	44.31	52.62
26	13.84	15.38	25.34	30.43	35.56	38.89	41.92	45.64	54.05
27	14.57	16.15	26.34	31.53	36.74	40.11	43.19	46.96	55.48
28	15.31	16.93	27.34	32.62	37.92	41.34	44.46	48.28	56.89
29	16.05	17.71	28.34	33.71	39.09	42.56	45.72	49.59	58.30
30	16.79	18.49	29.34	34.80	40.26	43.77	46.98	50.89	59.70
35	20.57	22.47	34.34	40.22	46.06	49.80	53.20	57.34	66.62
40	24.43	26.51	39.34	45.62	51.81	55.76	59.34	63.69	73.40
45	28.37	30.61	44.34	50.98	57.51	61.66	65.41	69.96	80.08
50	32.36	34.76	49.33	56.33	63.17	67.50	71.42	76.15	86.66
55	36.40	38.96	54.33	61.66	68.80	73.31	77.38	82.29	93.17
60	40.48	43.19	59.33	66.98	74.40	79.08	83.30	88.38	99.61
65	44.60	47.45	64.33	72.28	79.97	84.82	89.18	94.42	105.99
70	48.76	51.74	69.33	77.58	85.53	90.53	95.02	100.43	112.32
75	52.94	56.05	74.33	82.86	91.06	96.22	100.84	106.39	118.60
80	57.15	60.39	79.33	88.13	96.58	101.88	106.63	112.33	124.84
85	61.39	64.75	84.33	93.39	102.08	107.52	112.39	118.24	131.04
90	65.65	69.13	89.33	98.65	107.57	113.15	118.14	124.12	137.21
95	69.92	73.52	94.33	103.90	113.04	118.75	123.86	129.97	143.34
100	74.22	77.93	99.33	109.14	118.50	124.34	129.56	135.81	149.45

For more than 100 degrees of freedom chi-square critical values may be found in terms of the degrees of freedom and the corresponding two-sided critical value for a standard normal deviate Z by the equation $X^2 = 0.5 \cdot (Z + \sqrt{2 \cdot D - 1})^2$.

Table A.4 Critical Values (Percentiles) for the t-Distribution

The table entries are the critical values (percentiles) for the t-distribution. The column headed d.f. (degrees of freedom) gives the degrees of freedom for the values in that row. The columns are labeled by "percent," "one-sided," and "two-sided." "Percent" is 100 × cumulative distribution function—the table entry is the corresponding percentile. "One-sided" is the significance level for the one-sided upper critical value—the table entry is the critical value. "Two-sided" gives the two-sided significance level—the table entry is the corresponding two-sided critical value.

	Percent											
	75	90	95	97.5	99	99.5	99.75	99.9	99.95	99.975	99.99	99.995
	One-Sided α											
	.25	.10	.05	.025	.01	.005	.0025	.001	.0005	.00025	.0001	.00005
	Two-Sided α											
	.50	.20	.10	.05	.02	.01	.005	.002	.001	.0005	.0002	.0001
d.f.												
1	1.00	3.08	6.31	12.71	31.82	63.66	127.32	318.31	636.62	1273.24	3183.10	6366.20
2	.82	1.89	2.92	4.30	6.96	9.22	14.09	22.33	31.60	44.70	70.70	99.99
3	.76	1.64	2.35	3.18	4.54	5.84	7.45	10.21	12.92	16.33	22.20	28.00
4	.74	1.53	2.13	2.78	3.75	4.60	5.60	7.17	8.61	10.31	13.03	15.54
5	.73	1.48	2.02	2.57	3.37	4.03	4.77	5.89	6.87	7.98	9.68	11.18
6	.72	1.44	1.94	2.45	3.14	3.71	4.32	5.21	5.96	6.79	8.02	9.08
7	.71	1.42	1.90	2.37	3.00	3.50	4.03	4.79	5.41	6.08	7.06	7.88
8	.71	1.40	1.86	2.31	2.90	3.36	3.83	4.50	5.04	5.62	6.44	7.12
9	.70	1.38	1.83	2.26	2.82	3.25	3.69	4.30	4.78	5.29	6.01	6.59
10	.70	1.37	1.81	2.23	2.76	3.17	3.58	4.14	4.59	5.05	5.69	6.21
11	.70	1.36	1.80	2.20	2.72	3.11	3.50	4.03	4.44	4.86	5.45	5.92
12	.70	1.36	1.78	2.18	2.68	3.06	3.43	3.93	4.32	4.72	5.26	5.69
13	.69	1.35	1.77	2.16	2.65	3.01	3.37	3.85	4.22	4.60	5.11	5.51
14	.69	1.35	1.76	2.15	2.63	2.98	3.33	3.79	4.14	4.50	4.99	5.36
15	.69	1.34	1.75	2.13	2.60	2.95	3.29	3.73	4.07	4.42	4.88	5.24
16	.69	1.34	1.75	2.12	2.58	2.92	3.25	3.69	4.02	4.35	4.79	5.13
17	.69	1.33	1.74	2.11	2.57	2.90	3.22	3.65	3.97	4.29	4.71	5.04
18	.69	1.33	1.73	2.10	2.55	2.88	3.20	3.61	3.92	4.23	4.65	4.97
19	.69	1.33	1.73	2.09	2.54	2.86	3.17	3.58	3.88	4.19	4.59	4.90
20	.69	1.33	1.73	2.09	2.53	2.85	3.15	3.55	3.85	4.15	4.54	4.84
21	.69	1.32	1.72	2.08	2.52	2.83	3.14	3.53	3.82	4.11	4.49	4.78
22	.69	1.32	1.72	2.07	2.51	2.82	3.12	3.51	3.79	4.08	4.45	4.74
23	.68	1.32	1.71	2.07	2.50	2.81	3.10	3.49	3.77	4.05	4.42	4.69
24	.68	1.32	1.71	2.06	2.49	2.80	3.09	3.47	3.75	4.02	4.38	4.65
25	.68	1.32	1.71	2.06	2.49	2.79	3.08	3.45	3.73	4.00	4.35	4.62
26	.68	1.32	1.71	2.06	2.48	2.78	3.07	3.44	3.71	3.97	4.32	4.59
27	.68	1.31	1.70	2.05	2.47	2.77	3.06	3.42	3.69	3.95	4.30	4.56
28	.68	1.31	1.70	2.05	2.47	2.76	3.05	3.41	3.67	3.94	4.28	4.53
29	.68	1.31	1.70	2.05	2.46	2.76	3.04	3.40	3.66	3.92	4.25	4.51
30	.68	1.31	1.70	2.04	2.46	2.75	3.03	3.39	3.65	3.90	4.23	4.48
35	.68	1.31	1.69	2.03	2.44	2.72	3.00	3.34	3.59	3.84	4.15	4.39
40	.68	1.30	1.68	2.02	2.42	2.70	2.97	3.31	3.55	3.79	4.09	4.32
45	.68	1.30	1.68	2.01	2.41	2.69	2.95	3.28	3.52	3.75	4.05	4.27
50	.68	1.30	1.68	2.01	2.40	2.68	2.94	3.26	3.50	3.72	4.01	4.23
55	.68	1.30	1.67	2.00	2.40	2.67	2.93	3.25	3.48	3.70	3.99	4.20
60	.68	1.30	1.67	2.00	2.39	2.66	2.91	3.23	3.46	3.68	3.96	4.17
65	.68	1.29	1.67	2.00	2.39	2.65	2.91	3.22	3.45	3.66	3.94	4.15
70	.68	1.29	1.67	1.99	2.38	2.65	2.90	3.21	3.44	3.65	3.93	4.13
75	.68	1.29	1.67	1.99	2.38	2.64	2.89	3.20	3.43	3.64	3.91	4.11
80	.68	1.29	1.66	1.99	2.37	2.64	2.89	3.20	3.42	3.63	3.90	4.10
85	.68	1.29	1.66	1.99	2.37	2.64	2.88	3.19	3.41	3.62	3.89	4.08
90	.68	1.29	1.66	1.99	2.37	2.63	2.88	3.18	3.40	3.61	3.88	4.07
95	.68	1.29	1.66	1.99	2.37	2.63	2.87	3.18	3.40	3.60	3.87	4.06
100	.68	1.29	1.66	1.98	2.36	2.63	2.87	3.17	3.39	3.60	3.86	4.05
200	.68	1.29	1.65	1.97	2.35	2.60	2.84	3.13	3.34	3.54	3.79	3.97
500	.68	1.28	1.65	1.97	2.33	2.59	2.82	3.11	3.31	3.50	3.75	3.92
∞	.67	1.28	1.65	1.96	2.33	2.58	2.81	3.10	3.30	3.49	3.73	3.91

Table A.5 Critical Values (Percentiles) for the F-Distribution

Upper one-sided 0.05 significance levels; two-sided 0.10 significance levels; 95% percentiles. Tabulated are critical values for the F-distribution. The column headings give the numerator degrees of freedom and the row headings the denominator degrees of freedom. Lower one-sided critical values may be found from these tables by reversing the degrees of freedom and using the reciprocal of the tabled value at the same significance level (100 minus the percent for the percentile).

	Numerator Degrees of Freedom																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	245.9	248.0	249.1	250.1	251.1	252.2	253.3	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.43	19.45	19.45	19.46	19.47	19.48	19.49	19.50
3	10.13	9.55	9.28	9.12	9.01	8.94	8.89	8.85	8.81	8.79	8.74	8.70	8.66	8.64	8.62	8.59	8.57	8.55	8.53
4	7.71	6.94	6.59	6.39	6.26	6.16	6.09	6.04	6.00	5.96	5.91	5.86	5.80	5.77	5.75	5.72	5.69	5.66	5.63
5	6.61	5.79	5.41	5.19	5.05	4.95	4.88	4.82	4.77	4.74	4.68	4.62	4.56	4.53	4.50	4.46	4.43	4.40	4.36
6	6.99	5.14	4.76	4.53	4.39	4.28	4.21	4.15	4.10	4.06	4.00	3.94	3.87	3.84	3.81	3.77	3.74	3.70	3.67
7	5.59	4.74	4.35	4.12	3.97	3.87	3.79	3.73	3.68	3.64	3.57	3.51	3.44	3.41	3.38	3.34	3.30	3.27	3.23
8	5.32	4.46	4.07	3.84	3.69	3.58	3.50	3.44	3.39	3.35	3.28	3.22	3.15	3.12	3.08	3.04	3.01	2.97	2.93
9	5.12	4.26	3.86	3.63	3.48	3.37	3.29	3.23	3.18	3.14	3.07	3.01	2.94	2.90	2.86	2.83	2.79	2.75	2.71
10	4.96	4.10	3.71	3.48	3.33	3.22	3.14	3.07	3.02	2.98	2.91	2.85	2.77	2.74	2.70	2.66	2.62	2.58	2.54
11	4.84	3.98	3.59	3.36	3.20	3.09	3.01	2.95	2.90	2.85	2.79	2.72	2.65	2.61	2.57	2.53	2.49	2.45	2.40
12	4.75	3.89	3.49	3.26	3.11	3.00	2.91	2.85	2.80	2.75	2.69	2.62	2.54	2.51	2.47	2.43	2.38	2.34	2.30
13	4.67	3.81	3.41	3.18	3.03	2.92	2.83	2.77	2.71	2.67	2.60	2.53	2.46	2.42	2.38	2.34	2.30	2.25	2.21
14	4.60	3.74	3.34	3.11	2.96	2.85	2.76	2.70	2.65	2.60	2.53	2.46	2.39	2.35	2.31	2.27	2.22	2.18	2.13
15	4.54	3.68	3.29	3.06	2.90	2.79	2.71	2.64	2.59	2.54	2.48	2.40	2.33	2.29	2.25	2.20	2.16	2.11	2.07
16	4.49	3.63	3.24	3.01	2.85	2.74	2.66	2.59	2.54	2.49	2.42	2.35	2.28	2.24	2.19	2.15	2.11	2.06	2.01
17	4.45	3.59	3.20	2.96	2.81	2.70	2.61	2.55	2.49	2.45	2.38	2.31	2.23	2.19	2.15	2.10	2.06	2.01	1.96

(*continued overleaf*)

Table A.5 (*continued*)

	Numerator Degrees of Freedom																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	4.41	3.55	3.16	2.93	2.77	2.66	2.58	2.51	2.46	2.41	2.34	2.27	2.19	2.15	2.11	2.06	2.02	1.97	1.92
19	4.38	3.52	3.13	2.90	2.74	2.63	2.54	2.48	2.42	2.38	2.31	2.23	2.16	2.11	2.07	2.03	1.98	1.93	1.88
20	4.35	3.49	3.10	2.87	2.71	2.60	2.51	2.45	2.39	2.35	2.28	2.20	2.12	2.08	2.04	1.99	1.95	1.90	1.84
21	4.32	3.47	3.07	2.84	2.68	2.57	2.49	2.42	2.37	2.32	2.25	2.18	2.10	2.05	2.01	1.96	1.92	1.87	1.81
22	4.30	3.44	3.05	2.82	2.66	2.55	2.46	2.40	2.34	2.30	2.23	2.15	2.07	2.03	1.98	1.94	1.89	1.84	1.78
23	4.28	3.42	3.03	2.80	2.64	2.53	2.44	2.37	2.32	2.27	2.20	2.13	2.05	2.01	1.96	1.91	1.86	1.81	1.76
24	4.26	3.40	3.01	2.78	2.62	2.51	2.42	2.36	2.30	2.25	2.18	2.11	2.03	1.98	1.94	1.89	1.84	1.79	1.73
25	4.24	3.39	2.99	2.76	2.60	2.49	2.40	2.34	2.28	2.24	2.16	2.09	2.01	1.96	1.92	1.87	1.82	1.77	1.71
26	4.23	3.37	2.98	2.74	2.59	2.47	2.39	2.32	2.27	2.22	2.15	2.07	1.99	1.95	1.90	1.85	1.80	1.75	1.69
27	4.21	3.35	2.96	2.73	2.57	2.46	2.37	2.31	2.25	2.20	2.13	2.06	1.97	1.93	1.88	1.84	1.79	1.73	1.67
28	4.20	3.34	2.95	2.71	2.56	2.45	2.36	2.29	2.24	2.19	2.12	2.04	1.96	1.91	1.87	1.82	1.77	1.71	1.65
29	4.18	3.33	2.93	2.70	2.55	2.43	2.35	2.28	2.22	2.18	2.10	2.03	1.94	1.90	1.85	1.81	1.75	1.70	1.64
30	4.17	3.32	2.92	2.69	2.53	2.42	2.33	2.27	2.21	2.16	2.09	2.01	1.93	1.89	1.84	1.79	1.74	1.68	1.62
40	4.08	3.23	2.84	2.61	2.45	2.34	2.25	2.18	2.12	2.08	2.00	1.92	1.84	1.79	1.74	1.69	1.64	1.58	1.51
60	4.00	3.15	2.76	2.53	2.37	2.25	2.17	2.10	2.04	1.99	1.92	1.84	1.75	1.70	1.65	1.59	1.53	1.47	1.39
120	3.92	3.07	2.68	2.45	2.29	2.17	2.09	2.02	1.96	1.91	1.83	1.75	1.66	1.61	1.55	1.50	1.43	1.35	1.25
∞	3.84	3.00	2.60	2.37	2.21	2.10	2.01	1.94	1.88	1.83	1.75	1.67	1.57	1.52	1.46	1.39	1.32	1.22	1.00

Table A.6 Critical Values (Percentiles) for the F-Distribution

Upper one-sided 0.01 significance levels; two-sided 0.02 significance levels; 99% percentiles.

	Numerator Degrees of Freedom																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	4052	5000	5403	5625	5764	5859	5928	5982	6022	6056	6106	6157	6209	6235	6261	6287	6313	6339	6366
2	98.50	99.00	99.17	99.25	99.30	99.33	99.36	99.37	99.39	99.40	99.42	99.43	99.45	99.46	99.47	99.47	99.48	99.49	99.50
3	34.12	30.82	29.46	28.71	28.24	27.91	27.67	27.49	27.35	27.23	27.05	26.87	26.69	26.60	26.50	26.41	26.32	26.22	26.13
4	21.20	18.00	16.69	15.98	15.52	15.21	14.98	14.80	14.66	14.55	14.37	14.20	14.02	13.93	13.84	13.75	13.65	13.56	13.46
5	16.26	13.27	12.06	11.39	10.97	10.67	10.46	10.29	10.16	10.05	9.89	9.72	9.55	9.47	9.38	9.29	9.20	9.11	9.02
6	13.75	10.92	9.78	9.15	8.75	8.47	8.26	8.10	7.98	7.87	7.72	7.56	7.40	7.31	7.23	7.14	7.06	6.97	6.88
7	12.25	9.55	8.45	7.85	7.46	7.19	6.99	6.84	6.72	6.62	6.47	6.31	6.16	6.07	5.99	5.91	5.82	5.74	5.65
8	11.26	8.65	7.59	7.01	6.63	6.37	6.18	6.03	5.91	5.81	5.67	5.52	5.36	5.28	5.20	5.12	5.03	4.95	4.86
9	10.56	8.02	6.99	6.42	6.06	5.80	5.61	5.47	5.35	5.26	5.11	4.96	4.81	4.73	4.65	4.57	4.48	4.40	4.31
10	10.04	7.56	6.55	5.99	5.64	5.39	5.20	5.06	4.94	4.85	4.71	4.56	4.41	4.33	4.25	4.17	4.08	4.00	3.91
11	9.65	7.21	6.22	5.67	5.32	5.07	4.89	4.74	4.63	4.54	4.40	4.25	4.10	4.02	3.94	3.86	3.78	3.69	3.60
12	9.33	6.93	5.95	5.41	5.06	4.82	4.64	4.50	4.39	4.30	4.16	4.01	3.86	3.78	3.70	3.62	3.54	3.45	3.36
13	9.07	6.70	5.74	5.21	4.86	4.62	4.44	4.30	4.19	4.10	3.96	3.82	3.66	3.59	3.51	3.43	3.34	3.25	3.17
14	8.86	6.51	5.56	5.04	4.69	4.46	4.28	4.14	4.03	3.94	3.80	3.66	3.51	3.43	3.35	3.27	3.18	3.09	3.00
15	8.68	6.36	5.42	4.89	4.56	4.32	4.14	4.00	3.89	3.80	3.67	3.52	3.37	3.29	3.21	3.13	3.05	2.96	2.87
16	8.53	6.23	5.29	4.77	4.44	4.20	4.03	3.89	3.78	3.69	3.55	3.41	3.26	3.18	3.10	3.02	2.93	2.84	2.75
17	8.40	6.11	5.18	4.67	4.34	4.10	3.93	3.79	3.68	3.59	3.46	3.31	3.16	3.08	3.00	2.92	2.83	2.75	2.65

(*continued overleaf*)

Table A.6 (***continued***)

	Numerator Degrees of Freedom																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
18	8.29	6.01	5.09	4.58	4.25	4.01	3.84	3.71	3.60	3.51	3.37	3.23	3.08	3.00	2.92	2.84	2.75	2.66	2.57
19	8.18	5.93	5.01	4.50	4.17	3.94	3.77	3.63	3.52	3.43	3.30	3.15	3.00	2.92	2.84	2.76	2.67	2.58	2.49
20	8.10	5.85	4.94	4.43	4.10	3.87	3.70	3.56	3.46	3.37	3.23	3.09	2.94	2.86	2.78	2.69	2.61	2.52	2.42
21	8.02	5.78	4.87	4.37	4.04	3.81	3.64	3.51	3.40	3.31	3.17	3.03	2.88	2.80	2.72	2.64	2.55	2.46	2.36
22	7.95	5.72	4.82	4.31	3.99	3.76	3.59	3.45	3.35	3.26	3.12	2.98	2.83	2.75	2.67	2.58	2.50	2.40	2.31
23	7.88	5.66	4.76	4.26	3.94	3.71	3.54	3.41	3.30	3.21	3.07	2.93	2.78	2.70	2.62	2.54	2.45	2.35	2.26
24	7.82	5.61	4.72	4.22	3.90	3.67	3.50	3.36	3.26	3.17	3.03	2.89	2.74	2.66	2.58	2.49	2.40	2.31	2.21
25	7.77	5.57	4.68	4.18	3.85	3.63	3.46	3.32	3.22	3.13	2.99	2.85	2.70	2.62	2.54	2.45	2.36	2.27	2.17
26	7.72	5.53	4.64	4.14	3.82	3.59	3.42	3.29	3.18	3.09	2.96	2.81	2.66	2.58	2.50	2.42	2.33	2.23	2.13
27	7.68	5.49	4.60	4.11	3.78	3.56	3.39	3.26	3.15	3.06	2.93	2.78	2.63	2.55	2.47	2.38	2.29	2.20	2.10
28	7.64	5.45	4.57	4.07	3.75	3.53	3.36	3.23	3.12	3.03	2.90	2.75	2.60	2.52	2.44	2.35	2.26	2.17	2.06
29	7.60	5.42	4.54	4.04	3.73	3.50	3.33	3.20	3.09	3.00	2.87	2.73	2.57	2.49	2.41	2.33	2.23	2.14	2.03
30	7.56	5.39	4.51	4.02	3.70	3.47	3.30	3.17	3.07	2.98	2.84	2.70	2.55	2.47	2.39	2.30	2.21	2.11	2.01
40	7.31	5.18	4.31	3.83	3.51	3.29	3.12	2.99	2.89	2.80	2.66	2.52	2.37	2.29	2.20	2.11	2.02	1.92	1.80
60	7.08	4.98	4.13	3.65	3.34	3.12	2.95	2.82	2.72	2.63	2.50	2.35	2.20	2.12	2.03	1.94	1.84	1.73	1.60
120	6.85	4.79	3.95	3.48	3.17	2.96	2.79	2.66	2.56	2.47	2.34	2.19	2.03	1.95	1.86	1.76	1.66	1.53	1.38
∞	6.63	4.61	3.78	3.32	3.02	2.80	2.64	2.51	2.41	2.32	2.18	2.04	1.88	1.79	1.70	1.59	1.47	1.32	1.00

Table A.7 Fisher's Exact Test for 2 × 2 Tables

Consider a 2 × 2 table: $\begin{matrix} aA-a|A \\ bB-b|B \end{matrix}$ with rows and/or columns exchanged so that (1) $A \geq B$ and (2) $(a/A) \geq (b/B)$. The table entries are ordered lexicographically by A (ascending). B (descending) and a (descending). For each triple (A, B, a) the table presents critical values for one-sided tests of the hypothesis that the true proportion corresponding to a/A is greater than the true proportion corresponding to b/B. Significance levels of 0.05, 0.025, and 0.01 are considered. For $A \leq 15$ all values where critical values exist are tabulated. For each significance level two columns give (1) the nominal critical value for b (i.e., reject the null hypothesis if the observed b is less than or equal to the table entry) and (2) the p-value corresponding to the critical value (this is less than the nominal significance level in most cases due to the discreteness of the distribution).

