STAT 517
Clinical Trials

One-sided tests
for group sequential clinical trials

Table 4.1 *Constants* $\tilde{C}_1(K,\alpha,\beta,\Delta)$, $\tilde{C}_2(K,\alpha,\beta,\Delta)$ *and* $\tilde{R}(K,\alpha,\beta,\Delta)$ *for power family one-sided tests with shape parameter* Δ. *Also shown are expected sample sizes at* $\theta = 0$, $\delta/2$ *and* δ *expressed as percentages of the corresponding fixed sample size. Tests are for* K *groups of observations, Type I error probability* $\alpha = 0.05$ *at* $\theta = 0$ *and power* $1-\beta = 0.8$ *at* $\theta = \delta$.

K	$\tilde{C}_1$	$\tilde{C}_2$	$\tilde{R}$	Expected sample size, as percentage of fixed sample size, at $\theta=0$	$\theta=\delta/2$	$\theta=\delta$
$\Delta = -0.5$						
1	1.645	0.842	1.000	100.0	100.0	100.0
2	1.632	0.870	1.012	75.3	90.9	95.7
3	1.622	0.899	1.028	72.8	86.4	87.5
4	1.621	0.916	1.041	69.0	83.5	84.9
5	1.622	0.927	1.051	67.0	82.0	83.0
10	1.628	0.956	1.080	63.8	78.9	79.6
15	1.632	0.970	1.095	62.8	78.0	78.5
20	1.635	0.978	1.104	62.4	77.5	78.0
$\Delta = -0.25$						
1	1.645	0.842	1.000	100.0	100.0	100.0
2	1.623	0.901	1.031	71.7	87.7	90.9
3	1.625	0.928	1.055	67.7	83.3	84.7
4	1.629	0.947	1.073	65.4	80.9	81.6
5	1.633	0.960	1.087	63.5	79.3	79.9
10	1.646	0.993	1.127	60.1	76.2	76.5
15	1.653	1.009	1.146	59.0	75.2	75.5
20	1.658	1.018	1.158	58.5	74.8	74.9
$\Delta = 0.0$						
1	1.645	0.842	1.000	100.0	100.0	100.0
2	1.634	0.942	1.073	69.9	84.9	85.6
3	1.645	0.978	1.113	63.4	80.2	80.9
4	1.656	0.999	1.140	60.8	77.8	78.0
5	1.664	1.015	1.161	59.2	76.3	76.2
10	1.688	1.057	1.219	55.8	73.2	72.8
15	1.700	1.076	1.247	54.7	72.1	71.7
20	1.708	1.088	1.264	54.1	71.6	71.1
$\Delta = 0.25$						
1	1.645	0.842	1.000	100.0	100.0	100.0
2	1.688	0.990	1.160	70.5	83.9	82.7
3	1.720	1.054	1.245	61.9	78.5	77.2
4	1.741	1.093	1.299	58.0	75.8	74.4
5	1.757	1.119	1.338	55.9	74.1	72.6
10	1.802	1.185	1.443	51.7	70.6	68.8
15	1.823	1.215	1.493	50.3	69.3	67.5
20	1.837	1.233	1.524	49.5	68.7	66.8

Table 4.2 *Constants* $\tilde{C}_1(K,\alpha,\beta,\Delta)$, $\tilde{C}_2(K,\alpha,\beta,\Delta)$ *and* $\tilde{R}(K,\alpha,\beta,\Delta)$ *f power family one-sided tests with shape parameter* Δ. *Also shown are expect sample sizes at* $\theta = 0$, $\delta/2$ *and* δ *expressed as percentages of the correspondi fixed sample size. Tests are for* K *groups of observations, Type I err probability* $\alpha = 0.05$ *at* $\theta = 0$ *and power* $1-\beta = 0.9$ *at* $\theta = \delta$.

