

**power logrank, cluster** — Power analysis for the log-rank test, CRD

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## Description

`power logrank, cluster` computes group-specific numbers of clusters, group-specific cluster sizes, power, or the hazard ratio for the log-rank test comparing survivor functions in two groups in a cluster randomized design (CRD). Without censoring, the survival input parameter is the hazard ratio; otherwise, the survival input parameters are the control-group and experimental-group survival probabilities.

`power logrank, cluster` computes group-specific numbers of clusters given cluster sizes, power, and survival parameters. It also computes group-specific cluster sizes given numbers of clusters, power, and survival parameters. Alternatively, it computes power given numbers of clusters, cluster sizes, and survival parameters, or it computes the hazard ratio given numbers of clusters, cluster sizes, power, and, in the presence of censoring, the control-group survival probability. See [PSS] [power logrank](#) for a general discussion of power and sample-size analysis for the log-rank test. Also see [PSS] [power](#) for a general introduction to the `power` command using hypothesis tests.

## Quick start

Numbers of clusters for uncensored design with alternative hazard ratio  $\Delta_a = 0.76$  for the log-rank test of  $H_0: \Delta = 1$  versus  $H_a: \Delta \neq 1$  given a cluster size of 5 in both groups and using default intraclass correlation of 0.5, power of 0.8, and significance level  $\alpha = 0.05$

```
power logrank, m1(5) m2(5) hratio(0.76)
```

As above, but use intraclass correlation of 0.4

```
power logrank, m1(5) m2(5) hratio(0.76) rho(0.4)
```

Assume cluster sizes vary with an average cluster size of 5 and a coefficient of variation of 0.6

```
power logrank, m1(5) m2(5) hratio(0.76) cvcluster(0.6)
```

Group-specific numbers of clusters using ratio of experimental clusters to control clusters of 0.5

```
power logrank, m1(5) m2(5) hratio(0.76) kratio(0.5)
```

Cluster sizes for censored design with control- and experimental-group survival probabilities of 0.3 and 0.4 for the log-rank test of  $H_0: \Delta = 1$  versus  $H_a: \Delta \neq 1$  with 200 clusters in both groups using default intraclass correlation of 0.5, power of 0.8, and significance level  $\alpha = 0.05$

```
power logrank 0.3 0.4, k1(200) k2(200)
```

Power for 50 clusters of size 5 in the control group and 50, 100, 150, or 200 clusters of size 5 in the experimental group with results shown in a power plot

```
power logrank 0.3 0.4, k1(50) k2(50(50)200) m1(5) m2(5) graph
```

Hazard ratio and experimental-group survival probability with power of 0.8

```
power logrank 0.3, k1(50) k2(50) m1(5) m2(5) power(0.8)
```

## Menu

Statistics > Power and sample size

## Syntax

Compute numbers of clusters

```
power logrank [surv1 [surv2]], {mspec|nspec cluster} [options]
```

Compute cluster sizes

```
power logrank [surv1 [surv2]], kspec [options]
```

Compute power

```
power logrank [surv1 [surv2]], kspec {mspec|nspec} [options]
```

Compute effect size

```
power logrank [surv1], kspec {mspec|nspec} power(numlist) [options]
```

where  $surv_1$  is the survival probability in the control (reference) group at the end of the study  $t^*$  and  $surv_2$  is the survival probability in the experimental (comparison) group at the end of the study  $t^*$ .  $surv_1$  and  $surv_2$  may each be specified either as one number or as a list of values in parentheses (see [U] 11.1.8 numlist).