A	B	a	b	p	b	p	b	p	A	B	a	b	p	b	p	b	p
3	3	3	0	.050	—	—	—	—	8	7	5	0	.019	0	.019	—	—
4	4	4	0	.014	0	.014	—	—	8	6	8	2	.015	2	.015	1	.003
4	3	4	0	.029	—	—	—	—	8	6	7	1	.016	1	.016	0	.002
5	5	5	1	.024	1	.024	0	.004	8	6	6	0	.009	0	.009	0	.009
5	5	4	0	.024	0	.024	—	—	8	6	5	0	.028	—	—	—	—
5	4	5	1	.048	0	.008	0	.008	8	5	8	2	.035	1	.007	1	.007
5	4	4	0	.040	—	—	—	—	8	5	7	1	.032	0	.005	0	.005
5	3	5	0	.018	0	.018	—	—	8	5	6	0	.016	0	.016	—	—
5	2	5	0	.048	—	—	—	—	8	5	5	0	.044	—	—	—	—
6	6	6	2	.030	1	.008	1	.008	8	4	8	1	.018	1	.018	0	.002
6	6	5	1	.040	0	.008	0	.008	8	4	7	0	.010	0	.010	—	—
6	6	4	0	.030	—	—	—	—	8	4	6	0	.030	—	—	—	—
6	5	6	1	.015	1	.015	0	.002	8	3	8	0	.006	0	.006	0	.006
6	5	5	0	.013	0	.013	—	—	8	3	7	0	.024	0	.024	—	—
6	5	4	0	.045	—	—	—	—	8	2	8	0	.022	0	.022	—	—
6	4	6	1	.033	0	.005	0	.005	9	9	9	5	.041	4	.015	3	.005
6	4	5	0	.024	0	.024	—	—	9	9	8	3	.025	3	.025	2	.008
6	3	6	0	.012	0	.012	—	—	9	9	7	2	.028	1	.008	1	.008
6	3	5	0	.048	—	—	—	—	9	9	6	1	.025	1	.025	0	.005
6	2	6	0	.036	—	—	—	—	9	9	5	0	.015	0	.015	—	—
7	7	7	3	.035	2	.010	1	.002	9	9	4	0	.041	—	—	—	—
7	7	6	1	.015	1	.015	0	.002	9	8	9	4	.029	3	.009	3	.009
7	7	5	0	.010	0	.010	—	—	9	8	8	3	.043	2	.013	1	.003
7	7	4	0	.035	—	—	—	—	9	8	7	2	.044	1	.012	0	.002
7	6	7	2	.021	2	.021	1	.005	9	8	6	1	.036	0	.007	0	.007
7	6	6	1	.025	0	.004	0	.004	9	8	5	0	.020	0	.020	—	—
7	6	5	0	.016	0	.016	—	—	9	7	9	3	.019	3	.019	2	.005
7	6	4	0	.049	—	—	—	—	9	7	8	2	.024	2	.024	1	.006
7	5	7	2	.045	1	.010	0	.001	9	7	7	1	.020	1	.020	0	.003
7	5	6	1	.045	0	.008	0	.008	9	7	6	0	.010	0	.010	—	—
7	5	5	0	.027	—	—	—	—	9	7	5	0	.029	—	—	—	—
7	4	7	1	.024	1	.024	0	.003	9	6	9	3	.044	2	.011	1	.002
7	4	6	0	.015	0	.015	—	—	9	6	8	2	.047	1	.011	0	.001
7	4	5	0	.045	—	—	—	—	9	6	7	1	.035	0	.006	0	.006
7	3	7	0	.008	0	.008	0	.008	9	6	6	0	.017	0	.017	—	—
7	3	6	0	.033	—	—	—	—	9	6	5	0	.042	—	—	—	—
7	2	7	0	.028	—	—	—	—	9	5	9	2	.027	1	.005	1	.005
8	8	8	4	.038	3	.013	2	.003	9	5	8	1	.023	1	.023	0	.003
8	8	7	2	.020	2	.020	1	.005	9	5	7	0	.010	0	.010	—	—
8	8	6	1	.020	1	.020	0	.003	9	5	6	0	.028	—	—	—	—
8	8	5	0	.013	0	.013	—	—	9	4	9	1	.014	1	.014	0	.001
8	8	4	0	.038	—	—	—	—	9	4	8	0	.007	0	.007	0	.007
8	7	8	3	.026	2	.007	2	.007	9	4	7	0	.021	0	.021	—	—
8	7	7	2	.035	1	.009	1	.009	9	4	6	0	.049	—	—	—	—
8	7	6	1	.032	0	.006	0	.006	9	3	9	1	.045	0	.005	0	.005

(*continued overleaf*)

Table A.7 (***continued***)

A	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*	*A*	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*
9	3	8	0	.018	0	.018	—	—	11	11	8	3	.043	2	.015	1	.004
9	3	7	0	.045	—	—	—	—	11	11	7	2	.040	1	.012	0	.002
9	2	9	0	.018	0	.018	—	—	11	11	6	1	.032	0	.006	0	.006
10	10	10	6	.043	5	.016	4	.005	11	11	5	0	.018	0	.018	—	—
10	10	9	4	.029	3	.010	3	.010	11	11	4	0	.045	—	—	—	—
10	10	8	3	.035	2	.012	1	.003	11	10	11	6	.035	5	.012	4	.004
10	10	7	2	.035	1	.010	1	.010	11	10	10	4	.021	4	.021	3	.007
10	10	6	1	.029	0	.005	0	.005	11	10	9	3	.024	3	.024	2	.007
10	10	5	0	.016	0	.016	—	—	11	10	8	2	.023	2	.023	1	.006
10	10	4	0	.043	—	—	—	—	11	10	7	1	.017	1	.017	0	.003
10	9	10	5	.033	4	.011	3	.003	11	10	6	1	.043	0	.009	0	.009
10	9	9	4	.050	3	.017	2	.005	11	10	5	0	.023	0	.023	—	—
10	9	8	2	.019	2	.019	1	.004	11	9	11	5	.026	4	.008	4	.008
10	9	7	1	.015	1	.015	0	.002	11	9	10	4	.038	3	.012	2	.003
10	9	6	1	.040	0	.008	0	.008	11	9	9	3	.040	2	.012	1	.003
10	9	5	0	.022	0	.022	—	—	11	9	8	2	.035	1	.009	1	.009
10	8	10	4	.023	4	.023	3	.007	11	9	7	1	.025	1	.025	0	.004
10	8	9	3	.032	2	.009	2	.009	11	9	6	0	.012	0	.012	—	—
10	8	8	2	.031	1	.008	1	.008	11	9	5	0	.030	—	—	—	—
10	8	7	1	.023	1	.023	0	.004	11	8	11	4	.018	4	.018	3	.005
10	8	6	0	.011	0	.011	—	—	11	8	10	3	.024	3	.024	2	.006
10	8	5	0	.029	—	—	—	—	11	8	9	2	.022	2	.022	1	.005
10	7	10	3	.015	3	.015	2	.003	11	8	8	1	.015	1	.015	0	.002
10	7	9	2	.018	2	.018	1	.004	11	8	7	1	.037	0	.007	0	.007
10	7	8	1	.013	1	.013	0	.002	11	8	6	0	.017	0	.017	—	—
10	7	7	1	.036	0	.006	0	.006	11	8	5	0	.040	—	—	—	—
10	7	6	0	.017	0	.017	—	—	11	7	11	4	.043	3	.011	2	.002
10	7	5	0	.041	—	—	—	—	11	7	10	3	.047	2	.013	1	.002
10	6	10	3	.036	2	.008	2	.008	11	7	9	2	.039	1	.009	1	.009
10	6	9	2	.036	1	.008	1	.008	11	7	8	1	.025	1	.025	0	.004
10	6	8	1	.024	1	.024	0	.003	11	7	7	0	.010	0	.010	—	—
10	6	7	0	.010	0	.010	—	—	11	7	6	0	.025	0	.025	—	—
10	6	6	0	.026	—	—	—	—	11	6	11	3	.029	2	.006	2	.006
10	5	10	2	.022	2	.022	1	.004	11	6	10	2	.028	1	.005	1	.005
10	5	9	1	.017	1	.017	0	.002	11	6	9	1	.018	1	.018	0	.002
10	5	8	1	.047	0	.007	0	.007	11	6	8	1	.043	0	.007	0	.007
10	5	7	0	.019	0	.019	—	—	11	6	7	0	.017	0	.017	—	—
10	5	6	0	.042	—	—	—	—	11	6	6	0	.037	—	—	—	—
10	4	10	1	.011	1	.011	0	.001	11	5	11	2	.018	2	.018	1	.003
10	4	9	1	.041	0	.005	0	.005	11	5	10	1	.013	1	.013	0	.001
10	4	8	0	.015	0	.015	—	—	11	5	9	1	.036	0	.005	0	.005
10	4	7	0	.035	—	—	—	—	11	5	8	0	.013	0	.013	—	—
10	3	10	1	.038	0	.003	0	.003	11	5	7	0	.029	—	—	—	—
10	3	9	0	.014	0	.014	—	—	11	4	11	1	.009	1	.009	1	.009
10	3	8	0	.035	—	—	—	—	11	4	10	1	.033	0	.004	0	.004
10	2	10	0	.015	0	.015	—	—	11	4	9	0	.011	0	.011	—	—
10	2	9	0	.045	—	—	—	—	11	4	8	0	.026	—	—	—	—
11	11	11	7	.045	6	.018	5	.006	11	3	11	1	.033	0	.003	0	.003
11	11	10	5	.032	4	.012	3	.004	11	3	10	0	.011	0	.011	—	—
11	11	9	4	.040	3	.015	2	.004	11	3	9	0	.027	—	—	—	—

Table A.7 (***continued***)

A	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*	*A*	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*
11	2	11	0	.013	0	.013	—	—	12	6	11	2	.022	2	.022	1	.004
11	2	10	0	.038	—	—	—	—	12	6	10	1	.013	1	.013	0	.002
12	12	12	8	.047	7	.019	6	.007	12	6	9	1	.032	0	.005	0	.005
12	12	11	6	.034	5	.014	4	.005	12	6	8	0	.011	0	.011	—	—
12	12	10	5	.045	4	.018	3	.006	12	6	7	0	.025	0	.025	—	—
12	12	9	4	.050	3	.020	2	.006	12	6	6	0	.050	—	—	—	—
12	12	8	3	.050	2	.018	1	.005	12	5	12	2	.015	2	.015	1	.002
12	12	7	2	.045	1	.014	0	.002	12	5	11	1	.010	1	.010	1	.010
12	12	6	1	.034	0	.007	0	.007	12	5	10	1	.028	0	.003	0	.003
12	12	5	0	.019	0	.019	—	—	12	5	9	0	.009	0	.009	0	.009
12	12	4	0	.047	—	—	—	—	12	5	8	0	.020	0	.020	—	—
12	11	12	7	.037	6	.014	5	.005	12	5	7	0	.041	—	—	—	—
12	11	11	5	.024	5	.024	4	.008	12	4	12	2	.050	1	.007	1	.007
12	11	10	4	.029	3	.010	2	.003	12	4	11	1	.027	0	.003	0	.003
12	11	9	3	.030	2	.009	2	.009	12	4	10	0	.008	0	.008	0	.008
12	11	8	2	.026	1	.007	1	.007	12	4	9	0	.019	0	.019	—	—
12	11	7	1	.019	1	.019	0	.003	12	4	8	0	.038	—	—	—	—
12	11	6	1	.045	0	.009	0	.009	12	3	12	1	.029	0	.002	0	.002
12	11	5	0	.024	0	.024	—	—	12	3	11	0	.009	0	.009	0	.009
12	10	12	6	.029	5	.010	5	.010	12	3	10	0	.022	0	.022	—	—
12	10	11	5	.043	4	.015	3	.005	12	3	9	0	.044	—	—	—	—
12	10	10	4	.048	3	.017	2	.005	12	2	12	0	.011	0	.011	—	—
12	10	9	3	.046	2	.015	1	.004	12	2	11	0	.033	—	—	—	—
12	10	8	2	.038	1	.010	0	.002	13	13	13	9	.048	8	.020	7	.007
12	10	7	1	.026	0	.005	0	.005	13	13	12	7	.037	6	.015	5	.006
12	10	6	0	.012	0	.012	—	—	13	13	11	6	.048	5	.021	4	.008
12	10	5	0	.030	—	—	—	—	13	13	10	4	.024	4	.024	3	.008
12	9	12	5	.021	5	.021	4	.006	13	13	9	3	.024	3	.024	2	.008
12	9	11	4	.029	3	.009	3	.009	13	13	8	2	.021	2	.021	1	.006
12	9	10	3	.029	2	.008	2	.008	13	13	7	2	.048	1	.015	0	.003
12	9	9	2	.024	2	.024	1	.006	13	13	6	1	.037	0	.007	0	.007
12	9	8	1	.016	1	.016	0	.002	13	13	5	0	.020	0	.020	—	—
12	9	7	1	.037	0	.007	0	.007	13	13	4	0	.048	—	—	—	—
12	9	6	0	.017	0	.017	—	—	13	12	13	8	.039	7	.015	6	.005
12	9	5	0	.039	—	—	—	—	13	12	12	6	.027	5	.010	5	.010
12	8	12	5	.049	4	.014	3	.004	13	12	11	5	.033	4	.013	3	.004
12	8	11	3	.018	3	.018	2	.004	13	12	10	4	.036	3	.013	2	.004
12	8	10	2	.015	2	.015	1	.003	13	12	9	3	.034	2	.011	1	.003
12	8	9	2	.040	1	.010	1	.010	13	12	8	2	.029	1	.008	1	.008
12	8	8	1	.025	1	.025	0	.004	13	12	7	1	.020	1	.020	0	.004
12	8	7	0	.010	0	.010	—	—	13	12	6	1	.046	0	.010	0	.010
12	8	6	0	.024	0	.024	—	—	13	12	5	0	.024	0	.024	—	—
12	7	12	4	.036	3	.009	3	.009	13	11	13	7	.031	6	.011	5	.003
12	7	11	3	.038	2	.010	2	.010	13	11	12	6	.048	5	.018	4	.006
12	7	10	2	.029	1	.006	1	.006	13	11	11	4	.021	4	.021	3	.007
12	7	9	1	.017	1	.017	0	.002	13	11	10	3	.021	3	.021	2	.006
12	7	8	1	.040	0	.007	0	.007	13	11	9	3	.050	2	.017	1	.004
12	7	7	0	.016	0	.016	—	—	13	11	8	2	.040	1	.011	0	.002
12	7	6	0	.034	—	—	—	—	13	11	7	1	.027	0	.005	0	.005
12	6	12	3	.025	3	.025	2	.005	13	11	6	0	.013	0	.013	—	—

(*continued overleaf*)

Table A.7 (*continued*)

A	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*	*A*	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*
13	11	5	0	.030	—	—	—	—	13	4	11	0	.006	0	.006	0	.006
13	10	13	6	.024	6	.024	5	.007	13	4	10	0	.015	0	.015	—	—
13	10	12	5	.035	4	.012	3	.003	13	4	9	0	.029	—	—	—	—
13	10	11	4	.037	3	.012	2	.003	13	3	13	1	.025	1	.025	0	.002
13	10	10	3	.033	2	.010	1	.002	13	3	12	0	.007	0	.007	0	.007
13	10	9	2	.026	1	.006	1	.006	13	3	11	0	.018	0	.018	—	—
13	10	8	1	.017	1	.017	0	.003	13	3	10	0	.036	—	—	—	—
13	10	7	1	.038	0	.007	0	.007	13	2	13	0	.010	0	.010	0	.010
13	10	6	0	.017	0	.017	—	—	13	2	12	0	.029	—	—	—	—
13	10	5	0	.038	—	—	—	—	14	14	14	10	.049	9	.020	8	.008
13	9	13	5	.017	5	.017	4	.005	14	14	13	8	.038	7	.016	6	.006
13	9	12	4	.023	4	.023	3	.007	14	14	12	6	.023	6	.023	5	.009
13	9	11	3	.022	3	.022	2	.006	14	14	11	5	.027	4	.011	3	.004
13	9	10	2	.017	2	.017	1	.004	14	14	10	4	.028	3	.011	2	.003
13	9	9	2	.040	1	.010	0	.001	14	14	9	3	.027	2	.009	2	.009
13	9	8	1	.025	1	.025	0	.004	14	14	8	2	.023	2	.023	1	.006
13	9	7	0	.010	0	.010	—	—	14	14	7	1	.016	1	.016	0	.003
13	9	6	0	.023	0	.023	—	—	14	14	6	1	.038	0	.008	0	.008
13	9	5	0	.049	—	—	—	—	14	14	5	0	.020	0	.020	—	—
13	8	13	5	.042	4	.012	3	.003	14	14	4	0	.049	—	—	—	—
13	8	12	4	.047	3	.014	2	.003	14	13	14	9	.041	8	.016	7	.006
13	8	11	3	.041	2	.011	1	.002	14	13	13	7	.029	6	.011	5	.004
13	8	10	2	.029	1	.007	1	.007	14	13	12	6	.037	5	.015	4	.005
13	8	9	1	.017	1	.017	0	.002	14	13	11	5	.041	4	.017	3	.006
13	8	8	1	.037	0	.006	0	.006	14	13	10	4	.041	3	.016	2	.005
13	8	7	0	.015	0	.015	—	—	14	13	9	3	.038	2	.013	1	.003
13	8	6	0	.032	—	—	—	—	14	13	8	2	.031	1	.009	1	.009
13	7	13	4	.031	3	.007	3	.007	14	13	7	1	.021	1	.021	0	.004
13	7	12	3	.031	2	.007	2	.007	14	13	6	1	.048	0	.010	—	—
13	7	11	2	.022	2	.022	1	.004	14	13	5	0	.025	0	.025	—	—
13	7	10	1	.012	1	.012	0	.002	14	12	14	8	.033	7	.012	6	.004
13	7	9	1	.029	0	.004	0	.004	14	12	13	6	.021	6	.021	5	.007
13	7	8	0	.010	0	.010	—	—	14	12	12	5	.025	4	.009	4	.009
13	7	7	0	.022	0	.022	—	—	14	12	11	4	.026	3	.009	3	.009
13	7	6	0	.044	—	—	—	—	14	12	10	3	.024	3	.024	2	.007
13	6	13	3	.021	3	.021	2	.004	14	12	9	2	.019	2	.019	1	.005
13	6	12	2	.017	2	.017	1	.003	14	12	8	2	.042	1	.012	0	.002
13	6	11	2	.046	1	.010	1	.010	14	12	7	1	.028	0	.005	0	.005
13	6	10	1	.024	1	.024	0	.003	14	12	6	0	.013	0	.013	—	—
13	6	9	1	.050	0	.008	0	.008	14	12	5	0	.030	—	—	—	—
13	6	8	0	.017	0	.017	—	—	14	11	14	7	.026	6	.009	6	.009
13	6	7	0	.034	—	—	—	—	14	11	13	6	.039	5	.014	4	.004
13	5	13	2	.012	2	.012	1	.002	14	11	12	5	.043	4	.016	3	.005
13	5	12	2	.044	1	.008	1	.008	14	11	11	4	.042	3	.015	2	.004
13	5	11	1	.022	1	.022	0	.002	14	11	10	3	.036	2	.011	1	.003
13	5	10	1	.047	0	.007	0	.007	14	11	9	2	.027	1	.007	1	.007
13	5	9	0	.015	0	.015	—	—	14	11	8	1	.017	1	.017	0	.003
13	5	8	0	.029	—	—	—	—	14	11	7	1	.038	0	.007	0	.007
13	4	13	2	.044	1	.006	1	.006	14	11	6	0	.017	0	.017	—	—
13	4	12	1	.022	1	.022	0	.002	14	11	5	0	.038	—	—	—	—

Table A.7 (***continued***)