K	$\tilde{C}_1$	$\tilde{C}_2$	$\tilde{R}$	Expected sample size, as percentage of fixed sample size, at $\theta=0$	$\theta=\delta/2$	$\theta=\delta$
$\Delta = -0.5$						
1	1.645	1.282	1.000	100.0	100.0	100.0
2	1.643	1.286	1.002	84.7	96.4	94.3
3	1.643	1.302	1.012	77.8	90.1	84.3
4	1.645	1.312	1.021	73.9	87.5	81.6
5	1.648	1.320	1.029	72.3	85.9	79.6
10	1.660	1.342	1.052	68.7	82.7	76.0
15	1.667	1.353	1.065	67.6	81.7	74.9
20	1.671	1.360	1.073	67.1	81.2	74.3
$\Delta = -0.25$						
1	1.645	1.282	1.000	100.0	100.0	100.0
2	1.643	1.300	1.011	77.8	92.6	87.9
3	1.650	1.320	1.030	73.9	87.5	81.3
4	1.656	1.334	1.044	70.2	84.7	77.7
5	1.662	1.344	1.055	68.2	83.2	76.0
10	1.681	1.371	1.087	64.8	80.1	72.5
15	1.690	1.384	1.104	63.7	79.1	71.4
20	1.696	1.392	1.114	63.2	78.6	70.9
$\Delta = 0.0$						
1	1.645	1.282	1.000	100.0	100.0	100.0
2	1.657	1.332	1.043	73.0	88.5	81.4
3	1.673	1.357	1.072	68.2	84.2	76.7
4	1.686	1.375	1.094	65.6	81.7	73.7
5	1.696	1.389	1.111	63.8	80.1	71.8
10	1.725	1.425	1.158	60.1	77.0	68.2
15	1.739	1.442	1.181	59.0	75.9	67.1
20	1.747	1.452	1.195	58.4	75.4	66.5
$\Delta = 0.25$						
1	1.645	1.282	1.000	100.0	100.0	100.0
2	1.710	1.389	1.121	71.4	86.2	77.8
3	1.746	1.438	1.184	64.2	81.4	72.0
4	1.770	1.469	1.225	61.0	79.0	69.1
5	1.788	1.490	1.255	59.1	77.4	67.3
10	1.836	1.546	1.336	55.2	74.1	63.5
15	1.860	1.572	1.375	53.9	72.9	62.2
20	1.874	1.588	1.400	53.2	72.3	61.5

Table 4.3 *Constants* $\tilde{C}_1(K,\alpha,\beta,\Delta)$, $\tilde{C}_2(K,\alpha,\beta,\Delta)$ *and* $\tilde{R}(K,\alpha,\beta,\Delta)$ *for power family one-sided tests with shape parameter* Δ. *Also shown are expected sample sizes at* $\theta = 0$, $\delta/2$ *and* δ *expressed as percentages of the corresponding fixed sample size. Tests are for* K *groups of observations, Type I error probability* $\alpha = 0.05$ *at* $\theta = 0$ *and power* $1-\beta = 0.95$ *at* $\theta = \delta$.