A	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*	*A*	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*
14	10	14	6	.020	6	.020	5	.006	14	5	8	0	.040	—	—	—	—
14	10	13	5	.028	4	.009	4	.009	14	4	14	2	.039	1	.005	1	.005
14	10	12	4	.028	3	.009	3	.009	14	4	13	1	.019	1	.019	0	.002
14	10	11	3	.024	3	.024	2	.007	14	4	12	1	.044	0	.005	0	.005
14	10	10	2	.018	2	.018	1	.004	14	4	11	0	.011	0	.011	—	—
14	10	9	2	.040	1	.011	0	.002	14	4	10	0	.023	0	.023	—	—
14	10	8	1	.024	1	.024	0	.004	14	4	9	0	.041	—	—	—	—
14	10	7	0	.010	0	.010	0	.010	14	3	14	1	.022	1	.022	0	.001
14	10	6	0	.022	0	.022	—	—	14	3	13	0	.006	0	.006	0	.006
14	10	5	0	.047	—	—	—	—	14	3	12	0	.015	0	.015	—	—
14	9	14	6	.047	5	.014	4	.004	14	3	11	0	.029	—	—	—	—
14	9	13	4	.018	4	.018	3	.005	14	2	14	0	.008	0	.008	0	.008
14	9	12	3	.017	3	.017	2	.004	14	2	13	0	.025	0	.025	—	—
14	9	11	3	.042	2	.012	1	.002	14	2	12	0	.050	—	—	—	—
14	9	10	2	.029	1	.007	1	.007	15	15	15	11	.050	10	.021	9	.008
14	9	9	1	.017	1	.017	0	.002	15	15	14	9	.040	8	.018	7	.007
14	9	8	1	.036	0	.006	0	.006	15	15	13	7	.025	6	.010	5	.004
14	9	7	0	.014	0	.014	—	—	15	15	12	6	.030	5	.013	4	.005
14	9	6	0	.030	—	—	—	—	15	15	11	5	.033	4	.013	3	.005
14	8	14	5	.036	4	.010	4	.010	15	15	10	4	.033	3	.013	2	.004
14	8	13	4	.039	3	.011	2	.002	15	15	9	3	.030	2	.010	1	.003
14	8	12	3	.032	2	.008	2	.008	15	15	8	2	.025	1	.007	1	.007
14	8	11	2	.022	2	.022	1	.005	15	15	7	1	.018	1	.018	0	.003
14	8	10	2	.048	1	.012	0	.002	15	15	6	1	.040	0	.008	0	.008
14	8	9	1	.026	0	.004	0	.004	15	15	5	0	.021	0	.021	—	—
14	8	8	0	.009	0	.009	0	.009	15	15	4	0	.050	—	—	—	—
14	8	7	0	.020	0	.020	—	—	15	14	15	10	.042	9	.017	8	.006
14	8	6	0	.040	—	—	—	—	15	14	14	8	.031	7	.013	6	.005
14	7	14	4	.026	3	.006	3	.006	15	14	13	7	.041	6	.017	5	.007
14	7	13	3	.025	2	.006	2	.006	15	14	12	6	.046	5	.020	4	.007
14	7	12	2	.017	2	.017	1	.003	15	14	11	5	.048	4	.020	3	.007
14	7	11	2	.041	1	.009	1	.009	15	14	10	4	.046	3	.018	2	.006
14	7	10	1	.021	1	.021	0	.003	15	14	9	3	.041	2	.014	1	.004
14	7	9	1	.043	0	.007	0	.007	15	14	8	2	.033	1	.009	1	.009
14	7	8	0	.015	0	.015	—	—	15	14	7	1	.022	1	.022	0	.004
14	7	7	0	.030	—	—	—	—	15	14	6	1	.049	0	.011	—	—
14	6	14	3	.018	3	.018	2	.003	15	14	5	0	.025	—	—	—	—
14	6	13	2	.014	2	.014	1	.002	15	13	15	9	.035	8	.013	7	.005
14	6	12	2	.037	1	.007	1	.007	15	13	14	7	.023	7	.023	6	.009
14	6	11	1	.018	1	.018	0	.002	15	13	13	6	.029	5	.011	4	.004
14	6	10	1	.038	0	.005	0	.005	15	13	12	5	.031	4	.012	3	.004
14	6	9	0	.012	0	.012	—	—	15	13	11	4	.030	3	.011	2	.003
14	6	8	0	.024	0	.024	—	—	15	13	10	3	.026	2	.008	2	.008
14	6	7	0	.044	—	—	—	—	15	13	9	2	.020	2	.020	1	.005
14	5	14	2	.010	2	.010	1	.001	15	13	8	2	.043	1	.013	0	.002
14	5	13	2	.037	1	.006	1	.006	15	13	7	1	.029	0	.005	0	.005
14	5	12	1	.017	1	.017	0	.002	15	13	6	0	.013	0	.013	—	—
14	5	11	1	.038	0	.005	0	.005	15	13	5	0	.031	—	—	—	—
14	5	10	0	.011	0	.011	—	—	15	12	15	8	.028	7	.010	7	.010
14	5	9	0	.022	0	.022	—	—	15	12	14	7	.043	6	.016	5	.006

(*continued overleaf*)

Table A.7 (*continued*)

A	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*	*A*	*B*	*a*	*b*	*p*	*b*	*p*	*b*	*p*
15	12	13	6	.049	5	.019	4	.007	15	8	10	1	.019	1	.019	0	.003
15	12	12	5	.049	4	.019	3	.006	15	8	9	1	.038	0	.006	0	.006
15	12	11	4	.045	3	.017	2	.005	15	8	8	0	.013	0	.013	—	—
15	12	10	3	.038	2	.012	1	.003	15	8	7	0	.026	—	—	—	—
15	12	9	2	.028	1	.007	1	.007	15	8	6	0	.050	—	—	—	—
15	12	8	1	.018	1	.018	0	.003	15	7	15	4	.023	4	.023	3	.005
15	12	7	1	.038	0	.007	0	.007	15	7	14	3	.021	3	.021	2	.004
15	12	6	0	.017	0	.017	—	—	15	7	13	2	.014	2	.014	1	.002
15	12	5	0	.037	—	—	—	—	15	7	12	2	.032	1	.007	1	.007
15	11	15	7	.022	7	.022	6	.007	15	7	11	1	.015	1	.015	0	.002
15	11	14	6	.032	5	.011	4	.003	15	7	10	1	.032	0	.005	0	.005
15	11	13	5	.034	4	.012	3	.003	15	7	9	0	.010	0	.010	—	—
15	11	12	4	.032	3	.010	2	.003	15	7	8	0	.020	0	.020	—	—
15	11	11	3	.026	2	.008	2	.008	15	7	7	0	.038	—	—	—	—
15	11	10	2	.019	2	.019	1	.004	15	6	15	3	.015	3	.015	2	.003
15	11	9	2	.040	1	.011	0	.002	15	6	14	2	.011	2	.011	1	.002
15	11	8	1	.024	1	.024	0	.004	15	6	13	2	.031	1	.006	1	.006
15	11	7	1	.049	0	.010	0	.010	15	6	12	1	.014	1	.014	0	.002
15	11	6	0	.022	0	.022	—	—	15	6	11	1	.029	0	.004	0	.004
15	11	5	0	.046	—	—	—	—	15	6	10	0	.009	0	.009	0	.009
15	10	15	6	.017	6	.017	5	.005	15	6	9	0	.017	0	.017	—	—
15	10	14	5	.023	5	.023	4	.007	15	6	8	0	.032	—	—	—	—
15	10	13	4	.022	4	.022	3	.007	15	5	15	2	.009	2	.009	2	.009
15	10	12	3	.018	3	.018	2	.005	15	5	14	2	.032	1	.005	1	.005
15	10	11	3	.042	2	.013	1	.003	15	5	13	1	.014	1	.014	0	.001
15	10	10	2	.029	1	.007	1	.007	15	5	12	1	.031	0	.004	0	.004
15	10	9	1	.016	1	.016	0	.002	15	5	11	0	.008	0	.008	0	.008
15	10	8	1	.034	0	.006	0	.006	15	5	10	0	.016	0	.016	—	—
15	10	7	0	.013	0	.013	—	—	15	5	9	0	.030	—	—	—	—
15	10	6	0	.028	—	—	—	—	15	4	15	2	.035	1	.004	1	.004
15	9	15	6	.042	5	.012	4	.003	15	4	14	1	.016	1	.016	0	.001
15	9	14	5	.047	4	.015	3	.004	15	4	13	1	.037	0	.004	0	.004
15	9	13	4	.042	3	.013	2	.003	15	4	12	0	.009	0	.009	0	.009
15	9	12	3	.032	2	.009	2	.009	15	4	11	0	.018	0	.018	—	—
15	9	11	2	.021	2	.021	1	.005	15	4	10	0	.033	—	—	—	—
15	9	10	2	.045	1	.011	0	.002	15	3	15	1	.020	1	.020	0	.001
15	9	9	1	.024	1	.024	0	.004	15	3	14	0	.005	0	.005	0	.005
15	9	8	1	.048	0	.009	0	.009	15	3	13	0	.012	0	.012	—	—
15	9	7	0	.019	0	.019	—	—	15	3	12	0	.025	0	.025	—	—
15	9	6	0	.037	—	—	—	—	15	3	11	0	.043	—	—	—	—
15	8	15	5	.032	4	.008	4	.008	15	2	15	0	.007	0	.007	0	.007
15	8	14	4	.033	3	.009	3	.009	15	2	14	0	.022	0	.022	—	—
15	8	13	3	.026	2	.006	2	.006	15	2	13	0	.044	—	—	—	—
15	8	12	2	.017	2	.017	1	.003									
15	8	11	2	.037	1	.008	1	.008	23	10	21	5	.016	5	.016	4	.004
									32	13	32	10	.020	10	.020	9	.005

Table A.8 Sample Sizes for Comparing Two Proportions with a One-Sided Fisher's Exact Test in 2 × 2 Tables

Let P_A and P_B be the true proportions in two populations. The sample size, N, for two equally sized groups is tabulated for one-sided significance level α and probability β of not rejecting the null hypothesis. Each rectangular portion of the table contains sample sizes for *two* pairs of α and β values, one above the diagonal and one below it. The arcsine approximation was used to estimate N.

P_A	P_B							$\alpha = .01$ and $\beta = .01$						
	.001	.01	.05	.10	.15	.20	.25	.30	.40	.50	.60	.70	.80	.90
.001	—	2305	288	129	81	58	45	37	26	20	15	12	10	8
.01	1679	—	689	221	123	82	61	48	32	24	18	14	11	9
.05	210	502	—	1169	366	191	122	87	52	35	25	19	14	11
.10	94	161	852	—	1877	538	266	163	83	51	34	25	18	13
.15	59	90	266	1368	—	2489	683	327	132	73	46	31	22	15
.20	43	60	140	392	1814	—	3012	805	222	105	61	39	27	18
.25	33	44	89	194	498	2194	—	3447	417	158	83	50	32	21
.30	27	35	63	119	239	587	2511	—	981	256	116	64	39	25
.40	19	24	38	60	96	162	304	715	—	1068	267	116	61	34
.50	14	17	26	37	53	77	116	187	778	—	1068	256	105	51
.60	11	13	19	25	34	45	61	84	195	778	—	981	222	83
.70	9	10	14	18	23	29	37	47	84	187	715	—	805	163
.80	7	8	11	13	16	20	24	29	45	77	162	587	—	538
.90	6	6	8	10	11	13	15	18	25	37	60	119	392	—
							$\alpha = .01$ and $\beta = .05$ (or $\alpha = .05$ and $\beta = .01$)							

P_A	P_B						$\alpha = .025$ and $\beta = .05$ (or $\alpha = .05$ and $\beta = .025$)							
	.001	.01	.05	.10	.15	.20	.25	.30	.40	.50	.60	.70	.80	.90
.001	—	1384	173	78	49	35	27	22	16	12	9	8	6	5
.01	1119	—	414	133	74	50	37	29	20	14	11	9	7	5
.05	140	335	—	702	220	115	74	52	31	21	15	12	9	7
.10	63	108	568	—	1127	323	160	98	50	31	21	15	11	8
.15	40	60	178	911	—	1494	410	197	79	44	28	19	13	9
.20	29	40	93	261	1208	—	1808	483	133	63	37	24	16	11
.25	22	30	60	129	332	1462	—	2069	251	95	50	30	20	13
.30	18	23	42	79	159	391	1673	—	589	154	70	39	24	15
.40	13	16	25	40	64	108	203	476	—	641	161	70	37	21
.50	10	12	17	25	35	51	77	125	519	—	641	154	63	31
.60	8	9	13	17	23	30	40	56	130	519	—	589	133	50
.70	6	7	9	12	15	19	25	32	56	125	476	—	483	98
.80	5	6	7	9	11	13	16	19	30	51	108	391	—	323
.90	4	4	6	7	8	9	10	12	17	25	40	79	261	—
							$\alpha = .025$ and $\beta = .10$ (or $\alpha = .10$ and $\beta = .025$)							

P_A	P_B							$\alpha = .05$ and $\beta = .05$						
	.001	.01	.05	.10	.15	.20	.25	.30	.40	.50	.60	.70	.80	.90
.001	—	1152	144	65	41	29	23	19	13	10	8	6	5	4
.01	912	—	345	111	62	41	31	24	16	12	9	7	6	5
.05	114	273	—	585	183	96	61	44	26	18	13	10	7	6
.10	51	88	463	—	939	269	133	82	42	26	17	13	9	7
.15	32	49	145	743	—	1245	342	164	66	36	23	16	11	8
.20	23	33	76	213	985	—	1506	403	111	53	31	20	14	9
.25	18	24	49	106	271	1192	—	1723	209	79	42	25	16	11
.30	15	19	35	65	130	319	1364	—	491	128	58	32	20	13
.40	11	13	21	33	52	88	165	388	—	534	134	58	31	17
.50	8	10	14	20	29	42	63	102	423	—	534	128	53	26
.60	6	7	10	14	18	24	33	46	106	423	—	491	111	42
.70	5	6	8	10	13	16	20	26	46	102	388	—	403	82
.80	4	5	6	7	9	11	13	16	24	42	88	319	—	269
.90	3	4	5	5	6	7	9	10	14	20	33	65	213	—
							$\alpha = .05$ and $\beta = .10$ (or $\alpha = .10$ and $\beta = .05$)							

(*continued overleaf*)

Table A.8 (*continued*)

P_A	P_B	$\alpha = .10$ and $\beta = .10$												
	.001	.01	.05	.10	.15	.20	.25	.30	.40	.50	.60	.70	.80	.90
.001	—	700	88	40	25	18	14	11	8	6	5	4	3	3
.01	480	—	210	67	38	25	19	15	10	7	6	5	4	3
.05	60	144	—	355	111	58	37	27	16	11	8	6	5	4
.10	27	46	244	—	570	164	81	50	25	16	11	8	6	4
.15	17	26	77	391	—	756	208	100	40	22	14	10	7	5
.20	13	18	40	112	519	—	914	245	68	32	19	12	8	6
.25	10	13	26	56	143	628	—	1046	127	48	25	16	10	7
.30	8	10	18	34	69	168	718	—	298	78	35	20	12	8
.40	6	7	11	18	28	47	87	205	—	325	82	35	19	11
.50	4	5	8	11	15	22	33	54	223	—	325	78	32	16
.60	4	4	6	8	10	13	18	25	56	223	—	298	68	25
.70	3	3	4	6	7	9	11	14	25	54	205	—	245	50
.80	2	3	3	4	5	6	7	9	13	22	47	168	—	164
.90	2	2	3	3	4	4	5	6	8	11	18	34	112	—
	$\alpha = .10$ and $\beta = .20$ (or $\alpha = .20$ and $\beta = .10$)													

Table A.9 Critical Values for the Signed Ranks Test

For the given n, critical values for the signed ranks test are tabled corresponding to the upper one- and two-sided significance levels in the column headings.

	One-Sided α												
	.05	.025	.01	.005	.05	.025	.01	.005	.05	.025	.01	.005
	Two-Sided α												
	.10	.05	.02	.01	.10	.05	.02	.01	.10	.05	.02	.01
n					n				n				
5	1	—	—	—	20	60	52	43	37	35	214	195	174	160
6	2	1	—	—	21	68	59	49	43	36	228	208	186	171
7	4	2	0	—	22	75	66	56	49	37	242	222	198	183
8	6	4	2	0	23	83	73	62	55	38	256	235	211	195
9	8	6	3	2	24	92	81	69	61	39	271	250	224	208
10	11	8	5	3	25	101	90	77	68	40	287	264	238	221
11	14	11	7	5	26	110	98	85	76	41	303	279	252	234
12	17	14	10	7	27	120	107	93	84	42	319	295	267	248
13	21	17	13	10	28	130	117	102	92	43	336	311	281	262
14	26	21	16	13	29	141	127	111	100	44	353	327	297	277
15	30	25	20	16	30	152	137	120	109	45	371	344	313	292
16	36	30	24	19	31	163	148	130	118	46	389	361	329	307
17	41	35	28	23	32	175	159	141	128	47	408	379	345	323
18	47	40	33	28	33	188	171	151	138	48	427	397	362	339
19	54	46	38	32	34	201	183	162	149	49	446	415	380	356
										50	466	434	398	373

Table A.10 Critical Values for the Mann–Whitney (Wilcoxon) Statistic

This table presents upper one- and two-sided critical values for the Mann–Whitney U statistic. Lower one-sided critical values are computed from the upper one-sided critical value (at the same significance level) as $(M \cdot N) - U$. The Wilcoxon two-sample statistic, W, is related to U by the equation $W = (M \cdot N) + (M \cdot (M + 1)/2) - U$, where W is the sum of the ranks of the sample of size M in the combined sample.

		One-Sided α								*One-Sided α*					
		.10	.05	.025	.01	.005	.001			.10	.05	.025	.01	.005	.001
		Two-Sided α								*Two-Sided α*					
		.20	.10	.05	.02	.01	.002			.20	.10	.05	.02	.01	.002
n	*m*							*n*	*m*						
3	2	6	—	—	—	—	—	10	1	10	—	—	—	—	—
3	3	8	9	—	—	—	—	10	2	17	19	20	—	—	—
								10	3	24	26	27	29	30	—
4	2	8	—	—	—	—	—	10	4	30	33	35	37	38	40
4	3	11	12	—	—	—	—	10	5	37	39	42	44	46	49
4	4	13	15	16	—	—	—	10	6	43	46	49	52	54	57
								10	7	49	53	56	59	61	65
5	2	9	10	—	—	—	—	10	8	56	60	63	67	69	74
5	3	13	14	15	—	—	—	10	9	62	66	70	74	77	82
5	4	16	18	19	20	—	—	10	10	68	73	77	81	84	90
5	5	20	21	23	24	25	—								
								11	1	11	—	—	—	—	—
6	2	11	12	—	—	—	—	11	2	19	21	22	—	—	—
6	3	15	16	17	—	—	—	11	3	26	28	30	32	33	—
6	4	19	21	22	23	24	—	11	4	33	36	38	40	42	44
6	5	23	25	27	28	29	—	11	5	40	43	46	48	50	53
6	6	27	29	31	33	34	—	11	6	47	50	53	57	59	62
								11	7	54	58	61	65	67	71
7	2	13	14	—	—	—	—	11	8	61	65	69	73	75	80
7	3	17	19	20	21	—	—	11	9	68	72	76	81	83	89
7	4	22	24	25	27	28	—	11	10	74	79	84	88	92	98
7	5	27	29	30	32	34	—	11	11	81	87	91	96	100	106
7	6	31	34	36	38	39	42								
7	7	36	38	41	43	45	48	12	1	12	—	—	—	—	—
								12	2	20	22	23	—	—	—
8	2	14	15	16	—	—	—	12	3	28	31	32	34	35	—
8	3	19	21	22	24	—	—	12	4	36	39	41	43	45	48
8	4	25	27	28	30	31	—	12	5	43	47	49	52	54	58
8	5	30	32	34	36	38	40	12	6	51	55	58	61	63	68
8	6	35	38	40	42	44	47	12	7	58	63	66	70	72	77
8	7	40	43	46	49	50	54	12	8	66	70	74	79	81	87
8	8	45	49	51	55	57	60	12	9	73	78	82	87	90	96
								12	10	81	86	91	96	99	106
9	1	9	—	—	—	—	—	12	11	88	94	99	104	108	115
9	2	16	17	18	—	—	—	12	12	95	102	107	113	117	124
9	3	22	23	25	26	27	—								
9	4	27	30	32	33	35	—	13	1	13	—	—	—	—	—
9	5	33	36	38	40	42	44	13	2	22	24	25	26	—	—
9	6	39	42	44	47	49	52	13	3	30	33	35	37	38	—
9	7	45	48	51	54	56	60	13	4	39	42	44	47	49	51
9	8	50	54	57	61	63	67	13	5	47	50	53	56	58	62
9	9	56	60	64	67	70	74	13	6	55	59	62	66	68	73

(*continued overleaf*)

Table A.10 (***continued***)

		One-Sided α												
		.10	.05	.025	.01	.005	.001		.10	.05	.025	.01	.005	.001
		Two-Sided α												
		.20	.10	.05	.02	.01	.002		.20	.10	.05	.02	.01	.002
n	*m*							*n*	*m*					
13	7	63	67	71	75	78	83	16	12	125	132	139	146	151	161
13	8	71	76	80	84	87	93	16	13	134	143	149	157	163	173
13	9	79	84	89	94	97	103	16	14	144	153	160	168	174	185
13	10	87	93	97	103	106	113	16	15	154	163	170	179	185	197
13	11	95	101	106	112	116	123	16	16	163	173	181	190	196	208
13	12	103	109	115	121	125	133								
13	13	111	118	124	130	135	143	17	1	17	—	—	—	—	—
								17	2	28	31	32	34	—	—
14	1	14	—	—	—	—	—	17	3	39	42	45	47	49	51
14	2	23	25	27	28	—	—	17	4	50	53	57	60	62	66
14	3	32	35	37	40	41	—	17	5	60	65	68	72	75	80
14	4	41	45	47	50	52	55	17	6	71	76	80	84	87	93
14	5	50	54	57	60	63	67	17	7	81	86	91	96	100	106
14	6	59	63	67	71	73	78	17	8	91	97	102	108	112	119
14	7	67	72	76	81	83	89	17	9	101	108	114	120	124	132
14	8	76	81	86	90	94	100	17	10	112	119	125	132	136	145
14	9	85	90	95	100	104	111	17	11	122	130	136	143	148	158
14	10	93	99	104	110	114	121	17	12	132	140	147	155	160	170
14	11	102	108	114	120	124	132	17	13	142	151	158	166	172	183
14	12	110	117	123	130	134	143	17	14	153	161	169	178	184	195
14	13	119	126	132	139	144	153	17	15	163	172	180	189	195	208
14	14	127	135	141	149	154	164	17	16	173	183	191	201	207	220
								17	17	183	193	202	212	219	232
15	1	15	—	—	—	—	—								
15	2	25	27	29	30	—	—	18	1	18	—	—	—	—	—
15	3	35	38	40	42	43	—	18	2	30	32	34	36	—	—
15	4	44	48	50	53	55	59	18	3	41	45	47	50	52	54
15	5	53	57	61	64	67	71	18	4	52	56	60	63	66	69
15	6	63	67	71	75	78	83	18	5	63	68	72	76	79	84
15	7	72	77	81	86	89	95								
15	8	81	87	91	96	100	106	18	6	74	80	84	89	92	98
15	9	90	96	101	107	111	118	18	7	85	91	96	102	105	112
15	10	99	106	111	117	121	129	18	8	96	103	108	114	118	126
15	11	108	115	121	128	132	141	18	9	107	114	120	126	131	139
15	12	117	125	131	138	143	152	18	10	118	125	132	139	143	153
15	13	127	134	141	148	153	163								
15	14	136	144	151	159	164	174	18	11	129	137	143	151	156	166
15	15	145	153	161	169	174	185	18	12	139	148	155	163	169	179
								18	13	150	159	167	175	181	192
16	1	16	—	—	—	—	—	18	14	161	170	178	187	194	206
16	2	27	29	31	32	—	—	18	15	172	182	190	200	206	219
16	3	37	40	42	45	46	—	18	16	182	193	202	212	218	232
16	4	47	50	53	57	59	62	18	17	193	204	213	224	231	245
16	5	57	61	65	68	71	75	18	18	204	215	225	236	243	258
16	6	67	71	75	80	83	88								
16	7	76	82	86	91	94	101	19	1	18	19	—	—	—	—
16	8	86	92	97	102	106	113	19	2	31	34	36	37	38	—
16	9	96	102	107	113	117	125	19	3	43	47	50	53	54	57
16	10	106	112	118	124	129	137	19	4	55	59	63	67	69	73
16	11	115	122	129	135	140	149	19	5	67	72	76	80	83	88