K	$\tilde{C}_1$	$\tilde{C}_2$	$\tilde{R}$	Expected sample size, as percentage of fixed sample size, at $\theta=0$	$\theta=\delta/2$	$\theta=\delta$
$\Delta = -0.5$						
1	1.645	1.645	1.000	100.0	100.0	100.0
2	1.645	1.645	1.000	91.6	98.4	91.6
3	1.650	1.650	1.006	80.7	91.9	80.7
4	1.656	1.656	1.013	77.9	89.4	77.9
5	1.661	1.661	1.019	75.8	87.7	75.8
10	1.676	1.676	1.039	72.0	84.4	72.0
15	1.685	1.685	1.049	70.9	83.3	70.9
20	1.690	1.690	1.056	70.3	82.8	70.3
$\Delta = -0.25$						
1	1.645	1.645	1.000	100.0	100.0	100.0
2	1.649	1.649	1.005	83.8	95.1	83.8
3	1.661	1.661	1.020	77.5	89.2	77.5
4	1.670	1.670	1.031	73.5	86.6	73.5
5	1.677	1.677	1.040	71.7	85.0	71.7
10	1.699	1.699	1.067	68.1	81.8	68.1
15	1.710	1.710	1.081	67.0	80.8	67.0
20	1.717	1.717	1.090	66.4	80.3	66.4
$\Delta = 0.0$						
1	1.645	1.645	1.000	100.0	100.0	100.0
2	1.668	1.668	1.028	76.6	90.5	76.6
3	1.687	1.687	1.052	72.2	86.0	72.2
4	1.702	1.702	1.071	69.0	83.4	69.0
5	1.713	1.713	1.085	67.0	81.8	67.0
10	1.745	1.745	1.125	63.3	78.7	63.3
15	1.760	1.760	1.145	62.2	77.6	62.2
20	1.770	1.770	1.158	61.6	77.1	61.6
$\Delta = 0.25$						
1	1.645	1.645	1.000	100.0	100.0	100.0
2	1.722	1.722	1.097	72.9	87.4	72.9
3	1.762	1.762	1.147	66.6	82.9	66.6
4	1.787	1.787	1.181	63.6	80.4	63.6
5	1.806	1.806	1.206	61.8	78.9	61.8
10	1.857	1.857	1.274	58.0	75.6	58.0
15	1.881	1.881	1.307	56.6	74.4	56.6
20	1.896	1.896	1.328	56.0	73.9	56.0

Two-sided Tests

Pocock

Table 2.1 *Pocock tests: constants $C_P(K, \alpha)$ for two-sided tests with K groups of observations and Type I error probability α*

	$C_P(K, \alpha)$		
K	$\alpha = 0.01$	$\alpha = 0.05$	$\alpha = 0.10$
1	2.576	1.960	1.645
2	2.772	2.178	1.875
3	2.873	2.289	1.992
4	2.939	2.361	2.067
5	2.986	2.413	2.122
6	3.023	2.453	2.164
7	3.053	2.485	2.197
8	3.078	2.512	2.225
9	3.099	2.535	2.249
10	3.117	2.555	2.270
11	3.133	2.572	2.288
12	3.147	2.588	2.304
15	3.182	2.626	2.344
20	3.225	2.672	2.392

Table 2.2 *Pocock tests: constants $R_P(K, \alpha, \beta)$ to determine group sizes for two-sided tests with K groups of observations, Type I error probability α and power $1 - \beta$*

	$R_P(K, \alpha, \beta)$					
	$1 - \beta = 0.8$			$1 - \beta = 0.9$		
K	α=0.01	α=0.05	α=0.10	α=0.01	α=0.05	α=0.10
1	1.000	1.000	1.000	1.000	1.000	1.000
2	1.092	1.110	1.121	1.084	1.100	1.110
3	1.137	1.166	1.184	1.125	1.151	1.166
4	1.166	1.202	1.224	1.152	1.183	1.202
5	1.187	1.229	1.254	1.170	1.207	1.228
6	1.203	1.249	1.277	1.185	1.225	1.249
7	1.216	1.265	1.296	1.197	1.239	1.266
8	1.226	1.279	1.311	1.206	1.252	1.280
9	1.236	1.291	1.325	1.215	1.262	1.292
10	1.243	1.301	1.337	1.222	1.271	1.302
11	1.250	1.310	1.348	1.228	1.279	1.312
12	1.257	1.318	1.357	1.234	1.287	1.320
15	1.272	1.338	1.381	1.248	1.305	1.341
20	1.291	1.363	1.411	1.264	1.327	1.367

O'Brien - Fleming

Table 2.3 *O'Brien & Fleming tests: constants $C_B(K, \alpha)$ for two-sided tests with K groups of observations and Type I error probability α*

	$C_B(K, \alpha)$		
K	$\alpha = 0.01$	$\alpha = 0.05$	$\alpha = 0.10$
1	2.576	1.960	1.645
2	2.580	1.977	1.678
3	2.595	2.004	1.710
4	2.609	2.024	1.733
5	2.621	2.040	1.751
6	2.631	2.053	1.765
7	2.640	2.063	1.776
8	2.648	2.072	1.786
9	2.654	2.080	1.794
10	2.660	2.087	1.801
11	2.665	2.092	1.807
12	2.670	2.098	1.813
15	2.681	2.110	1.826
20	2.695	2.126	1.842