Table A.10 (*continued*)

		One-Sided α												
		.10	.05	.025	.01	.005	.001		.10	.05	.025	.01	.005	.001
		Two-Sided α												
		.20	.10	.05	.02	.01	.002		.20	.10	.05	.02	.01	.002
n	m							n	m					
19	6	78	84	89	94	97	103	20	4	58	62	66	70	72	77
19	7	90	96	101	107	111	118	20	5	70	75	80	84	87	93
19	8	101	108	114	120	124	132	20	6	82	88	93	98	102	108
19	9	113	120	126	133	138	146	20	7	94	101	106	112	116	124
19	10	124	132	138	146	151	161	20	8	106	113	119	126	130	139
19	11	136	144	151	159	164	175	20	9	118	126	132	140	144	154
19	12	147	156	163	172	177	188	20	10	130	138	145	153	158	168
19	13	158	167	175	184	190	202	20	11	142	151	158	167	172	183
19	14	169	179	188	197	203	216	20	12	154	163	171	180	186	198
19	15	181	191	200	210	216	230	20	13	166	176	184	193	200	212
19	16	192	203	212	222	230	244	20	14	178	188	197	207	213	226
19	17	203	214	224	235	242	257	20	15	190	200	210	220	227	241
19	18	214	226	236	248	255	271	20	16	201	213	222	233	241	255
19	19	226	238	248	260	268	284	20	17	213	225	235	247	254	270
20	1	19	20	—	—	—	—	20	18	225	237	248	260	268	284
20	2	33	36	38	39	40	—	20	19	237	250	261	273	281	298
20	3	45	49	52	55	57	60	20	20	249	262	273	286	295	312

Table A.11 Critical Values of the Bivariate Normal Sample Correlation Coefficient ρ

When $\rho = 0$, the distribution is symmetric about zero; thus, one-sided lower critical values are -1 times the tabled one-sided upper critical values. Column headings are also labeled for the corresponding two-sided significance level and the percentage of the distribution less than the tabled value. N is the number of observations; the degrees of freedom is two less than this.

	Percent								Percent						
	90	95	97.5	99	99.5	99.9	99.95		90	95	97.5	99	99.5	99.9	99.95
	One-Sided α								One-Sided α						
	.10	.05	.025	.01	.005	.001	.0005		.10	.05	.025	.01	.005	.001	.0005
	Two-Sided α								Two-Sided α						
	.20	.10	.05	.02	.01	.002	.001		.20	.10	.05	.02	.01	.002	.001
N								N							
3	.951	.988	.997	1.000	1.000	1.000	1.000	20	.299	.378	.444	.516	.562	.648	.679
4	.800	.900	.950	.980	.990	.998	.999	25	.265	.337	.396	.462	.505	.588	.618
5	.687	.805	.878	.934	.959	.986	.991	30	.241	.306	.361	.423	.463	.542	.570
6	.608	.729	.811	.882	.917	.963	.974								
7	.551	.669	.755	.833	.875	.935	.951	35	.222	.283	.334	.392	.430	.505	.532
								40	.207	.264	.312	.367	.403	.474	.501
8	.507	.622	.707	.789	.834	.905	.925	45	.195	.248	.294	.346	.380	.449	.474
9	.472	.582	.666	.750	.798	.875	.898	50	.184	.235	.279	.328	.361	.427	.451
10	.443	.549	.632	.716	.765	.847	.872	55	.176	.224	.266	.313	.345	.408	.432
11	.419	.522	.602	.685	.735	.820	.847								
12	.398	.497	.576	.658	.708	.795	.823	60	.168	.214	.254	.300	.330	.391	.414
								65	.161	.206	.244	.288	.317	.376	.399
13	.380	.476	.553	.634	.684	.772	.801	70	.155	.198	.235	.278	.306	.363	.385
14	.365	.458	.533	.612	.661	.750	.780	75	.150	.191	.227	.268	.296	.351	.372
15	.351	.441	.514	.592	.641	.730	.760	80	.145	.185	.220	.260	.286	.341	.361
16	.338	.426	.497	.574	.623	.711	.742								
17	.327	.412	.482	.558	.606	.694	.725	85	.140	.180	.213	.252	.278	.331	.351
								90	.136	.175	.207	.245	.270	.322	.341
18	.317	.400	.468	.543	.590	.678	.708	95	.133	.170	.202	.238	.263	.313	.332
19	.308	.389	.456	.529	.575	.662	.693	100	.129	.165	.197	.232	.257	.305	.324

Table A.12 Critical Values for Spearman's Rank Correlation Coefficient

For a sample of size n, two-sided critical values are given for significance levels .10, .05, and .01. Reject the null hypothesis of independence if the absolute value of the sample Spearman correlation coefficient exceeds the tabled value.

	Two-Sided α		
	.10	.05	.01
n			
5	.900	—	—
6	.829	.886	—
7	.714	.786	.929
8	.643	.738	.881
9	.600	.700	.833
10	.564	.648	.794
11	.536	.618	.818
12	.497	.591	.780
13	.475	.566	.745
14	.457	.545	.716
15	.441	.525	.689
16	.425	.507	.666
17	.412	.490	.645
18	.399	.476	.625
19	.388	.462	.608
20	.377	.450	.591
21	.368	.438	.576
22	.359	.428	.562
23	.351	.418	.549
24	.343	.409	.537
25	.336	.400	.526
26	.329	.392	.515
27	.323	.385	.505
28	.317	.377	.496
29	.311	.370	.487
30	.305	.364	.478

Table A.13 Expected Values of Normal Order Statistics

A sample of $NN(0, 1)$ observations is ranked from largest (rank 1) to smallest (rank N). The expected values of the order statistics (the ranked values) are given. Only the expected values for the upper half of the order statistics are given since the expected values are symmetric about zero. The column headings give the size of the sample and the row headings the rank of the order statistic.

	Sample Size												
Rank	2	3	4	5	6	7	8	9	10	11	12	13	14
1	.56419	.34628	1.02938	1.16296	1.26721	1.35218	1.42360	1.48501	1.53875	1.58644	1.62923	1.66799	1.70338
2		.00000	.29701	.49502	.64176	.75737	.85222	.93230	1.00136	1.06192	1.11573	1.16408	1.20790
3				.00000	.20155	.35271	.47282	.57197	.65606	.72884	.79284	.84983	.90113
4						.00000	.15251	.27453	.37576	.46198	.53684	.60285	.66176
5								.00000	.12267	.22489	.31225	.38833	.45557
6										.00000	.10259	.19052	.26730
7												.00000	.08816

	Sample Size												
Rank	15	16	17	18	19	20	21	22	23	24	25	26	27
1	1.73591	1.76599	1.79394	1.82003	1.84448	1.86748	1.88917	1.90969	1.92916	1.94767	1.96531	1.98216	1.99827
2	1.24794	1.28474	1.31878	1.35041	1.37994	1.40760	1.43362	1.45816	1.48137	1.50338	1.52430	1.54423	1.56326
3	.94769	.99027	1.02946	1.06573	1.09945	1.13095	1.16047	1.18824	1.21445	1.23924	1.26275	1.28511	1.30641
4	.71488	.76317	.80738	.84812	.88586	.92098	.95380	.98459	1.01356	1.04091	1.06679	1.09135	1.11471
5	.51570	.57001	.61946	.66479	.70661	.74538	.78150	.81527	.84697	.87682	.90501	.93171	.95705
6	.33530	.39622	.45133	.50158	.54771	.59030	.62982	.66667	.70115	.73354	.76405	.79289	.82021
7	.16530	.23375	.29519	.35084	.40164	.44833	.49148	.53157	.56896	.60299	.63690	.66794	.69727
8	.00000	.07729	.14599	.20774	.26374	.31493	.36203	.40559	.44609	.48391	.51935	.55267	.58411
9			.00000	.06880	.13072	.18696	.23841	.28579	.32965	.37047	.40860	.44436	.47801
10					.00000	.06200	.11836	.16997	.21755	.26163	.30268	.34105	.37706
11							.00000	.05642	.10813	.15583	.20006	.24128	.27983
12									.00000	.05176	.09953	.14387	.18520
13											.00000	.04781	.09220
14													.00000

(*continued overleaf*)

Table A.13 (*continued*)

	Sample Size											
Rank	28	29	30	31	32	33	34	35	36	37	38	39
1	2.01371	2.02852	2.04276	2.05646	2.06967	2.08241	2.09471	2.10661	2.11812	2.12928	2.14009	2.15059
2	1.58145	1.59888	1.61560	1.63166	1.64712	1.66200	1.67636	1.69023	1.70362	1.71659	1.72914	1.74131
3	1.32674	1.34619	1.36481	1.38268	1.39985	1.41637	1.43228	1.44762	1.46244	1.47676	1.49061	1.50402
4	1.13697	1.15822	1.17855	1.19803	1.21672	1.23468	1.25196	1.26860	1.28466	1.30016	1.31514	1.32964
5	.98115	1.00414	1.02609	1.04709	1.06721	1.08652	1.10509	1.12295	1.14016	1.15677	1.17280	1.18830
6	.84615	.87084	.89439	.91688	.93841	.95905	.97886	.99790	1.01624	1.03390	1.05095	1.06741
7	.72508	.75150	.77666	.80066	.82359	.84555	.86660	.88681	.90625	.92496	.94300	.96041
8	.61385	.64205	.66885	.69438	.71875	.74204	.76435	.78574	.80629	.82605	.84508	.86343
9	.50977	.53982	.56834	.59545	.62129	.64596	.66954	.69214	.71382	.73465	.75468	.77398
10	.41096	.44298	.47329	.50206	.52943	.55552	.58043	.60427	.62710	.64902	.67009	.69035
11	.31603	.35013	.38235	.41287	.44185	.46942	.49572	.52084	.54488	.56793	.59005	.61131
12	.22389	.26023	.29449	.32686	.35755	.38669	.41444	.44091	.46620	.49042	.51363	.53592
13	.13361	.17240	.20885	.24322	.27573	.30654	.33582	.36371	.39032	.41576	.44012	.46348
14	.04442	.08588	.12473	.16126	.19572	.22832	.25924	.28863	.31663	.34336	.36892	.39340
15		.00000	.04148	.08037	.11695	.15147	.18415	.21515	.24463	.27272	.29954	.32520
16				.00000	.03890	.07552	.11009	.14282	.17388	.20342	.23159	.25849
17						.00000	.03663	.07123	.10399	.13509	.16469	.19292
18								.00000	.03461	.06739	.09853	.12817
19										.00000	.03280	.06395
20												.00000

Author Index

ALLHAT Officers and Coordinators, 804, 814
Abraham, S., 509, 517
Acheson, R. M., 492, 498, 501, 517
Acton, F. S., 326, 356
Agresti, A., 219, 251
Akaike, H., 561, 582
Akritas, M. G., 412, 425
Alderman, E. L., 273, 702, 707, 708, 791, 814, 816
Alderman, M. H., 816
Allan, I. D., 659
Amato, D. A., 765
American Statistical Association, 767, 783
Anderson, J. A., 569, 578, 582
Anderson, G. D., 707
Annegers, J. F., 656, 659
Anscombe, F. J., 307, 356
Arensberg, D., 783
Aristotle, 767
Armitage, P., 816
Armstrong, J. S., 617, 639
Arnett, F. C., 252
Arnold, S., 549
Arsenault, A., 420, 425
Arthes, F. G., 207
Ascione, F. J., 782, 783
Ashburn, W., 356, 518
Assmann, S. E., 518
Atlas, S. J., 518
Atwood, J. E., 356, 518

Baak, J. P. A., 418, 425
Bacharach, S. L., 205
Baker, A., 783
Baker, W., 205
Ballenger, J. C., 426
Bangdiwala, I. S., 426
Barboriak, J. J., 367, 425
Barker, A. H., 783
Barnett, V., 99, 115
Battezzati, M., 6, 9
Battie, M. C., 799, 814, 815
Battler, A., 356, 518
Baxter, D., 582
Baylink, D. J., 60, 289
Beauchamp, T. L., 767, 782, 783
Bednarek, E., 282, 288
Bednarek, F. J., 115, 124, 149
Belanger, A. M., 583
Benedetti, J., 784
Bennet, P. H., 116
Bennett, W. M., 426
Berger, R. L., 639, 707
Berkow, R., 80, 115
Bernstein, E. F., 252
Berry, D. A., 99
Beyer, W. H, 156, 205, 267, 288, 368, 369, 425, 718, 726
Bie, O., 707
Bigger, J. T., Jr., 772, 783
Bigos, S. J., 799, 800, 814, 815, 816
Bingham, C., 405, 427
Bingham, J. B., 356, 517
Birnbaum, Z. W., 207, 289, 426
Bishop, Y. M. M., 229, 234, 251
Bitter, J. E., 9, 251
Bitter, T., 252
Black, H. R., 782, 783
Blalock, H. M., Jr., 482, 517
Blessed, G., 816
Block, P. C., 356, 517
Bodmer, W. F., 153, 205
Borer, J. S., 196, 205, 796, 815
Borgan, O., 707
Borgen, K. T., 813, 815

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Botstein, D., 582
Boucher, C. A., 349, 352, 356, 527
Boucher, R., 426
Bourassa, M. G., 251, 252, 288, 639, 707, 814
Box, G. E. P., 402, 425, 481, 517, 775
Box, J. F., 190, 205, 775, 783
Boyd, K., 583
Bradley, J. V., 277, 278, 288
Bras, G., 416, 426
Brater, D. C., 785
Brauman, H., 425
Breiman, L., 566, 582
Breslow, N. E., 194, 205, 693, 694, 707, 708, 724, 725, 826
Brittain, E., 723, 726
Brown, B., 708
Brown, C., 206, 726
Brown, H., 762, 764
Brown, M. S., 259, 288
Brown, P. O., 582
Bruce, E., 650, 659
Bruce, R. A., 9, 293, 294, 296, 341, 345, 356, 465, 467, 514, 517, 518, 523, 545, 549, 620, 639, 659
Buchanan, W. W., 582
Bucher, K. A., 153, 159, 160, 181, 184, 185, 205
Bulpitt, C. J., 782, 783
Bunker, J. P., 654, 659
Bunney, W. E., 426
Burch, T. A., 116
Burnett, R.T., 816
Bush,T., 707
Byar, D. P., 206, 694, 708, 726

CASS Principal Investigators, 242, 251, 289, 789, 791, 815, 816
Calin, A., 252
Cameron, A., 251, 252
Campbell, D. T., 482, 517
Canale, V., 426
Cardiac Arrhythmia Pilot Study (CAPS) Investigators, 771, 783
Cardiac Arrhythmia Suppression Trial (CAST) Investigators, 771, 783
Carey, V., 759, 764
Carlin, J. B., 99, 115
Carlin, B. P., 115, 752, 764
Carrico, C. J., 583
Carroll, R. J., 326, 356
Carver, W. A., 202, 205
Casagrande, J. T., 722, 726, 727
Castelluccio, P., 761, 765
Cato, A. E., 782, 783
Cattaneo, A. D., 9
Cavalli-Sforza, L. L., 153, 205
Chaitin, G. J., 280, 289
Chaitman, B. R., 252, 604, 639, 684, 702, 707, 708, 791, 815
Chalmers, I., 782, 783
Chalmers, T. C., 206, 784
Chapin, A. M., 518
Cheadle, A., 765
Chen, L., 283, 356
Chen, J. R., 115, 146, 149, 289
Chen, N. S., 150
Chernoff, H., 194, 205
Cherry, N., 570, 582
Chikos, P. M., 369, 425
Childress, J. F., 767, 783
Chinn, N. M., 207, 252
Chow, S.-C., 782, 783
Church, J. D., 268, 289
Clark, D. A., 649, 659, 705, 707
Clark, V. A., 723, 727
Cleophas, T. H., 783
Cleophas, T. J., 782
Cleveland, W. S., 37, 39, 44, 59
Cobb, L. A., 6, 7, 9
Cochran, W. G., 387, 427, 712, 726
Coggin, C. J., 816
Cohen, H., 205
Cohen, J., 218, 251, 726
Cohen, L., 708
Cohen, L. S., 814
Coleman, C. N., 707
Coletti, A., 730, 764
Colton, T., 785
Comstock, G. W., 177, 197, 206
Conney, A. H., 149
Conover, W. J., 139, 149, 193, 206, 412, 425
Conti, C. R., 356, 518
Conway, M. D., 782, 784
Cooley, D. A., 708
Cooney, M. K., 659
Cornell, R. G., 252
Cornfield, J., 583
Coronary Drug Project Research Group, 768, 783
Corvilain, J., 417, 425
Cousac, I., 765
Cover, T. M., 560, 582
Cox, D. R., 539, 540, 549, 707, 816
Creed, F., 582
Crockett, J. E., 9
Crouch, E. A. C., 812, 815
Crowder, M. J., 762, 764
Crowley, J., 673, 694, 707, 784
Cuche, J. L., 426
Cui, L., 780, 783
Cullen, B. F., 430, 453, 457, 458, 459, 478, 517, 526, 549
Cummings, K.B., 60, 289
Curran, W. J., 785
Curreiro, F.C., 765
Cushman, M., 707

Custead, S. E., 419, 426
Cutler, S. J., 707

D'Agostino, R. B., 583
Dalen, J. E., 149
Damon, A., 519, 639
Daniel, C., 405, 425, 481, 517
David, A. S., 582
Davis, K. B., 251, 639, 707, 708, 814, 815, 816
Davison, A. C., 274, 289
Day, N. E., 194, 205, 707
Day, S., 518, 693, 694, 782, 783
DeLury, D. B., 48, 59
DeMets, D. L., 9, 772, 780, 783, 784
DeRouen, T. A., 518
DeSilva, R., 784
Delcroix, C., 425
Delgado, G., 207
Dellinger, E. P., 583
Dennett, D. C., 280, 289
Dern, R. J., 295, 296, 319, 356
Detels, R., 764
Detre, K. M., 816, 708
Devlin, S. J., 327, 356
Deyo, R. A., 518
Diaconis, P., 549, 639
Dichter, M. A., 784
Dickens, J. W., 60, 426
Diefenbach, M., 583
Diehr, P., 289, 356, 765, 784
Diggle, P., 746, 751, 753, 754, 761, 762, 763, 764
Dillard, D. H., 7, 9
Dimond, E. G., 7, 8, 9
Dingman, J., 149
Dixon, D. O., 784, 815
Dixon, W. J., 517
Dobson, J. C., 115, 142, 149, 281, 289
Doll, R., 4, 9
Dominici, F., 765
Donahue, D., 205
Donner, A., 747, 764
Draper, N. R., 333, 356, 406, 425, 481, 517
Dry, T. J., 708
Duan, N., 583, 558
Duley, L., 782, 783
Duncan, O. D., 482, 517
Dunn, G., 582
Dunnet, C. W., 532, 545, 549
Durack, F. T., 583
Dyck, A. J., 785

Echt, D. S., 771, 783
Ederer, F., 707, 782, 783
Edgington, E. S., 276, 289, 775, 783
Edwards, A. W. F., 195, 206
Edwardes, M. D., 764
Efron, B., 274, 289, 473, 517, 557, 783, 779
Eisen, M. B., 570, 582
Eisenhart, C., 385, 425
Elkins, H. B., 426
Ellenberg, S. S., 779, 781, 783, 785
Elston, R. C., 205
Elveback, L. R., 115, 659
Emerson, S., 289, 356
Enos, L. E., 518
Epstein, S. E., 205
Everitt, B. S., 229, 251, 570, 582

Faden, R. R., 782, 783
Fairclough, D. L., 782, 783
Farewell, V. T., 583, 708
Farrell, B., 782, 783
Faxon, D., 251
Federal Regulations, 767, 784
Feigl, P., 163, 206, 783
Feinleib, M., 518
Feng, Z., 782, 784
Fienberg, S. E., 229, 234, 251
Figley, M. M., 425
Finkelstein, D. M., 782, 784
Finney, D. J., 8, 9
Fisher, L. D., 194, 206, 207, 217, 243, 251, 252, 278, 288, 289, 425–427, 549, 599, 639, 659, 707, 708, 767, 780, 784, 790, 796, 814–816
Fisher, R. A., 8, 9, 45, 59, 70, 115, 182, 186, 189, 190, 202, 203, 206, 357, 425, 582
Fleiss, J. L., 8, 115, 180, 193, 206, 218, 219, 251, 721, 722, 726, 727
Fleming, T. R., 37, 59, 707, 772, 780, 783–785
Florey, C. du V., 55, 59, 416, 425, 492, 498, 501, 517
Flournoy, N., 708
Follman, D., 522, 549
Ford, D. K., 252
Fordyce, W. E., 815
Forest, W. H., Jr., 659
Forrester, J. E., 764
Foster, E. D., 815
Foy, H. M., 658, 659
Fraccaro, M., 195, 206
Francisco, R. B., 115, 149, 289
Franckson, J. R. M., 425
Frankowski, R. F., 784, 815
Fray, D., 708
Frederick, R., 659
Free, S. M. Jr., 24
Freeman, M. F., 426
French, J. A., 782, 784
Frenkel, L. D., 206, 784
Friedman, E. G., 115, 149, 289
Friedman, J. H., 582, 583
Friedman, L., 8, 9, 779, 782–784
Friedman, M., 383, 426
Friel, P., 519

Friis, R., 657, 659
Frison, L.J., 739, 741, 764
Fritz, J. K., 206, 251
Frolicher, V., 356, 518
Frommer, P. L., 815
Fuertes-de la Haba, A., 423, 424, 426
Furberg, C. D., 9, 707, 771, 784, 816

Gage, R. P., 708
Gail, M., 712–714, 726
Galton, F., 56, 59, 81, 115
Gardner, M. J., 279, 438, 517
Gehan, E. A., 668, 707
Geissler, A., 203, 206
Gelber, R., 707
Gelman, R., 698, 707
Gelman, A., 99, 115
Genest, J., 426
Gersh, B. J., 816
Gey, G. D., 535, 549
Gey, G. O., Jr., 549
Giardina, E.-G., 815
Gibson, K., 816
Giffels, J. J., 782, 784
Gillespie, M. J., 288, 815, 816
Glebatis, D. M., 206
Gnanadesikan, R., 356
Goldberg, J. D., 116, 207
Goldberger, A. S., 482, 517
Goldstein, S., 707
Golubjatnikov, R., 73, 115
Good, A. E., 252
Goodkin, D. E., 782, 784
Goodman, L. A., 231, 244, 251, 540, 549
Gorsuch, R. L., 608, 610, 616, 639
Gosselin, A., 251, 252
Gossett, W. S., 786
Gould, S. J., 46, 59, 617, 639
Graboys, T. B., 770, 784
Grady, D., 707
Graham, D. Y., 381, 383, 410, 414, 426
Grambsch, P., 693, 698, 708
Grandjean, E., 207
Graunt, J., 26, 59, 151, 206
Graybill, F. A., 482, 517
Green, B., 518
Green, M. V., 205
Green, S. B., 782, 784
Greenberg, B. G., 782, 784
Greene, G. R., 207
Greene, H. L., 783
Greenhouse, S. W., 193, 206
Greenland, S., 451, 454, 518, 765
Greenwood, M., 668, 707
Grieppe, R. B., 659, 707
Grizzle, J. E., 9, 193, 206, 207, 234, 251, 252
Gross, A. J., 691, 698, 723, 727
Gross, M., 764
Gruber, C. M., Jr., 419, 426
Guillier, L., 115
Guilogg, R. J., 782, 784
Guo, S., 519
Guttman, L., 615, 639

Haberman, S. J., 229, 234, 251
Hacking, I., 98, 99, 115
Haenszel, W., 206, 708
Hagerup, L., 74, 115
Hajek, J., 277, 280, 289
Hall, P., 558, 583
Hallman, W. K., 570, 583
Hamacher, H., 116
Hamet, P., 422, 426
Hamilton, H. B., 116
Hand, D. J., 762, 764
Hanley, J. A., 195, 206, 756, 764
Hansson, T. H., 814, 815
Hardy, R. J., 167, 206
Harrell, F. E., Jr., 571, 583, 785
Harrington, D. P., 37, 59, 707, 765
Harris, B., 268, 289
Harris, J. R., 707
Harris, R. C., 549
Harrison, D. B., 707
Harrison, D. C., 659
Haseman, J. K., 722, 727
Hastie, T., 571, 583
Hauck, W. W., 578, 583
Hauser, W. A., 659
Haynes, S. G., 493, 496, 497, 500, 518
Heagerty, P. J., 764
Hearron, M. S., 784
Heckbert, S. R. 692, 707
Heilmann, K., 811, 816
Henderson, I. C., 707
Henkin, R. I., 150, 289
Hennekens, C. H., 782, 784
Henry, R. C., 612, 639
Herrington, D., 707
Herson, J., 784, 815
Hettmansberger, T. P., 412, 426
Hieb, E., 427
Hightower, N. C., 9, 252
Hillel, A., 387–388, 426
Hinkley, D. V., 274, 289
Hitchcock, C. R., 6, 9, 209, 251
Hocking, R. R., 440, 518
Hogan, J. W., 762, 764
Holland, P. W., 251
Hollander, M., 277, 278, 289, 336, 256, 412, 426
Holmes, D. R., 816
Holmes, D., 205
Holmes, O., 116
Holt, V. L., 692, 707
Holtzman, N. A., 144, 149

Horwitz, D., 150, 289
Hosmer, D., 356, 517, 571, 583, 639
Hossack, K. F., 486, 504, 516, 518
Howard, S. V., 816
Hsu, P., 206
Hu, F.-C., 765
Hu, M., 673, 694, 707, 708
Huber, J., 418, 425
Huber, P. J., 277, 278, 280, 289, 333, 356
Huff, D., 33, 59
Hulley, S., 692, 707
Hultgren, H. N., 708, 816
Hung, H. M. J., 783
Hurlock, J. T., 259, 288
Hurvich, C. M., 454, 518
Hutchinson, G. B., 116, 207
Huther, M. L., 783
Hyde, J. S., 815

IMPACT Research Group, 771, 784
Iman, R. L., 139, 149, 412, 425
Inhorn, S. L., 115
International Conference on Harmonisation, 803, 815
Inui, T. S., 583
Ismail, K., 582

Jablon, S., 207
Jackson, G. L., 24
Jackson, S. H., 149
Janerich, D. T., 200, 206, 659
Jenkins, G. M., 481, 517
Jennison, C., 780, 784
Jensen, D., 347, 356, 500, 518
Jerina, D. M., 149
Jermini, C., 207
Jick, H., 196, 206
Johnson, C. L., 517
Johnson, R. A., 263, 289
Joiner, B. L., 404, 426
Jonas, B. S., 206
Jones, C. A., 205
Jones, M. C., 617, 639
Jones, R. H., 569, 583
Joosens, J. V., 772, 784
Judkins, M. P., 251, 252, 639, 707
Julian, D., 785

Kagan, A., 60
Kahneman, D., 108, 116
Kaiser, G. C., 251, 288, 707, 708, 791, 814–816
Kaiser, G. W., 206
Kalb, S., 427
Kalbfleisch, J. D., 652, 659, 693, 698, 707, 708
Kang, H., 583
Kannel, W. B., 518, 583
Kapitulnik, J., 144, 149
Kaplan, E. L., 707
Kaplan, R. C., 707
Kaptchuk, T. J., 782, 784
Karlowski, T. R., 153, 206, 774, 784
Kaslow, R. A., 730, 764
Kasten, L. E., 518
Kato, H., 60, 116, 290
Kaufman, D. W., 207
Kay, G. L., 519
Kazan, A., 116, 290
Kealey, K. A., 785
Keating, F. R., Jr., 115
Keller, R. B., 448, 518
Keller, S. E., 415, 426
Kelsey, J. L., 167, 206
Kemp, H. G., 251, 252
Kempthorne, O., 782, 784
Kendall, M. G., 8, 9, 194, 206, 326, 356
Kennedy, J. W., 158, 206, 240, 251, 252, 708
Kenny, G. E., 659
Kent, K. M., 205
Kernic, M. A., 707
Kertes, P. J., 782, 784
Kesteloot, H., 74, 75, 116, 772, 784
Kettenring, J. R., 356
Khachaturian, Z. S., 815
Killip, T., 639, 814–816, 707, 708
Kim, J.-O., 608, 639
Kipen, H. M., 583
Kirkman, H. N. Jr., 205
Kirsner, J. B., 9, 252
Kittle, C. F., 9
Klar, N., 747, 764
Klein, J. P., 693, 707
Kleinbaum, D. G., 234, 252, 454, 518, 693, 707
Knoke, J. D., 558, 583
Koblin, B. A., 764
Koch, G. G., 251
Koenig, J., 765
Koepsell, T. D., 573, 583, 747, 761
Kolb, S., 150
Kopin, I. J., 426
Kosinski, A. S., 816
Kouchakas, N., 708
Kowey, P. R., 785, 796, 815
Kraemer, H. C., 219, 252
Kraft, C. H., 277, 289
Krewski, D., 816
Kronmal, R. A., 331, 356, 707, 815
Kruskal, W. H., 8, 9, 116, 100, 231, 233, 251, 426
Kuchel, O., 426
Kupper, L. L., 252, 481, 518
Kushida, E., 115, 149, 289
Kusumi, F., 356, 517, 518, 639

LaCroix, A. Z., 707
Labarthe, D. R., 659
Lachenbruch, P. A., 571, 583

Lachin, J. M., 722, 727
Laird, N. M., 749, 760, 762, 764, 765
Lake, C. R., 205, 417, 426
Lan, K. K. G., 780, 784
Larson, E. B., 816
Latscha, R., 206
Lawson, D. H., 196, 206
Layfield, L. J., 284, 289, 376, 378, 379 401, 426
Le Bel, E., 425
Leachman, R. E., 708
Lebowitz, M. D., 729, 765
Lee, E. W., 759, 765
Lee, J.W., 765
Lehmann, E. L., 194, 205, 277, 289
Lehtonen, R., 103, 116
Leier, C. V., 785, 815
Lemeshow, S., 103, 116, 571, 583
Lennard, E. S., 583
Lepley, D., Jr., 425
Leppik, I. E., 784
Lesperance, J., 251, 252
Leurgans, S., 519
Leventhal, H., 583
Levin, B., 790, 816
Levin, W., 149
Levine, F. H., 356
Levine, R. B., 517
Levine, S., 518
Levine, F., 707
Levy, D., 583
Levy, P. S., 103, 116
Levy, R. H., 549
Lewis, T. L., 206, 784
Li, C.C., 482, 518
Li, K-C, 558, 583
Liang, K.-Y., 754, 756, 758, 764, 765
Liebson, P. R., 783
Liestol, K., 707
Lifton, R. J., 766, 784
Lin, L. I., 816
Lin, D., 698, 707, 765
Link, R. F., 9
Linn, M. C., 808, 815
Lippman-Hand, A., 195, 206
Lipsitz, S., 758, 765
Lipton, M., 708, 816
Little, R. J. A., 193, 206, 453, 455, 518, 761, 765, 777, 785
Litwin, P., 707
Liu, J.-P., 782, 783
Lohr, S., 103, 116
Looney, S. W., 391, 426
Louis, T. A., 99, 115, 752, 764
Lowenthal, D. T., 785, 815
Lown, B., 784
Lubin, J. H., 727
Luce, R. D., 52, 59
Lucier, E., 425
Lumley, T., 254, 289, 333, 356, 693, 707, 765, 803, 816
Lynch, J. M., 206, 784

MacKenzie, W. A., 206
MacMahon, B., 252
Macfarlane, G. J., 582
Maclure, M., 219, 252
Mainland, D., 8, 9
Maki, D. G., 215, 216, 252
Maldonado, G., 454, 518
Manly, B. F., 289
Mann, N. R., 691, 707
Mann, S. L., 785
Manolio, T. A., 707
Mantel, H., 723, 727
Mantel, N., 193, 194, 206, 694, 724, 816, 708
Marascuilo, L. A., 277, 278, 289
Marek, P. M., 785
Martin, D. C., 727, 765
Martin, N. A., 814, 816
Masi, A. T., 207, 252
Mason, R. L., 440, 518
Massart, P., 279, 289
Mathieu, M., 780, 785
Matthews, J. N., 782, 785
Maynard, C., 251, 252, 288, 639, 707
Mazze, R. I., 142, 149
McCabe, C. H., 252
McCullagh, P., 754, 765
McDonald, R. P., 617, 639
McFadden, E., 782, 785
McFarland, R. A., 519, 639
McHarcy, G., 9, 252
McKean, J. W., 412, 426
McKeown, T., 239, 252
McKirnan, M. D., 356, 518
McLerran, D., 784
McPherson, K., 816
McSweeney, M., 277, 278, 289
Mehta, J., 341, 346, 347, 356, 485, 518
Meier, P., 23, 24, 693, 707
Meinert, C. L., 8, 9, 779, 782, 785
Mellits, E. D., 149
Mendel, G., 50, 60, 189, 206
Mendlowitz, M., 54, 60, 281, 290
Merendino, K. A., 9
Messerli, E. F. H., 785, 815
Messmer, B. J., 676, 708
Metz, S. A., 60, 289
Metzger, D. S., 764
Meyer, K. K., 549
Meyer, M. B., 166, 206
Miall, W. E., 59
Miall, W. I., 425
Mickey, R. M., 454, 518

Miettinen, O. S., 194, 206, 207
Miller, N. E., 426
Miller, R. G., 531, 543, 549, 708
Miller, R. H., 205
Miller, T. E., 115, 149, 289
Miller, M., 116
Milner, R. D. G., 59, 425
Minshew, H., 583
Mitchell, B., 783
Mitchell, N., 149
Mock, M. B., 288, 639, 707, 708, 814–816
Moeschberger, M. L., 693, 707
Molenberghs, G., 746, 751, 761, 762, 765
Mood, A. M., 8, 9
Mooney, N. A., 518
Moore, D. H., 289
Moore, D. S., 116
Morehead, J. E., 239, 252
Mori, M., 698, 708
Morrison, D. R., 595, 639
Morrison, D. F., 482, 518
Moses, L. E., 39, 60
Mosteller, F., 9, 100, 116, 520, 549, 659
Mudd, J. G., 206, 251
Mueller, C. W., 608, 639
Mulay, M., 782, 785
Muller, K. G., 252
Multiple Risks Factor Intervention Group, 540, 549
Murphy, E. A., 10, 11, 16
Myers, W. O., 206, 251, 707, 791, 815, 816

Nachemson, A. L., 814–816
Najjar, M. F., 517
Nam, J. M., 712, 727
Nanjundappa, G., 659
Narens, L., 52, 59
National Cancer Institute, 640, 642, 653, 659
National Center for Health Statistics, 653, 657, 660
Negassa, A., 764
Nelder, J. A., 754, 765
Nelson, J. C., 219, 252
Neutra, R., 102, 116
New, M. I., 426
Newman, J. R., 26, 60, 206
Newman, T. G., 289
Neyman, J., 331, 356, 447, 518
Nichaman, M. Z., 116
Nicoloff, M., 252
Nicolson, G. L., 419, 426
Nochlin, D., 816
Noda, A., 252
Nora, J. J., 708
Norleans, M. X., 782, 785

O'Brien, P. C., 522, 538, 549, 780, 785
Oberman, A., 708, 816
Obias-Manno, D., 783
Odeh, R. E., 156, 207, 267, 289, 383, 384, 42
Odell, P. L., 289
Okada, R. D., 356, 517
Olsen, G. D., 414, 426
Olshen, R. A., 582
Ord, K., 549
Osbakken, M. D., 356, 517
Ostrow, D. G., 764
Ounsted, C., 196, 207
Owen, D. B., 157, 207, 267, 389, 426

Paatero, P., 612, 639
Packer, M., 785
Page, E. B., 412, 426
Pahkinen, E. J., 103, 116
Pahor, M., 816
Papworth, M. H., 16, 24
Parker, R. L., 668, 708
Partridge, K. B., 177, 197, 206
Paskey, T., 115
Passamani, E. R., 669, 678, 708, 791, 815, 816
Patil, K., 194, 206
Patrick, D. L., 518
Patten, C., 387–389, 426
Patterson, A. M., 205
Peace, K. E., 784, 815
Pearl, J., 455, 518
Pepe, M. S., 219, 252, 698, 708
Pepine, C. J., 356, 518
Periyakol, V. S., 252
Perrin, E. B., 765
Peter, E. T., 252
Peters, R. W., 783
Peterson, A. P., 278, 289
Peterson, A. V., 708, 782, 784, 785
Peterson, D. R., 145, 237, 252, 258, 278, 281, 297, 207, 549
Peto, J., 708, 816
Peto, R., 708, 790, 816
Pettet, G., 549
Pettinger, M., 814
Phillips, H. R., 356, 517
Phost, G. M., 356
Piantadosi, S., 782, 785
Piemme, T. E., 9
Pieters, R. S., 9
Pike, M. C., 702, 708, 722, 726, 727, 816
Pine, R. W., 552, 556, 562, 578, 583
Piper, J. M., 206
Pitt, B., 782, 785
Pocock, S. J., 454, 518, 539, 540, 549, 739, 741, 764, 782, 784, 785
Podrid, P. J., 784
Pohost, G. B., 517
Polednak, A. P., 658, 660
Pope, A., 766, 785

Poppers, J., 149
Porter, G. A., 426
Porter, I. H., 659
Porter, R. J., 782, 785
Post, R. M., 426
Pratt, C. M., 772, 785, 815
Preisser, J. S., 761
Prendergast, J. J., Jr., 659
Prentice, R. L., 652, 659, 693, 698, 702, 707, 708, 770, 782, 785
Prescott, R., 762, 764
Preston, T. A, 788, 816
Pritchett, E. L. C., 785
Proschan, M., 522, 549
Psaty, B., 707, 765, 804, 816

Quesenberry, P. D., 40, 56, 60, 401–403, 426

R Foundation for Statistical Computing, 38, 60
Raab, G. M., 454, 518
Ramsey, T. O., 806, 816
Rascati, K. L., 286, 289
Ratcliff, J. D., 6, 9
Ratney, R. S., 421, 426
Record, R. G., 252
Redmond, C. K., 782, 785
Reeck, G. R., 599, 639
Reiser, S. J., 767, 785
Remein, Q. R., 177, 198, 199, 207
Reynolds, H. T., 229, 233, 234, 252
Rhoads, G. G., 116
Richardson, D. W., 783
Rickman, R., 141, 149
Rieder, S. V., 116
Rifkind, A. B., 414, 426
Riggs, B., 707
Riley, V., 20, 24
Rimm, A., 425
Ringgvist, I., 288, 639, 707, 708
Ripley, B. D., 276, 289, 571, 583
Rising, G. R., 9
Rivara, F. P., 707
Roberts, J., 509, 518
Robertson, L. S., 212, 232, 235, 243, 252
Robertson, R. P., 58, 60, 284, 289
Robertson, T. L., 814
Robin, J. M., 761
Robinette, C. D., 201, 202, 207
Robins, J. M., 447, 518, 763, 765
Rodeheffer, R. J., 147, 149
Roethlisberger, F. S., 11, 24
Rogers, W. J., 791, 816, 639, 707, 708
Roloff, D. W., 115, 124, 149, 282, 288
Romner, J. A., 149
Rornik, D., 816
Rosenbaum, P. R., 452, 518
Rosenberg, L., 198, 207
Rosenblatt, J. R., 404, 426
Rosing, D. R., 205
Ross, J., Jr., 356, 518
Ross, M. H., 416, 426
Roth, M., 816
Rothman, K., 451, 518, 522, 549
Rotnitzky, A., 765
Rowland, R. E., 660
Royal Statistical Society, 767, 785
Rubin, D. B., 115, 447, 452, 453, 455, 518, 761, 765, 777, 785
Rudick, R. A., 782, 784
Ruffin, J. M., 6, 9, 209, 252
Ruiz, E., 9, 251
Runes, D. D., 116
Ruppert, D., 356
Rush, D., 147, 150
Rushforth, N. B., 77, 116
Ruskin, J. N., 772, 785, 815
Russell, R. O., 708
Rutledge, F., 207
Ryan, B. F., 426
Ryan, T. J., 206, 251, 252, 708, 815, 816
Ryan, T. A., Jr., 405, 426

Sachs, S. T., 116, 290
Sacks, S. T., 60
Sales, J., 518
Samet, J. M, 730, 765
Santiago, G., 426
Sarafin, H. W., 252
Sartwell, P. E., 179, 199, 207
Savage, I. R., 8, 9, 99, 116
Savage, L. J., 570, 583
Schafer, J. L., 761, 765
Schafer, R. C., 707
Schaff, H. V., 816
Schechter, P. J., 143, 160, 283, 289
Scheffe, H., 406, 407, 426
Schellenbaum, G., 816
Schleifer, S. J., 426
Schlesselman, J. J., 207, 721, 723, 726, 727
Schliftman, A., 9
Schloss, M., 252, 707
Schoenberg, B. S., 782, 785
Schoenfeld, D. A., 782, 784
Schouten, H. J. A., 780, 785
Schroeder, J. S., 659, 707
Schroeder, S. A., 5–7, 9
Schuster, J. J., 721, 727
Schwab, B., 35, 36, 60
Schweder, T., 539, 549
Scotch, N., 518
Seage, G.R., 764
Sen, P. K., 207
Shapiro, G., 765
Shapiro, S., 116, 166, 207
Sheffield, L. T., 816