Table 2.4 *O'Brien & Fleming tests: constants $R_B(K, \alpha, \beta)$ to determine group sizes of two-sided tests with K groups of observations, Type I error probability α and power $1 - \beta$*

	$R_B(K, \alpha, \beta)$					
	$1 - \beta = 0.8$			$1 - \beta = 0.9$		
K	α=0.01	α=0.05	α=0.10	α=0.01	α=0.05	α=0.10
1	1.000	1.000	1.000	1.000	1.000	1.000
2	1.001	1.008	1.016	1.001	1.007	1.014
3	1.007	1.017	1.027	1.006	1.016	1.025
4	1.011	1.024	1.035	1.010	1.022	1.032
5	1.015	1.028	1.040	1.014	1.026	1.037
6	1.017	1.032	1.044	1.016	1.030	1.041
7	1.019	1.035	1.047	1.018	1.032	1.044
8	1.021	1.037	1.049	1.020	1.034	1.046
9	1.022	1.038	1.051	1.021	1.036	1.048
10	1.024	1.040	1.053	1.022	1.037	1.049
11	1.025	1.041	1.054	1.023	1.039	1.051
12	1.026	1.042	1.055	1.024	1.040	1.052
15	1.028	1.045	1.058	1.026	1.042	1.054
20	1.030	1.047	1.061	1.029	1.045	1.057

Wang - Tsiatis

Table 2.9 *Wang & Tsiatis tests: constants $C_{WT}(K, \alpha, \Delta)$ for two-sided tests with K groups of observations and Type I error probability $\alpha = 0.05$*

	$C_{WT}(K, \alpha, \Delta)$		
	$\alpha = 0.05$		
K	$\Delta = 0.1$	$\Delta = 0.25$	$\Delta = 0.4$
1	1.960	1.960	1.960
2	1.994	2.038	2.111
3	2.026	2.083	2.186
4	2.050	2.113	2.233
5	2.068	2.136	2.267
6	2.083	2.154	2.292
7	2.094	2.168	2.313
8	2.104	2.180	2.329
9	2.113	2.190	2.343
10	2.120	2.199	2.355
11	2.126	2.206	2.366
12	2.132	2.213	2.375
15	2.146	2.229	2.397
20	2.162	2.248	2.423

Table 2.10 *Wang & Tsiatis tests: constants $R_{WT}(K, \alpha, \beta, \Delta)$ to determine group sizes for two-sided tests with K groups of observations, Type I error probability $\alpha = 0.05$ and power $1 - \beta$*

	$R_{WT}(K, \alpha, \beta, \Delta)$					
	$\alpha = 0.05$					
	$1 - \beta = 0.8$			$1 - \beta = 0.9$		
K	Δ=0.1	Δ=0.25	Δ=0.4	Δ=0.1	Δ=0.25	Δ=0.4
1	1.000	1.000	1.000	1.000	1.000	1.000
2	1.016	1.038	1.075	1.014	1.034	1.068
3	1.027	1.054	1.108	1.025	1.050	1.099
4	1.035	1.065	1.128	1.032	1.059	1.117
5	1.040	1.072	1.142	1.037	1.066	1.129
6	1.044	1.077	1.152	1.041	1.071	1.138
7	1.047	1.081	1.159	1.044	1.075	1.145
8	1.050	1.084	1.165	1.046	1.078	1.151
9	1.052	1.087	1.170	1.048	1.081	1.155
10	1.054	1.089	1.175	1.050	1.083	1.159
11	1.055	1.091	1.178	1.051	1.085	1.163
12	1.056	1.093	1.181	1.053	1.086	1.166
15	1.059	1.097	1.189	1.055	1.090	1.172
20	1.062	1.101	1.197	1.058	1.094	1.180