Shemanski, L. R., 356
Sheon, A. R., 764
Shepard, D. S., 102, 116
Sheppard, L., 765
Sherwin, R. P., 284, 289, 376, 378, 379, 401, 426
Shook, T. L., 519
Shouten, H. J. A., 780
Shreider, Yu A., 289
Shue, G. L., 149
Shull, H., 9, 252
Shumway, N. E., 659, 707
Sibson, R., 617, 639
Sidak, Z., 280, 289
Siegel, S., 277, 289
Silbershatz, H., 583
Silman, A., 582
Silverman, C., 207
Simes, J. M. C. 706
Singer, D. E., 518
Singer, B., 566, 571, 583
Singpurwalla, N. D., 707
Siskin, B., 816
Skalko, R. G., 659
Skov, F., 115
Slevin, M., 782, 785
Slone, D., 207
Slovic, P., 116, 813, 816
Smedley, J., 582
Smith, C. R., 149
Smith, H., 333, 356, 406, 425, 481, 517
Smith, H. E., 207
Smith, J. P., 196, 207
Smith, M. J., 289
Smith, P. C., 726
Smith, P. G, 816
Snedecor, G. W., 387, 427
Snell, E. J., 539, 549
Sosin, H., 252
Spanos, A., 565, 583
Spellman, P. T., 582
Spengler, D. M., 814–816
Spicker, S. F., 16, 24
Spilker, B., 782, 785
Spjotvoll, E., 539, 549
Squires, K. C., 143, 150
Staller, J., 816
Stanley, J. C., 482, 517
Stanley, W. B., 391, 426
Stark, R. M., 205
Starkweather, D. B., 629, 639
Starmer, C. F., 193, 207, 251
Starr, A., 150
Starr, J. S., 707
Stefanski, L. A., 356
Stehney, A. F., 660
Stein, M., 426
Stein, Z., 150
Steinberg, A. G., 116
Stephenson, J., 785
Stern, H. S., 115
Sternberg, D. E., 426
Stinson, E. B., 659, 707
Stockdale, S. L., 427
Stolley, P. D., 207
Stone, C. J., 582
Storey, J. D., 539, 549
Stoudt, H. W., 498, 499, 503, 519, 598, 605, 619, 639
Stram, D. O., 765
Strauss, H. W., 356, 517
Stuart, A., 8, 9, 194, 206, 326, 356, 544, 549
Student, 121, 768, 785
Sumi, M., 816
Sun, G.-W., 454, 519
Susser, M., 150
Sutherland, D., 251
Sutherland, R. D., 9
Sutton, D. H., 55, 60
Sutton, L., 782, 783
Swaye, P., 251
Szefler, S, 729, 765

Tagliaferro, A., 9
Takaro, T., 684, 791, 816, 708
Tanur, J. M., 8, 9
Taylor, S., 582
Temple, R. J., 772, 774, 781, 783, 785
Therneau, T. M., 566, 583, 693, 698, 708
Thomas, G. I., 9
Thomas, L., 768, 785
Thompson, G. L., 139, 150
Thornton, H. G., 206
Tibshirani, R., 274, 289, 473, 517, 583
Tillotson, J., 116
Time Magazine, 6, 9, 209, 252
Timm, N. H., 482, 519, 595, 639
Tomaszewski, J. E., 149
Tomlinson, B. E., 806, 816
Tonascia, J. A., 206
Toussaint, C., 425
Tremann, J. A., 427
Trimble, S., 518
Tristani, F. E., 252, 425
Truett, J. 557, 576, 577, 583
Tsai, C.-L., 454, 518
Tsiatis, A. A., 698, 708
Tufte, E. R., 39, 60
Tukey, J. W., 40, 48, 60, 289, 407, 510, 426, 427
Turnbull, B. W., 694, 708, 780, 784
Tversky, A., 108, 116
Tyras, D. H., 639, 707
Tytun, A., 726

Ulam, S. M., 280, 289
Urquhart, J., 811, 816
Ury, H. K., 722, 726, 727
U.S. Department of Agriculture, 16, 24
U.S. Department of Health, Education and Welfare, 16, 24, 193, 207, 292, 356
U.S. EPA, 520, 613

van Belle, G., 52, 60, 207, 252, 416, 417, 427, 430, 453, 457–459, 478, 482, 517, 519, 526, 549, 659, 727, 807, 816
van Eeden, C., 277, 289
van Houte, O., 74, 75, 116
van Kammen, D. P., 426
Vandam, L. D., 659
Velleman, P. F., 60
Venables, W. N., 571, 583
Verbeke, G., 746, 751, 761, 762, 765
Vereerstraeten, P., 425
Verill, S., 289
Vessey, M. P., 4, 9
Vittinghoff, E., 707
Vlachakis, N. D., 54, 60, 281, 290
von Bortkiewicz, L., 182, 207
von Mises, R., 8, 9

Wagensteen, C. H., 252
Wagner, E. H., 765
Walder, A. I., 252, 425
Wall Street Journal, 785, 793–795, 816
Wallace, S. S, 394, 402, 427
Wallis, W. A., 426
Walter, S. D., 723, 727
Wang, M. H., 814
Wang, R. I. H., 421, 417
Wang, S.-J., 783
Wangensteen, C. H., 209
Wardlaw, A. C., 416, 417, 427
Ware, J. H., 729, 749, 765
Wartenberg, D., 583
Weber, A., 152, 207
Wedel, H., 708
Wegman, D. H., 426
Wei, L. J., 759, 765
Weiner, D. A., 224, 233, 245, 247, 252
Weinstein, G. S., 790, 816
Weisberg, S., 405, 427
Weise, C. E., 252
Weiss, J., 426
Weiss, N. S., 707, 761, 765, 816
Weiss, S. T., 729, 765
Weissfeld, L., 765
Welcher, D. M., 149
Welsh, M., 659
Wertz, M. J., 583
Wessely, S., 582
Wexler, L., 243, 251, 252
Whaley, K., 582
Whitaker, T. B., 60, 426
Whitehead, A., 782, 786
Whitehead, J., 780, 786
Wigley, F., 149
Wilkens, R. F., 248, 252
Wilkerson, H. L. C., 177, 198, 199, 207
Wilkinson, L., 39, 52, 60, 810, 816
Willett, W. C., 219, 252
Williams, R., 726
Williamson, J., 582
Williamson, M., 115, 149, 289
Willius, F. A., 708
Wilson, P. W. F., 550, 583
Wilson, R., 812, 815
Winer, B. J., 387, 393, 402, 427
Winick, M., 546, 549
Winkelstein, W., Jr., 31, 32, 60, 62, 100, 111, 116, 286, 290
Wiorkowski, J. J., 295, 296, 319, 356
Wolf, M. E., 707
Wolfe, D. A., 277, 278, 289, 336, 356, 412, 426
Wood, F., 405, 425
Wood, F. S., 481, 517
Wood, S., 782, 785
World Medical Association, 767, 786
Wortley, M. D., 814, 815
Wright, S. P., 121, 535, 766, 780
Wynne, B., 813, 816

Yanez, N. D., 330, 356
Yates, F., 23, 24
Yerby, M., 519
Yu, O., 730, 765

Zapikian, A. Z., 206, 784
Zeger, S. L., 754, 756, 758, 764, 765
Zeh, J., 814–6
Zeiner-Henriksen, T., 244, 245, 252
Zelazo, N. A., 150, 427
Zelazo, P. R., 129, 150, 359, 360, 405, 418, 427
Zervas, M., 80, 116
Zhang, H., 566, 571, 583
Zhao, L. P., 765
Zhou, X.-H., 761, 765
Ziegler, M. G., 426
Zorab, R., 782, 784
Zwinderman, A. H., 783

Subject Index

2 × 2 table, 157
  correction for continuity, 193
2 × 2 tables:
  pooled estimate of odds ratios, 172
  pooling, 170
  questions of interest, 172
  strata, 170

ABO incompatibility, 153
Accuracy, 551, 558, 808
  vs precision, 104
Actuarial method, 671
Adaptive randomization, 779
Addition rule:
  expectations, 104
  probability, 66
Additivity:
  ANOVA, 397, 406, 407
  Tukey test, 407–410
Adjusted group means, in the analysis of covariance, 478
Adjusted multiple correlation coefficient, 438
Adjusted rate, 644
  standard error, 645
Agreement, 217–219
  correlation, 323
  degree, 217
  location shift, 808
  measure of, 806
  scale shift, 808
AIC, 561–563
  relation to Cp, 561
  relation to likelihood, 561
Air pollution, 804
Akaike information criterion, 561
Alternative hypothesis, 89
Analysis:
  exploratory, 37
  intent-to-treat, 790
Analysis of covariance, 473
  model, 475
Analysis of variance, 357, 358
  one-way, 357, 359, 366
  regression, 304
  two-way, 357, 370
  See also ANOVA
ANCOVA, pre-post analysis, 741
Animal model, 22
Animal welfare, 16
ANOVA, 357, 358
  additive model, 371, 372
  additivity, 406, 407
  assumptions, 397
  balanced design, 372, 373
  between-group, 365, 366
  crossed design, 393
  degrees of freedom, 373
  Durbin–Watson statistic, 406
  expected mean squares, 386
  factorial design, 391
  fixed effect, 384–386
  Friedman test, 411
  general strategy, 410
  grand mean, 365
  hierarchical design, 391, 392
  independence assumption, 406
  interaction, 370, 372, 374, 376
  Kruskal–Wallis test, 411
  Kuskal–Wallis, 368, 369
  linear model, 362
  linearity, 406
  missing data, 394
  mixed effect, 385
  model, 361
  nested design, 391, 392
  nonparametric tests, 411
  normality assumption, 403

Biostatistics: A Methodology for the Health Sciences, Second Edition, by Gerald van Belle, Lloyd D. Fisher, Patrick J. Heagerty, and Thomas S. Lumley
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ANOVA *(Continued)*
one-way, 366
ordered alternatives, 411
orthogonal design, 372
random effect, 384–386
randomized block design, 380–382
rank analysis, 412
ranks, 368, 383, 384
repeated measures, 387, 391
residual, 365
robustness, 398
simultaneous comparison, 367
split-plot design, 392, 393
two-way, 370, 380
two-way table, 375, 377
unbalance design, 393
unweighted means analysis, 396, 397
validity, 397
variance components, 385
within-group, 365, 366
ANOVA table:
for multiple regression, 432
for simple linear regression, 432
Approximation, 48
Arithmetic mean, 41, 42, 46, 53, 55
Association, 211
and change, 329
categorical variables, 231, 233
Mantel–Haenszel test, 193
regression vs correlation, 329
vs causation, 168
Attenuation, 326
AUC (area under the curve), 737
Average deviation, 44–46
Average or slope analysis, 737

B-method, 534
Backpain, 798
Balanced design, ANOVA, 372, 373
Baseline characteristics, definition, 13
Basis for variables, 586
Bayes' theorem, 176, 177, 551
Behrens–Fisher problem, 139
Berkson's fallacy, 102
Between-subject variation, 734, 749
Bias, 20
incomplete data, 729
vs precision, 104
Bias in RCTs and blinding, 776
Bills of Mortality, 151
Binary response, 151
Binomial, 151
confidence interval, 157
continuity correction, 156
hypothesis testing, 155
large sample confidence interval, 157
large sample test, 156
mean, 154
model, 153
normal approximation, 156
p-value, 156
probability, 154
significance test, 155
trial, 153
variance, 154
Binomial coefficient, 153
Binomial distribution:
and McNemar procedure, 180
and rate, 641
extra-binomial variation, 653
Binormamin rotation, 610
Bins, 44
Bioequivalence, 782
Biomedical ethics:
human experimentation, 766
principles of, 767
standards and declarations, 767
Biquartimin rotation, 610
Bivariate normal distribution, 318
equation for, 335
Blinding, 776
Block, 380
Blocking, 23
Bonferroni inequality, 534
Bonferroni method, 534
Bonferroni methods, improved, 535
Bootstrap, 274, 473
Box plot, 40, 41, 54, 58
Box-and-whiskers plot, 40
Box–Cox transformation, 399

Carcinogenicity, 781
CART algorithm, 566
Case-control study:
definition, 13
example, 4
frequency matching, 14
matched, 13
paired, 179
Categorical, data, 208, 200
Categorical variable, 29
cross-classified, 224
Causal effect, 447
average, 448
average under random sampling, 449
Causal inference:
and counterfactual outcome, 447
and potential outcomes, 447
concepts, 447
potential outcomes framework, 447
Causal models, 482
Causation:
vs association, 168
and correlation, 332
Censoring, 662, 668, 670
competing risks, 698

independent, 671
informative, 673, 698, 776
noninformative, 671, 698
See also Survival analysis
Central limit theorem, 83–85
Change, and association, 329
Change analysis, 741
discrete variable, 743
Chebyshev's inequality, 100
Chi-square, 226, 227, 232, 233
goodness of fit, 223
likelihood ratio, 226, 227, 229
multinomial model, 187
Chi-square distribution, 95
large sample, 190
mean and variance, 189
relation to F-distribution, 140, 141
relation to the normal distribution, 140, 141
Chi-square statistic, 211, 212
Chi-square test:
comparing two proportions, 160
contingency table, 160
continuity correction, 160
correction for continuity, 193
Chi-square test for trend, 214–216
Child Asthma Management Program (CAMP), 729
Cigarette smoke, 152
Classes, prediction, 550, 551
Classification, 550, 551, 556
black-box, 563
neural network, 566
noiseless, 551
underlying continuous variable, 571
Classification tree, 564–566
CART algorithm, 566
rpart software, 566
Classification variable, 357
ANOVA, 370
Clinical study, definition, 12
Clinical trial, 766. *See also* Randomized trial
Cluster analysis, 550, 570, 571
Clustered data, correlation, 745
Coefficient of correlation, 314
Coefficient of variation, 57, 193
Coefficients, in linear equation, 428
Cohort, 729
definition, 12
Cohort scale, 729
Collinear, 437
Collinearity, 434
Column percent, 213
Combining 2 x 2 tables, 170
Communality, 602
Comparative experiment:
definition, 11
similarity, 20
Comparative study:
identical twins, 21
matched pairs, 21
randomization, 21
similarity, 20
validity, 21
Comparing two proportions, 157
chi-square test, 160
confidence interval, 159
Fisher's exact test, 157
flow chart for sample size, 162
graph for sample size, 163
large sample test, 159
sample size, 161
standardized difference, 162
Comparison group, 4
Competing risks, 698
Competing treatments, 798
Compound symmetry, 391
Concordance, 808
precision and accuracy, 808
Conditional independence, 226
Conditional normal distribution, 318
Conditional probability, 67, 177
Conditioning plot, 37, 38
Confidence interval, 86, 87
binomial, 157
for correlation, 322
for odds ratio, 169, 170
for odds ratio from matched pair study, 180
Poisson mean, 194
vs hypothesis test, 93–95
Confounder, 170
Confounding:
adjustment for measured confounders, 451
definition, 451
stratified adjustment, 451
Consent, informed, 767
Consistency check, 18
Constrained factor analysis, 611
Constraint, linear, 363
Constraints, linear, 49
Contingency table, 208, 210, 224, 225, 232, 233
association, 231
chi-square test, 160
multidimensional, 234
Contingency tables, simultaneous contrasts, 540
Continuity correction, 160
binomial, 156
Continuous, variable, 34
Contrast, 525
Contrasts:
orthogonal, 542
orthonormal, 542
Control, 4
definition, 13
historical, 22
Controlled trial, 766. *See also* Randomized trial
Coronary artery surgery, 787
Correction for continuity, 193

Correlated data, 729
Correlation:
  and attenuation, 326
  and causality, 332
  and covariance, 312
  and regression, 306, 317
  and *t* test, 323
  as measure of agreement, 323
  autoregressive, 745
  banded, 745
  clustered data, 745
  coefficient, 314
  compound symmetric, 745
  confidence interval, 322
  exchangeable, 745
  Kendall rank, 327
  longitudinal, 734, 736, 745, 754
  matrix, 736
  misapplications 330. *See also* Regression and correlation
  nonparametric, 327
  Pearson product moment, 314
  population, 316
  sample, 314
  sample size, 322
  serial, 745
  Spearman rank, 327
  spurious, 330
  test of significance, 318
  variance inflation factor, 746
  within-person, 731
  working, 754, 759
Correlation coefficient, 219
Correlation structure in longitudinal data:
  autoregressive correlation, 745
  banded correlation, 754
  exchangeable model, 745
Cost-complexity penalty, 564
Counterfactual outcome, and causal inference, 447
Counting data, 151
Covariance:
  and correlation, 312
  longitudinal, 734
  matrix, 734
Covariance matrix in longitudinal analysis, 734
Covariate, 298
  time-varying, 762
Covariates:
  or covariate variables, 429
  time-varying, 729
Covariate variables, 429
Cox model, 679
  stratification in the Cox model, 693
  time dependent covariates, 691
Cox proportional hazard regression analysis, 679
Cox proportional hazards model, 679–689
  checking, 687, 688
  for adjustment, 688, 689
  interpretation, 686, 687
  stratified, 693
  time-dependent covariates, 691
  time-varying covariates, 692
  time-varying effects, 692, 693
Cox regression, 680
  checking proportional hazards, 687
  See also Cox proportional hazards model
Cox regression model, 684
Cramer's V, 232
Critical value, 89
Cross-classified categorical variables, 224
Cross-product ratio, 165
Cross-sectional study, 166
  definition, 14
Cross-validation, 561, 564–566
  10-fold, 561
  for classification tree, 564, 565
Crossed design, ANOVA, 392
Crossover experiment, definition, 12
Cumulative frequency polygon, 35
Cumulative normal distribution, 557
Cystic Fibrosis Foundation Registry, 730

Data collection, 16
  clarity of questions, 17
  consistency checks, 18
  editing and verification, 18
  forms, 16
  missing forms, 19
  pilot test, 17
  pre-testing, 17
  range checks, 18
  validity checks, 18
Data handling:
  backup, 19
  coding, 19
  computers, 19
Data management, 779
Data, multivariate, 35
Death rate:
  age-specific, 671
  instantaneous, 671
  See also Hazard rate
Decile, 40
Declaration of Helsinki, 767
Degrees of freedom, 49, 50, 227
  ANOVA, 373
Demographic data, sources, 653
Density, 70
Dependent variable, 298
Derived variable analysis, 737
  average, 737
  slope, 737, 739, 740
Descriptive statistics, 25, 39
Design, data collection forms, 16
Design of experiment, and predictor variable, 334

Deviation:
average, 44–46
median absolute, 44–46
standard, 42, 46
Direct standardization, 642
Discrete variable, 208
Discriminant function, 557, 558
Discrimination, 550
linear, 552, 556, 557
linear vs logistic, 557, 558
logistic, 552–555
noiseless, 557
sample size, 715–720
underlying continuous variable, 571
Disease duration, 652
Disease, prevalence, 177
Distribution:
binomial, 154
bivariate normal, 335
chi-square, 95
frequency, 25
hypergeometric, 158
multivariate normal, 557
normal, 73
Poisson, 181
sampling, 82
Distribution-free, 255
asymptotically, 255
Double blind, example, 5
Double blind study, definition, 14
Double-blind trial, 773
Dropout, 650, 729, 747, 759
Drug development, 780
animal studies, 780, 781
phase I, 781
phase II, 781
phase III, 781
phase IV, 781
preclinical, 780
Drug development paradigm, 780
carcinogenicity testing, 781
mutagenicity studies, 781
noninferiority studies, 781
open label extensions, 781
phase I studies, 781
phase II studies, 781
phase III studies, 781
phase IV, or post-marketing, studies, 781
preclinical phase, 780
teratogenicity studies, 781
Dummy variable, 476
Duration, and incidence, prevalence, 652
Duration of disease, 652
Durbin–Watson statistic, 406

Editing data, 18
Element, 25
Ellipsoid of concentration, 587
Empirical, 30
Empirical cumulative distribution, 32, 34
(ECD), 32
Empirical cumulative distribution function, 54
Empirical frequency, 45
Empirical frequency distribution, 30, 47
(EFD), 30
Empirical relative frequency, 42, 45
Empirical relative frequency distribution, 31, 42
(ERFD), 31
Empirical standard errors in GEE, 756
Endpoint, definition, 12
Epidemiology, 22, 640
Error rate:
apparent, 560
in-sample, 560
internal, 560
prediction, 552
training, 560
Error, rounding, 49
Errors in both variables, 324
attenuation, 326
Estimate:
interval, 63
point, 63
Estimation, 62, 63
Huber–White, 337
maximum likelihood, 194, 333
minimum chi-square criterion, 191
robust regression, 337
sandwich, 337
Ethics, 15
animal welfare, 16
Helsinki Accord, 15
human experimentation, 766, 767
informed consent, 15
Nuremberg Code, 15
principles of, 767
Ethics of randomized clinical trials, 766
Event, 640
and Poisson model, 646
multiple events per subject, 652
Event data, 661
Event history analysis, 661
Expected, 211
Expected value, 71, 212
Experimental unit, definition, 12
Experiment, definition, 11
Explanatory variables, in multiple regression, 429
Exploratory analysis, 37
Exploratory data analysis:
group means over time, 731
variation among subjects, 733
Exponential survival, 690
constant hazard rate, 690
Exposure time, 648
Extra-binomial variation, 653
Extrapolation, beyond range, 331

F-distribution, 132, 360
  degrees of freedom, 132
  relation to chi-square distribution, 140, 141
F-test, for partial multiple correlation coefficient, 444
F to enter, in stepwise multiple regression, 461
Factor analysis, 571, 599
  analytic rotation, 609
  binormamin rotation, 610
  biquartimin rotation, 610
  common part of the variance, 602
  communality, 602
  constrained factor analysis, 611
  eigenvalues or roots of the correlation matrix, 615
  factor loadings, 602
  factors, 599
  general factor, 609
  indeterminacy of the factor space, 608
  interpretation of factors, 616
  maxplane rotation, 610
  number of factors, 614
  oblimax rotation, 610
  quartimax method of rotation, 609
  residual correlation, 602
  scree plot of variances, 615
  unique or specific part of the variance, 602
  uniqueness, 602
  varimax method of rotation, 609
  visual rotation, 609
Factor loadings, 602
Factorial design, ANOVA, 391
Factorial experiment, 23
Factorial study, 23
False discovery rate (FDR), 538
False negative, 551
False negative test, 176
False positive, 551
False positive test, 176
FDA, 792
FDR, 538
First principal component, 589
Fisher, R. A., *F*-distribution, 132
Fisher's exact test, 157
Fisher's linear discrimination, 557
Fisher *Z*-transformation, 321, 399, 400
Fitted value, 226
Fixed effect, 384, 385
  ANOVA, 384–386
Fixed effects, 749
Force of mortality, 648, 671. *See also* Hazard rate
Forms:
  design, 16
  layout, 18
Frequency, 28–30
  empirical, 31
  relative, 31, 34
Frequency distribution, 25, 39, 53, 54
Friedman, ANOVA, 411
Friedman statistics, 383

Gaussian, 46
Gaussian distribution, 73. *See also* Normal distribution
GEE, 754, 758
  correlation model, 756, 757, 759
  empirical standard errors, 756, 757, 759
  model-based standard errors, 756, 759
  robustness, 754
GEE with logistic regression, 756
Generalized estimating equations, 734, 754. *See also* GEE
Generic drugs, 782
Geometric mean, 44, 46, 53, 59
Goodness-of-fit:
  chi-square, 194, 223
  in multiple regression, 468
  normal probability plots, 468
  residual plots, 468
Goodness-of-fit test:
  cell probabilities known, 186
  cell probabilities unknown, 190
  large sample property, 191
  minimum chi-square estimate, 191
Gram–Schmidt orthogonalizaton process, 543
Grand mean, 364
Graph, 33, 36
  histogram, 33
Graphics, color, 48
Graunt, Bills of Mortality, 151
Greenwood's formula, 662, 668
  for Kaplan–Meier estimate, 674

Hazard rate, 648, 671
  actuarial, 672
  and dropout, 650
  and Poisson model, 651
  comparison of two rates, 651
  definition in actuarial life tables, 672
  estimate of, 649
  interval, 672
  mathematical details, 695
  standard error of, 672
  standard error of estimate, 650
Health Insurance Portability and Accountability Act (HIPAA), 767
Helsinki Accord, 15
Hemolytic disease, 153
Heterogeneity test, for odds ratios, 173
Heteroscedasticity, 134
Hierarchical design, ANOVA, 391, 392
Hierachical hypothesis, 225
Histogram, 33, 34, 54
Historical control, 22
HIVNET Informed Consent Substudy, 730

Homogeneity of variance:
  Cochran's test, 402
  Hartley's test, 402
  testing, 400
Homogeniety of variance, ANOVA, 397
Homogeneity test:
  for odds ratios, 173
  Poisson, 186
Homoscedasticity, 134
Huber–White standard error in regression, 337
Hypergeometric distribution, 158
Hypothesis:
  alternative, 89
  choosing null, 107
  hierarchical, 225
  null, 89
Hypothesis testing, 62, 63, 87–89
  binomial, 155
  vs confidence intervals, 93–95

Improved Bonferroni methods, 535
Imputation, 777
Imputation of missing data, 761
Incidence, 641
  and duration, prevalence, 652
Incident events, 728
Identical twin study, 21
Independence, 64
  assumption for ANOVA, 397
  conditional, 226
  row and column, 211
  testing, 229
Independent censoring, 671
Independent random variables:
  mean, 127
  variance, 127
Independent variables, in multiple regression, 429
Indication for a drug, 782
Indicator variable, 476
Indirect standardization, 642, 645
Inference, 22
  and random sampling, 22
  Poisson, 184
  regression, 301
Information:
  predictive, 802
  synthesis, 798
Information criterion:
  Akaike, 561
  See also AIC
Informative censoring, 776
Informed consent, 15, 767
Instantaneous death rate, 648
Instantaneous relative risk, 686
Institutional Review Boards, 767
Intent-to-treat analyses, 775
Intent-to-treat analysis, 775, 790
Interaction, 225
  ANOVA, 370, 372, 374, 376
  antagonistic, 374
  logistic regression, 557
  synergistic, 374
Intercept, 298, 429
  sample, 430
Interim analysis, 779, 780
Interim analysis of a randomized clinical trial, 779
Interquartile range, 40, 43, 46, 53
  (IQR), 40
Interval, 52
Interval estimate, 63

Jack-knife procedures, 274, 471

Kaplan–Meier estimator, 672–674
  standard error of, 674
Kaplan–Meier survival curve, 672
  definition, 673
  Greenwood's formula, 675
Kappa, 217–219
Kendall rank correlation, 327, 328
  adjustment for ties, 336
  expected value, 328
KM estimate, 673. *See also* Kaplan–Meier estimator
Kolmogorov-Smirnov test, 265–268
  is a rank test, 279
  one sample, 279
  one-sided, 279
Kruskal–Wallis, ANOVA, 411
Kruskal-Wallis statistic, 368, 369
Kurtosis, 51

Laboratory experiment, definition, 11
Laboratory test, 5
Large sample test, binomial, 156
Last observation carried forward (LOCF), 776
Least squares fit, 430
  in multiple regression, 483
Least squares, principle, 298
Left truncation, 694
Leptokurtic, 51
Life table, 664, 671
  probability density estimate and its standard error, 696
  See also Survival curve
Likelihood principle, 544
Likelihood ratio, 223, 226, 227, 229
Linear combination of parameters, 525
Linear constraint, 49, 363
Linear discriminant, 557
Linear discrimination, 552, 557, 558
  using linear regression software, 570
Linear equation, 428
Linearity, ANOVA, 397, 406
Linear mixed models, 748
Linear model, 357, 362

Linear regression, 299
in multiple regression, 429
Location, 44, 46
Logarithm, 47, 55
natural, 47, 220
Logistic discrimination, 552
more than two groups, 569
Logistic model, 552, 558
Logistic regression, 552–555
maximum likelihood, 567–569
polytomous, 569, 570
Logit, 552, 554, 556
Log likelihood, 561, 562, 568
Log-linear model, 208, 220–229, 233, 234
Log rank test, 674–677
approximation, 676
mathematical details, 695, 696
stratified, 678, 679
Longitudinal data, 728, 762
derived variable analysis, 737
individual change, 729
missing data, 759
mixed models, 747
Longitudinal data analysis:
age, 729
AUC (area under the curve), 737
autoregressive correlation structure, 745
average or slope analysis, 737
banded correlation structure, 745
between-subject variation, 734, 749
cohort scale, 729
derived variable analysis, 737
empirical standard errors in GEE, 756
exchangeable correlation structure, 745
exploratory data analysis, 731
fixed effects, 749
GEE with logistic regression, 756
generalized estimating equations (GEE), 754
group means over time, 731
imputation of missing data, 761
linear mixed models, 748
line plots for individual study participants, 734
marginal mean, 754
missing at random (MAR) data, 760
missing completely at random (MCAR) data, 760
missing data mechanisms, 760
missing data, monotone missing data, 759
mixed models, 747
mixed models: population residuals, 752
mixed models: residual plots, 752
mixed models: within-subject residuals, 752
nested model and likelihood ratio test, 751
nonignorable (NI) missing data, 760
period, 729
pre-post analysis, 741
pre-post analysis: average change, 741
pre-post analysis: covariance adjustment, 741
pre-post analysis: mean response at follow-up, 741
pre-post binary data, 742
random effects, 749
random intercept model, 749
regression methods, 747
time-varying covariates, 729
variability within and between subjects, 733
variance inflation factor, 746
within-subject correlation, 745
within-subject covariance matrix, 734
within-subject variation, 734, 749
Longitudinal mixed models:
empirical Bayes' estimation of individual random effects, 752
population residuals, 752
residual plots, 752
within-subject residuals, 752
Longitudinal study, 728
definition, 14
Loss function, 551
defining, 570
Lost to follow-up, 667
Lower quartile, 40, 53
Lowess, 44

Main effect, 363
Mallow's Cp, 456, 561
plot, 459
Mann–Whitney U test, 262, 265. *See also* Wilcoxon rank sum test
Mantel-Haenszel test, 193
Marginal mean, 754
Marginal table, 225, 226
Markov inequality, 100
Matched case-control study, 13
frequency matching, 14
Matched pair, 179
Matched pair study, 21, 194
confidence interval for odds ratio, 180
Maximum likelihood, 194, 554, 557, 568
logistic regression, 567–569
mixed model, 751
Maximum likelihood estimation, 333
Maxplane rotation, 610
McNemar procedure, 179
Mean, 44, 45, 47, 52–54, 56
arithmetic, 41, 42, 46, 53, 55
confidence interval with known variance, 87
geometric, 44, 46, 53, 59
hypothesis testing, 87, 90–93
inference about, 85
interval estimate, 86
point estimate, 85
Mean square error, 105
Mean squares, 360
Measures of association, 231, 233
Median, 40, 44, 46, 47, 52, 53, 55, 56
confidence interval, 269

Median absolute deviation, 44–46
Mesokurtic, 51
Meta-analysis, 803
Minimum chi-square estimate, 191
Missing at random (MAR) data, 760
Missing completely at random (MCAR) data, 760
Missing data, 759–761
  ANOVA, 394–396
  imputation, 761, 777
  in randomized trial, 776
  missing at random (MAR), 760, 761
  missing completely at random (MCAR), 760
  nonignorable (NI), 760, 761
  nonresponse weighting, 761
Missing data analysis by data modeling, 761
Missing data in longitudinal analysis, 759
Missing data mechanisms, 760
Missing form, 19
Mixed effect, 385
  ANOVA, 385
Mixed model:
  categorical data, 753
  count data, 753
  linear, 750, 754
  missing data, 761
  random effect, 749
  random intercept, 749–751
  random slope, 751
  variance components, 750, 754
Mixed models:
  linear, 748
  longitudinal data, 747
  nonlinear, 762
Mixed models for longitudinal data, 747
Model:
  additive, 371
  animal, 22
  binomial, 153
  Cox, 679
  linear, 357
  linear regression, 297, 301
  log-linear, 208, 220–229, 233, 234
  logistic, 552, 558
  multinomial, 187
  multivariate, 208, 220
  Poisson, 183
  testing goodness-of-fit, 186
Model selection, stepwise, 562, 563
Model-robust regression standard error, 337
Modified intent-to-treat analyses, 775
Moment, 39, 43, 50
Moments, 41
Monotone missing data in longitudinal analysis, 759
Monte Carlo tests, 272, 273
Multicenter AIDS Cohort Study, 730
Multicenter clinica trial, *see* Randomized trial
Multicenter clinical trial, 778
Multinomial model, 187
Multiple comparison problem, 520
Multiple comparisons, 213
Multiple correlation, 437
Multiple correlation coefficient, 437
  adjusted, 438
Multiple correlation coefficient, with covariates specified, 440
Multiple logistic model, and adjusted rates, 651
Multiple partial correlation coefficient, *see* Partial multiple correlation coefficient
Multiple regression:
  model, 432
  stepwise procedures, 460
Multiplication rule:
  expectations, 104
  probability, 67
Multivariate data, 35, 36
Multivariate model, 220
Multivariate normal, 557
Multivariate normal distribution, 318, 483
Multivariate statistical model, 208
Mutagenicity studies, 781
Mutually exclusive, 65

Negative predictive value, 559
Nested design, ANOVA, 391, 392
Nested hypotheses, 228, 229, 442
  definition, 442
Network meta-analysis, 803
Neural network, 566
  software, 567
Neural networks, 566
Newman–Keuls test, 543
Nominal, 52
Nontransitivity of rank tests, 279
Nonignorable (NI) missing data, 760
Noninferiority drug studies, 781
Noninformative censoring, 671
Nonlinear, mixed models, 762
Nonlinear regression models, 482
Nonparametric, 254, 255, 278
  confidence intervals, 268
Nonparametric correlation, 327
Normal, 46
Normal approximation, to binomial, 156
Normal distribution, 73
  ANOVA, 361
  bivariate, 318
  calculating areas, 74
  conditional, 318
  formula for density, 106
  multivariate, 318, 557
  relation to chi-square distribution, 140, 141
  standard, 76
  standard score, 75
  Z score, 75

Normal random variables:
distribution of linear combination, 127
mean of linear combination, 127
variance of linear combination, 127
Normal scores, transformation, 399, 400
Normality of residual, ANOVA, 397
Null hypothesis, 89
Null value of a parameter, 138
Nuremberg Code, 15, 767

Oblimax rotation, 610
Observational and experimental studies in humans, 767
Observational study, definition, 11
Observations, paired, 179
Observed, 211
Occam's razor, 227
Odds ratio, 164, 208, 219, 555
as approximation to relative risk, 165, 168
confidence interval, 169, 170
cross-product ratio, 165
from matched pair study, 179
limitations, 193
log odds, 169
standard error, 169, 193
Odds ratios:
pooling, 172
test for heterogeneity, 173
test for homogeneity of, 173
Off-label, 782
Off-label use of a drug, 782
One-sided confidence intervals, 141
One-sided tests, 141
One-way analysis of variance, 357, 359, 366. *See also* ANOVA
One-way ANOVA:
and Bonferroni simultaneous contrasts, 535
and simultaneous S-method confidence intervals, 527
and T-method simultaneous confidence intervals, 532
Open label extensions of drug studies, 781
Ordered alternatives, ANOVA, 411
Ordered categorical variable, 231
Ordering, 26
partial, 26
Order statistics, 269
Ordinal, 52
Orthogonal contrasts, 389, 390, 542
Orthogonal design, ANOVA, 372
Outcomes, 26
Outliers, 140
in regression, 333
Over-the-counter (OTC) drugs, 777

p-value, 90
binomial, 156
Parameter, 61
Parametric, 254, 255
Partial correlation coefficient, 440
definition, 441
relation to linear multiple regression, 444
Partial F-statistic, definition, 444
Partial multiple correlation coefficient, 442
definition, 442
F-test, 444
relation to regression sums of squares, 444
Path analysis, 482
Pearson product moment correlation, 314
properties, 315
Pearson's contingency coefficient, 232
Per comparison error rate, 521
Per experiment error rate, 521
Percent:
column, 213
row, 213
total, 213
Percentage, 213
Percentile, 39, 40, 46, 56
Perceptron capacity bound, 560
Period, 729
Permutation test, 270–272
PFDR, 538
Pharmacodynamics of drugs, 781
Pharmacokinetics of drugs, 781
Phase I drug studies, 781
Phase II drug studies, 781
Phase III drug studies, 781
Phase IV, or post-marketing, studies, 781
Pilot test, 17
Pivotal variable, 117, 138
comparing two proportions, 160
confidence interval, 120
definition, 118
regression, 301
rejection region, non-rejection region, 120
Placebo, 14, 153
effect, 14
Placebo control, 773
Placebo effect, example, 5
Placebo, inactive, medication, 773
Platykurtic, 51
Plot:
box, 40, 41, 54, 58
box-and-whiskers, 40
conditioning, 37
quantile-quantile, 80
residual from mixed model, 752
Point estimate, 63
Poisson:
homogeneity test, 186
model, 183
normal approximation, 184
rule of threes, 194
square root transformation, 184

Poisson distribution, 181
and hazard, 651
and rate, 646
assumptions, 181
Poisson mean, confidence interval, 194
Polynomial regression, 465
Polytomous logistic regression, 569, 570
Pooling 2 x 2 tables, 170
Pooling odds ratios, 172
by chi-square, 173
Mantel–Haenszel approach, 175
test of significance of pooled estimate, 173
Population, 27, 61
Population parameter values, in multiple regression, 429
Positive false discovery rate, pFDR, 538
Positive predictive value, 194, 559
Post hoc analysis, 539
data driven, 539
subgroup analysis, 539
Posterior probability, 177
Potential outcomes, and causal inference, 447
Potential outcomes framework, and causal inference, 447
Power, 89, 135
and multiple comparisons, 711
by simulation, 275
calculation of, 709
cost of sampling, 711–714
for testing discrimination, 718, 719
relation to sample size, 724
Pre-post analysis, 741
Pre-post data, 728
Precision, 22, 808
vs accuracy, 104
Prediction:
accuracy, 551, 558
classification tree, 564
cost-complexity penalty, 564
error rates, 552
neural networks, 566
recursive partitioning, 564
Predictive value:
negative, 559
positive, 559
Predictor variables, 298
in multiple regression, 429
Prevalence, 177, 641
and duration, incidence, 652
effect on positive predictive value, 194
Principal component analysis, 571
Principal components, 588
first principal component, 589
k-th principal component, 589
percent of variability explained by first m principle components, 590
percent of variability explained by k-th principle component, 590
Pythagorean theorem, 591
sample total variance, 590
statistical results, 595
total variance, 590
use of covariance or correlation matrix, 594
Prior probability, 177, 551
Probability, 63
addition rule, 66
Bayesian, 98
binomial, 154
conditional, 67, 177
posterior, 177
prior, 177
relative frequency, 63
subjective, 98
Probability density function, 33, 34, 70
estimating from life table, 696
Probability distribution:
chi-square, 95
Gaussian, 73
multivariate normal, 557
normal, 73
Probability function, 69
Probability plot, normal, 405
Probability theory, randomization, 21
Product limit survival curve, 672
definition, 673
Greenwood's formula, 675
Product-limit estimator, 672. *See also* Kaplan–Meier estimator
Projection, 586
Propensity score, 452
Proportion, 35
Proportional hazard regression model, 679
instantaneous relative risk, 686
stratification in the Cox model, 693
Proportional hazards, checking, 687, 688
Prospective ascertainment of exposure, 728
Prospective study, 166
definition, 13
Protected health information (PHI), 767
Pseudorandom number generators, 280, 778
Pure error, 484
Pythagorean theorem, 591

Quality of care, 5
Quantification of uncertainty, 23
Quantile-quantile plot, 80
Quantile test, 263
Quartile:
lower, 40, 53
upper, 40, 53
Quartimax method of rotation, 609

Random assignment, example, 5
Random effect, 384, 385, 749
ANOVA, 384–386
Random effects, 749

Random intercept, 749–751
Random intercept model, 749
Random number generators, 280
Random sample, 64
  simple, 64
Random sampling, and representativeness, 22
Random slope, 751
Randomization, 21, 775
  adaptive, 779
  block, 778
  effect of, 21
  practical considerations, 778
  reasons for, 775
Randomization distribution, 775
Randomization test, 270, 272, 775
Randomized block design, 23
  ANOVA, 380–382
  ranks, 382
  and simultaneous S-method confidence intervals, 531
  and T-method simultaneous confidence intervals, 533
Randomized clinical trials:
  adaptive randomization, 779
  blinding, 776
  case report forms (CRFs), 779
  clinical, 766
  consistency checks on data, 779
  data and safety monitoring boards (DSMBs), 779
  data management and processing, 779
  Declaration of Helsinki, 767
  double-blind trial, 773
  ethics, 766
  ethics: principle of autonomy, 767
  ethics: principle of beneficence, 767
  ethics: principle of justice, 767
  ethics: principle of nonmaleficence, 767
  informed consent, 767
  Institutional Review Boards, 767
  intent-to-treat analyses, 775
  interim analysis, 779
  last observation carried forward (LOCF), 776
  modified intent-to-treat analyses, 775
  Nuremberg Code, 767
  planning: multicenter clinical trials, 778
  planning: special populations, 777
  planning: study population, 777
  preservation of type I error, importance, 779
  pseudorandom treatment assignments, 778
  randomization, 775
  randomization distribution, 775
  remote data entry, 779
  sensitivity analysis for missing data, 777
  single-blind trial, 773
  wash out period, 773
  worst case analysis with missing data, 777
Randomized controlled trials, 766
Randomized experiment, 775
Randomized trial, 766, 775
  analysis, 779
  avoiding bias in assignment, 768
  blinding, 776
  cautionary examples, 767–774
  cluster, 782
  composite endpoints, 780
  conflict of interests, 779
  data and safety monitoring, 779
  data management, 779
  double-blind, 773
  intent-to-treat, 775
  interim analysis, 779, 780
  missing data, 776
  multicenter, 778
  multiple endpoints, 780
  noncompliance, 768, 769
  phase I, 781
  phase II, 781
  phase III, 781
  phase IV, 781
  placebo control, 773
  placebo effect, 774
  run-in period, 773
  sequential analysis, 780
  single-blind, 773
  special populations, 777
  study population, 777
  surrogate outcomes, 769–772
Random variable, 68
  binomial, 151
Range, 40, 46
Range check, 18
Rank, 39
Rank analysis, ANOVA, 412
Ranking, 26
Ranks, 257, 258
  ANOVA, 383, 384
  randomized block design, 382
Rank tests, general theory, 280
Rate, 640
  adjusted, 644
  binomial assumption, 653
  comparison of two rates, 645
  crude, 642
  hazard, 648
  incidence, 641
  instantaneous death rate, 648
  multiple logistic model, 651
  standard error, 641
  standardized mortality ratio, 646
  total, 642
Rate of decline, 752
Ratio, scale, 52
RCT, 767
  randomized clinical trial, 766
  randomized controlled trial, 766
  See also Randomized trial

Receiver operating characteristic curve, 559. *See also* ROC curve
Recursive partitioning, 564–566. *See also* Classification tree
Regression:
  analysis of variance, 304
  and correlation, 306, 317
  coefficients, 301
  covariate, 298
  Cox model, 680, 682–686
  dependent variable, 298
  error, 300
  errors in both variables, 324
  estimated line, 300
  estimate of error, 301
  extrapolation beyond range, 331
  homogeneity of variance, 307
  inference, 301
  inference about future observation, 303
  inference about population mean, 302
  interpretation of slope, 332, 334
  least squares, 298
  linear, 297, 299
  linearity, 307
  logistic, 552–555
  main effect, 363
  normality, 307
  origin of the term, 333
  outliers, 333
  partitioning of variation, 305
  population line, 300
  population parameters, 300
  predictor variable, 298
  proportional hazards, 680, 682–686
  residual from, 301
  response variable, 298
  robust, 337
  robust model, 333
  test of model, 307
  t-test, 309
  through the origin, 335
  to the mean, 330
  variance of intercept, 334
  variance of predicted value, 334
  weighted, 335, 336
Regression analysis in longitudinal data, 747
Regression and correlation, misapplications, 330
Regression coefficient:
  as intercept, 298
  as slope, 298
Regression coefficients, 429
  sample, 430
Regression to the mean, 330
Regulatory statistics and game theory, 541
Rejection region, 89
Relative efficiency, 255, 278
Relative frequency, 54
Relative risk, 164, 208
  as approximated by odds ratio, 165, 168
Reliability theory, 661
Repeated measures, 728, 762
  ANOVA, 387, 391
Representative sample, 100
Representativeness, 22, 152
Residual:
  adjusted, 213
  population, 752, 753
  within-subject, 752–754
Residual correlation, factor analysis, 602
Residual plot, 752
Residuals, in multiple regression, 429
Response, binary, 151
Retrospective study, 4, 166
  definition, 13
Risk, 809
  classification scheme, 813
  comparing risks, 810
  Richter-like scale for, 810
  risk unit, 810
  safety unit, 811
Risk factor, 4
Robust, 253, 276
Robust regression model, 333
Robustness, 46
ROC curve, 559, 560, 564
  area under, 560
Rounding, 48
Rounding error, 49
Row percent, 213
Rule of threes, 194

S-method, 525
Sample, 25
  Berkson's fallacy, 102
  cluster, 102
  length-biased, 102
  multivariate, 100
  pitfalls in drawing, 101
  random, 64
  representative, 100
  simple random, 64
  stratified, 102
  survey, 102
  two-phase, 103
  unequal probability, 102
  without replacement, 101
Sample size, 161, 709
  and multiple comparisons, 711
  and power, 724
  calculations, 134
  comparing two proportions, 161
  confidence, 20
  controls per case, 714, 715
  cost of sampling, 711–714
  critical value for correlation, 322

Sample size *(Continued)*
diminishing returns, 714
figure for measurement data, 137
flow chart for comparing two proportions, 162
for case-control studies, 722, 723
for cohort studies, 721
for discrimination, 715–718
graph for comparing two proportions, 163
one normal sample for mean zero, 136
per group, 2 normal samples for equal means, 135
power for testing discrimination, 718, 719
precision, 20
purpose of study, 19
quantifying discrimination, 720
relation to coefficient of variation, 724
two normal populations, equal variances, 134
Sample space, 27
Sample variances:
heterogeneous, 134
homogenous, 134
Sampling distribution, 82
Sampling variability, 49
Scatter diagram, *see* Scatterplot
Scattergram, *see* Scatterplot
Scatterplot, 291
Scatterplot smoother, 44
Scheffe method, 525
Schoenfeld residuals, 687
Science and regulation, 792
Science and stock market, 792
Screening, 176
logit model, 194
sensitivity, 176
specificity, 176
Screening study, 709
power, 710
sample size, 710
Semiparametric, 254, 255
Sensitivity, 176, 558, 559
Sensitivity analysis, 777
Sensititivity, effect on positive predictive value, 194
Sequential analysis, 780
Shift, 31
Sign test, 256
Signed-rank test, 258
Significance level, 92
nominal vs actual, 254
Significant digits, 48
Simple contrast, 525
Simple linear regression, 430
Simple random sample, 64
Simultaneous comparison, 367
Simultaneous confidence intervals, 523
in tests for linear models, 524
Single blind study, 14, 773
Skewed, 54
Skewness, 51
Slope, 298
variance of estimate, 310
Spearman rank correlation, 327
Specificity, 176, 558, 559
effect on positive predictive value, 194
factor analysis, 602
Split sampling, 471
Split-plot design, ANOVA, 392, 393
Spread, 44, 46
Spurious correlation, 330
Squared multiple correlation coefficient, proportion of variability explained, 437
Standard deviation, 42, 46, 53, 54, 56
confidence interval for ratio, 134
Standard error, 83
difference in hazard rates, 651
estimate of hazard rate, 650
for odds ratio in matched pair study, 180
of adjusted rate, 645
standardized rate, 647
Standardization:
direct and indirect, 642
indirect, 645
Standardized distance, 135
Standardized rate:
drawbacks of, 648
incidence ratio, 646
mortality ratio, 646
standard error, 647
standard error and Poisson, 646
varying observation time, 652
Standard normal distribution, 76
Statistic, 39
Statistical inference, 22
Statistically independent, 64
Statistics:
basic ideas, 151
definition, 8
descriptive, 25, 39
goals of the book, 2
levels of knowledge, 2
origin of word, 151
the field, 1
Stem-and-leaf diagram, 48, 54, 56
Step-down stepwise procedure, 465
Step function, 34
Step-up stepwise procedure, 465
Stepwise model selection, 562, 563
Stepwise procedures in multiple regression, 460
Stratified life table analysis, direct adjustment, 698
Structural models, 482
Student–Newman–Keuls test, 543
Studentized range, 531
Student's t-distribution, 121
Study:
bias, 20
inference, 20
steps in a study, 15

Study type:
and odds ratio, 167
and relative risk, 167
case-control, 13
comparisons, 167, 168
cross-sectional, 165
double blind, 14
factorial design, 23
matched case-control, 13
matched pair, 179, 194
prospective, 13, 166
randomized block design, 23
retrospective, 13, 166
single blind, 14
Study unit, definition, 12
Sum of squares:
ANOVA, 358
between-groups, 364
partitioning, 364, 373
Supervised learning, 550
Surrogate endpoint for antiarrhythmic drugs, 770
Survival analysis, 661
adjustment by stratification, 678
censored, 662, 668
censoring, 670
competing risks, 698
constant hazard and exponential survival, 690
counting process notation, 699
Cox model, 679
Cox model with time dependent covariates, 691
Cox regression model, 684
cumulative hazard, 695
delayed entry, 694
direct adjustment of stratified life table analysis, 698
exponential regression, 690
Greenwood's formula, 662
independent censoring, 671
Kaplan–Meier survival curve, 672
left truncation, 694
lognormal distribution, 691
log-rank statistic; stratified log-rank statistic, 695
lost to follow-up, 667
multiple event types, 698
noninformative censoring, 671, 698
parametric regression, 690, 691
product limit survival curve, 672
proportional hazards model, 670
recurrent events, 694
recurrent events; intensity, 694
Schoenfeld residuals, 687
stratification in the Cox model, 693
Weibull distribution, 691
Survival curve, 661–669, 671–679
actuarial method, 664
after last observed time, 673
better confidence intervals, 696
comparison of, 674–677
confounding in comparisons, 678, 679
definition, 662
Greenwood's formula, 668
individual vs group, 696, 697
Kaplan–Meier estimate, 672–674
life table method, 664–669, 671
log rank test, 674–677
related to cumulative distribution, 661, 663
standard error, 668
stratified comparison, 678, 679
Survivorship function, 661, 662
definition, 662
See also Survival curve

t-distribution, 121
'Student', 121
and correlation, 323
degrees of freedom, 121
Gossett, W. S., 121
heavy-tailed, 122
mean, 121
percentiles, 121
variance, 121
T-method of multiple comparisons, 531
t-test:
and regression, 309
for partial correlation, 444
heterogeneous variances, 139
on ranks, 139
one-sample inference, 122
paired-data inference, 123
unequal variances, Behrens–Fisher problem, 139
Taxonomy of data, 51
Teratogenicity, 781
Test:
positive predictive value, 176
true and false negative, 176
true and false positive, 176
Test of significance, correlation, 318
Test:negative predictive value, 176
Testing for symmetry, 233
Testing independence, 229
Time dependent covariates, 691
Time scales:
age, 729
cohort, 729
period, 729
Time series analysis, 481
Time varying covariates, in longitudinal data analysis, 729
Time-series, and air pollution, 804
Time-varying covariate, 729, 762
Total percent, 213
Total variance, 590
sample, 590
Total variation, partitioning, 357
t-PA, 792

Training data, 550, 551
Training set, 550
Transformation:
  Box–Cox, 399
  correlation coefficient, 321
  Fisher-Z, 399, 400
  linearizing, 406
  normal scores, 399, 400
  power, 413
  square root for Poisson, 185
  variable, 398, 400
  variance stabilizing, 398
Transition model, 743
Treatment, placebo, 14
Trial, 153, 766
  ethics, 766, 767
  informed consent, 767
  randomized clinical, 766
  randomized controlled, 766
Trimmed mean, 276
True negative test, 176
True positive test, 176
Tshuprow's T, 232
Tukey method of multiple comparisons, 531
  extensions, 543
Tukey test, additivity in ANOVA, 407–410
Two-sample inference, 124
  independent samples, 124
  known variances, 128
  scale, variances, 132
  unknown variances, 131
Two sample test, proportions, 157
Two-way ANOVA, 357, 370
  and simultaneous S-method confidence intervals, 529
  and T-method simultaneous confidence intervals, 533
Two-way table, 210, 221, 224
Type I error, 89
Type II error, 89

Unbalanced design:
  ANOVA, 393
  causes, 393
Uncertainty, 23
  and variation, 23
  reduction of, 23
Uniqueness, factor analysis, 602
Unsupervised learning, 550
Upper quartile, 40, 53

Validity, 22
Validity check, 18
Variability:
  background, 380
  sampling, 49
Variable, 25, 28, 29
  categorical, 26, 29
  class, 550
  classification, 357
  continuous, 27, 34
  discrete, 27, 208
  ordered categorical, 231
  precision, 741
  qualitative, 26, 52
  quantitative, 26, 27, 52
  transformation, 398
Variance, 43, 53, 72
  between-group, 362
  inference about, 96
  of predicted value in regression, 334
  within-group, 361, 362
Variance components, 385, 750
Variance inflation factor, 746
Variances, sample:
  heterogeneous, 134
  homogenous, 134
Variation, 43
  between-group, 366
  between-subject, 734
  precision, 22
  validity, 22
  within-group, 366
  within-subject, 734
Varimax method of rotation, 609
Vitamin C, 153
Von Bortkiewitz, 182

Wash out period, 773
Wilcoxon rank-sum, 368
Wilcoxon rank sum test, 262, 263
  as permutation test, 272
  large samples, 264
  nontransitivity, 279
  relative power, 263
Wilcoxon signed-rank test, 258–261
  large samples, 260, 261
Winsorized mean, 276
Within-group variance, 361
Within-subject variation, 734, 749

Zero cells, 234

Symbol Index

A, 362
A_i, 385
A_m, 675
A (accuracy), 809
$\widehat{a}$, 410
$a, b_1, b_2, \ldots, b_k$, 428
a_3, 51
a_4, 51
a_i, 373
a (sample intercept), 298
a_x, 317
a_y, 317

B, 362
B_j, 385
B_i, 648
b (sample slope), 298
$b(k; n, pi)$, 154
b_{21}, 334
b_{ij}, 334
b_{xy}, 317
b_{yx}, 317
b_j, 373, 430
$b_{i,0}$, 749

C_i, 648
C, 232, 402
C_p, 456, 457, 458, 459, 561
C_{FR}, 411
C_{KW}, 411

D_{00}, 748
D_{01}, 748
D_{11}, 748
D_{ij}, 392
D_i, 648
$\overline{D}_{1\cdot}$, 393
$\overline{D}_{2\cdot}$, 393
D, 266
D^+, 279
D_m, 675
d_i, 327
d_x, 667
d_{ij}, 675
d.f., 305, 360, 362

e (error in regression), 298
$E(Y \mid X_1, \ldots, X_k)$, 429
$E(Y_i \mid X_{i1}, \ldots, X_{ik})$, 432
$E(Y_i \mid X_i)$, 431
$E(Y_{ij} \mid \beta_i)$, 748
$E(Y \mid X, Z)$, 452
$E(\text{MS})$, 365
$E[Y]$, 71
E_i, 675
E (expected rate), 646
e_{ijk}, 373, 385

F, 444
F_{MAX}, 402
F_i, 601
$F_{1,v}$, 307
$f_X(x)$, 336
$f_Y(y)$, 336
$f_{X,Y}(x, y)$, 335

g_{ij}, 373
G_{ij}, 385

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g_{ijk}, 224, 225
g_{ij}^{IJ}, 221, 222

h_i^I, 221, 222
h_j^J, 221, 222
$h_0(t)$, 679
h_x, 672

$[I]$, 225, 226
$[IJK]$, 225, 226
$[IJ]$, 225, 226
$[IK]$, 225, 226

$[J]$, 225, 226
$[JK]$, 225, 226

$[K]$, 225, 226

L_A, 650
$L(j, k)$, 551
LRX^2, 223, 227
l (estimate of λ), 184
ℓ'_x, 668
ℓ_x, 667
logit, 552
logit(p), 194

M_i, 643
$\widehat{M}_{1\bullet}$, 396
$\widehat{M}_{2\bullet}$, 396
$\widehat{M}_{\bullet\bullet}$, 396
MS, 305, 360, 362
MS_α, 365, 374, 375
MS_β, 374, 375, 382, 409
MS_ϵ, 365, 374, 375, 382, 409
MS_γ, 374, 375
MS_λ, 409
MS_{REG}, 432
MS_{RESID}, 432, 433
MS_μ, 365, 374, 375, 382, 409
MS_τ, 382, 409
m_r^*, 50

$N(\mu_x, \mu_y, \sigma_x^2, \sigma_y^2, \rho)$, 318
N_i, 643
$N_i(t)$, 699
NUM, 162
$\widetilde{n}$, 396
n, 358
$[n_1 x]$, 215
$n!$, 154
n (sample size), 161
n_i^*, 643

$n^a st$, 163
$n_{1\bullet}$, 158
n_i, 362
$n_{\bullet\bullet\bullet}$, 226
$n_{\bullet\bullet}$, 158, 211, 212, 222, 358, 371
$n_{\bullet j}$, 211, 212, 222, 358, 371
$n_{i\bullet}$, 211, 212, 222, 371
n_{ijk}, 358
n_{ij}, 210, 222, 371

O (observed number of events), 646
O'_i, 650
O_i, 648, 675

P_A, 218
P_C, 218
PREV, 194
PV^+, 194
$P[C]$, 64
$P[C|D]$, 67
$P_{x(i)}$, 668
$P[B_i|A]$ (Bayes' theorem), 178
$\widehat{p}$, 155
$p_{\bullet j}$, 230
$p_{i\bullet}$, 230
p_{ij}, 230
p_k, 551

$Q_{k,m}$, 531
$q_{k,m,1=\alpha}$, 532

$\overline{R}_{\bullet\bullet}$, 368, 383
$\overline{R}_{\bullet j}$, 383
$\overline{R}_{i\bullet}$, 368
R^2, 437
R_a^2, 439
$R_{Y(X_1,\ldots,X_k)\bullet Z_1,\ldots,Z_p}$, 442
$R_{Y(X_1,\ldots,X_k)}$, 440
$R_{\bullet j}$, 383
$R_{i\bullet}$, 368
R_{ij}, 368, 383, 760
R_{ij}^W, 752
RU(E) (Risk Unit), 810
R_{ij}^P, 752
R_i, 280
r^2, 437, 306
r (adjusted rate), 644
r (precision), 809
r_s (Spearman rank correlation), 327
r_{REF}, 646
r_{STUDY}, 646
$r_{X,Y\bullet Z}$, 441

S, 260
$S(t)$, 663
$S(t|X)$, 682
$S_{0,\text{pop}}^{\exp(\alpha+\beta_1 X_1+\cdots+\beta_p X_p)}$, 682
SENS, 194
SE($\widehat{\lambda}$), 650
SPEC, 194
SU(E) (Safety Unit), 812
$SE(b_j)$, 433
$S^2_{Y.X_1,\ldots,X_k}$, 433
$\text{SS}_{\text{MODEL FIT}}$, 484
$\text{SS}_{\text{PURE ERROR}}$, 484
SS_{REG}, 462
$\text{SS}_{\text{REG}}(X_1, \ldots, X_j)$, 443
$\text{SS}_{\text{REG}}(X_{j+1}, \ldots, X_k \mid X_1, \ldots, X_j)$, 443
$\text{SS}_{\text{REG}}(\gamma \mid X)$, 478
SS_{RESID}, 462
$\text{SS}_{\text{RESID}}(X_1, \ldots, X_j)$, 443
$\text{SS}_{\text{RESID}}(\gamma \mid X)$, 478
SS_{α}, 365, 366, 373, 374, 375
SS_{β}, 373, 374, 375, 382, 396, 409
SS_{ϵ}, 365, 366, 373, 374, 375, 382, 409
SS_{γ}, 373, 374, 375, 396
SS_{λ}, 408, 409
SS_{REG}, 432, 437
SS_{RESID}, 432
SS_{TOTAL}, 366, 373, 437
$\text{SS}_{\text{nonadditivity}}$, 408
SS_{μ}, 365, 366, 375, 382, 396, 409
SS_{τ}, 382, 409
SE(r), 645
SS, 305
s, 42
s (standardized rate), 646
s_x^2, 313
s_y^2, 313
$s^2_{y.x}$, 301
s_1 , 299
s_2, 299
s_3, 299
s_b, 307
$s_{b_{yx}}$, 318
s_{xy}, 314
s_p^2, 359, 360
$s^2_{\overline{Y}}$, 359, 360
s_i^2, 361, 362

T, 232
$\overline{T}_{1.}$, 393
$\overline{T}_{2.}$, 393
T_m, 675
T_{ij}, 392
T_{FR}, 383
T_{KW}, 368, 369
T_{PAGE}, 412
T_{TJ}, 412
t^2, 444
t_0, 648
t_1, 648
t_{ij}, 730
$t_{\nu,\alpha}$, 121

U, 265
u, 223, 224, 225
u_i, 370
u_i^I, 221, 222, 223, 224, 225
u_j^J, 221, 222, 223, 224, 225
u_k^K, 224, 225
u_{ijk}^{IJK}, 224, 225
u_{ij}^{IJ}, 224, 225
u_{ik}^{IK}, 224, 225
u_{jk}^{JK}, 224, 225
u (location shift), 808
U_i, 406

V, 232
v (scale shift), 808
v_j, 370
V_j, 406

W, 262
w_k, 451
w_x, 667
$[wx^2]$, 337
$[wxy]$, 337

$[xy]$, 298
X^2, 160, 211, 212, 223, 675
X^2_{trend}, 215
X_{ij}, 429
X_c^2, 160
X_y, 320
$\widehat{X}_j$, 442
$[x^2]$, 215, 298

$\widehat{Y}$, 442
$\widehat{Y}_i$, 298, 430
$\widehat{Y}_{ij}$, 393
$\overline{Y}_0$, 449
$\overline{Y}_0^{(k)}$, 451
$\overline{Y}_1$, 449
$\overline{Y}_1^{(k)}$, 451

$\overline{Y}_{\bullet\bullet}$, 362
$\overline{Y}_{\bullet j\bullet}$, 358
$\overline{Y}_{i\bullet}$, 362
$\overline{Y}_{ij\bullet}$, 358
$\overline{y}$, 41, 42
$Y_i - \widehat{Y}_i$, 430
Y_i, 429
$Y_i(0)$, 447
$Y_i(1)$, 447
Y_i^M, 760
Y_i^O, 760
$Y_{\bullet jk}$, 358
$Y_{\bullet\bullet\bullet}$, 373
$Y_{\bullet\bullet}$, 358
$Y_{\bullet j\bullet}$, 358
$Y_{i\bullet}$, 358
Y_{ijk}, 358, 370, 372, 385, 475, 803
Y_{ij}, 358, 361, 362, 730
$Y_i(t)$, 699
$\widehat{y}_i$, 298
$[y^2]$, 298

$Z_i(t)$, 699
Z_X, 335
Z_Y, 335
Z_c (Z statistic with continuity correction), 156
Z_r (Fisher Z transform), 321
$Z_{(i)}$, 402
z_{ij}, 213

α (population intercept), 301
$\alpha_1 = \alpha_2 = \ldots = \alpha_I = 0$, 363
α_i, 362, 363, 370, 372, 475
$\widehat{\alpha}_i$, 366

β (population slope), 301
$\beta_1 = \beta_2 = \ldots = \beta_k = 0$, 433
β_j, 370, 372, 429, 475
β_X, 444
$\widehat{\beta}_i$, 739
$\beta_{i,0}$, 739
$\beta_{i,1}$, 739
$\beta_{j+1} = \ldots = \beta_k = 0$, 443

χ^2, 95, 211, 212
χ^2_A, 173
χ^2_H, 173

δ, 413, 715
$\delta^{(k)}$, 451
$\overline{\Delta}$, 448

Δ (effect size), 162
Δ, 557
Δ_i, 447
Δ_x, 672

ϵ_i, 430, 431
ϵ_{ijk}, 370, 372, 803
ϵ_{ij}, 361, 362

γ, 232
γ_{ij}, 372

κ (in Kendall τ), 328
κ, 217, 218

λ (hazard rate), 648
λ (Poisson mean), 183
$\widehat{\lambda}$, 407, 649
λ, 231, 407
$\widehat{\lambda}_A$, 650
$\widehat{\lambda}_D$, 651
λ_C, 231
λ_R, 232
λ_{ij}, 601

μ, 71, 359, 362, 372
$\mu_1 = \mu_2 = \ldots = \mu_I = \mu$, 361, 363, 368
$\mu_1, \mu_2, \mu_3, \mu_4$, 359
μ_i, 361
μ_{ij}, 370, 754

ω, 165
$\widehat{\omega}$, 168
$\widehat{\omega}_{paired}$, 180

Φ (cumulative normal), 190
Φ, 232
Φ^2, 232

π_i^0, 187
π_0, 155
$\pi_1 \leq \pi_2 \leq \ldots \pi_k$, 214
π_i, 666
π_j, 214
π_k, 551
$\pi_{i\bullet}$, 211, 221, 229
π_{ij}, 210, 221
$\widehat{\pi}_{ijk}$, 226
$\pi_{\bullet j}$, 211, 221, 229

ψ_i, 601

ρ (population correlation), 316
ρ, 164, 714

$\widehat{\rho}$, 168
$\rho^{|t_j - t_k|}$, 745
ρ_0, 320
ρ_{jk}, 736
$\widehat{\rho}_{jk}$, 736
ρ_{VW}, 326
$\rho_{X,Y \cdot X_1,\ldots,X_k}$, 441
$\rho_{X,Y \cdot Z}$, 441
ρ_{XY}, 326

σ^2, 359, 360, 361
σ^2, 72
σ_1^2, 301
σ_2^2, 303
σ_α^2, 385
$\widehat{\sigma}^2$, 366, 433
σ_β^2, 385
σ_γ^2, 385
σ_x, 316
σ_y, 316
σ_{xy}, 316

τ (Kendall), 328
τ, 328
τ_j, 381, 383

Θ, 191
$\widehat{\Theta}_1$, 191

ξ_{ij}, 804

$\prod_i$, 666

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