*mspec* is one of

```
m1() m2()  
m1() [mratio()]  
m2() [mratio()]
```

*nspec* is one of

```
n1() n2()  
n1() [nratio()]  
n2() [nratio()]
```

*kspec* is one of

```
k1() k2()  
k1() [kratio()]  
k2() [kratio()]
```

<i>options</i>	Description
Main	
<code>cluster</code>	perform computations for a CRD; implied by <code>k1()</code> , <code>k2()</code> , <code>m1()</code> , or <code>m2()</code>
* <code>alpha(numlist)</code>	significance level; default is <code>alpha(0.05)</code>
* <code>power(numlist)</code>	power; default is <code>power(0.8)</code>
* <code>beta(numlist)</code>	probability of type II error; default is <code>beta(0.2)</code>
* <code>k1(numlist)</code>	number of clusters in the control group
* <code>k2(numlist)</code>	number of clusters in the experimental group
* <code>kratio(numlist)</code>	cluster ratio, $K2/K1$ ; default is <code>kratio(1)</code>
* <code>m1(numlist)</code>	cluster size of the control group
* <code>m2(numlist)</code>	cluster size of the experimental group
* <code>mratio(numlist)</code>	cluster-size ratio, $M2/M1$ ; default is <code>mratio(1)</code>
* <code>n1(numlist)</code>	sample size of the control group
* <code>n2(numlist)</code>	sample size of the experimental group
* <code>nratio(numlist)</code>	sample-size ratio, $N2/N1$ ; default is <code>nratio(1)</code>
<code>nfractional</code>	allow fractional numbers of clusters, cluster sizes, and sample sizes
* <code>hratio(numlist)</code>	hazard ratio of the experimental to the control group; default is <code>hratio(0.5)</code>
* <code>lnhratio(numlist)</code>	log hazard-ratio of the experimental to the control group
* <code>rho(numlist)</code>	intraclass correlation; default is <code>rho(0.5)</code>
* <code>cvcluster(numlist)</code>	coefficient of variation for cluster sizes
<code>direction(lower upper)</code>	direction of the effect for effect-size determination; default is <code>direction(lower)</code> , which means that the postulated value of the parameter is smaller than the hypothesized value
<code>onesided</code>	one-sided test; default is two sided
<code>parallel</code>	treat number lists in starred options or in command arguments as parallel when multiple values per option or argument are specified (do not enumerate all possible combinations of values)
Table	
<code>[no]table[ (tablespec) ]</code>	suppress table or display results as a table; see [PSS] <a href="#">power, table</a>
<code>saving(filename [ , replace ])</code>	save the table data to <i>filename</i> ; use <code>replace</code> to overwrite existing <i>filename</i>
Graph	
<code>graph[ (graphopts) ]</code>	graph results; see [PSS] <a href="#">power, graph</a>

iteration	
<code>init(#)</code>	initial value for hazard ratio
<code>iterate(#)</code>	maximum number of iterations; default is <code>iterate(500)</code>
<code>tolerance(#)</code>	parameter tolerance; default is <code>tolerance(1e-12)</code>
<code>ftolerance(#)</code>	function tolerance; default is <code>ftolerance(1e-12)</code>
<code>[no]log</code>	suppress or display iteration log
<code>[no]dots</code>	suppress or display iterations as dots
<code>notitle</code>	suppress the title

\*Specifying a list of values in at least two starred options, or at least two command arguments, or at least one starred option and one argument results in computations for all possible combinations of the values; see [U] 11.1.8 `numlist`. Also see the `parallel` option.

`notitle` does not appear in the dialog box.

where `tablespec` is

`column[:label] [column[:label] [...]] [, tableopts]`

`column` is one of the columns defined below, and `label` is a column label (may contain quotes and compound quotes).

<i>column</i>	Description	Symbol
<code>alpha</code>	significance level	$\alpha$
<code>power</code>	power	$1 - \beta$
<code>beta</code>	type II error probability	$\beta$
<code>K1</code>	number of clusters in the control group	$K_1$
<code>K2</code>	number of clusters in the experimental group	$K_2$
<code>kratio</code>	ratio of numbers of clusters, experimental to control	$K_2/K_1$
<code>M1</code>	cluster size of the control group	$M_1$
<code>M2</code>	cluster size of the experimental group	$M_2$
<code>mratio</code>	ratio of cluster sizes, experimental to control	$M_2/M_1$
<code>N</code>	total number of observations	$N$
<code>N1</code>	number of observations in the control group	$N_1$
<code>N2</code>	number of observations in the experimental group	$N_2$
<code>nratio</code>	ratio of sample sizes, experimental to control	$N_2/N_1$
<code>delta</code>	effect size	$\delta$
<code>E</code>	total number of events (failures)	$E$
<code>hratio</code>	hazard ratio	$\Delta$
<code>lnhratio</code>	log hazard-ratio	$\ln(\Delta)$
<code>s1</code>	survival probability in the control group	$S_1(T)$
<code>s2</code>	survival probability in the experimental group	$S_2(T)$
<code>Pr_E</code>	overall probability of an event (failure)	$p_E$
<code>rho</code>	intraclass correlation	$\rho$
<code>CV_cluster</code>	coefficient of variation for cluster sizes	$CV_{cl}$
<code>target</code>	target parameter; <code>hratio</code>	
<code>_all</code>	display all supported columns	

Column `beta` is shown in the default table in place of column `power` if specified.

Column `N` is shown in the table if specified.

Columns `N1` and `N2` are shown in the default table if `n1()` or `n2()` is specified.

Column `lnhratio` is shown in the default table in place of column `hratio` if specified.

Columns `s1` and `s2` are available only when specified.

Columns `nratio` and `CV_cluster` are shown in the default table if specified.

## Options

### Main

`cluster` specifies that computations should be performed for a CRD. This option is implied when the `k1()`, `k2()`, `m1()`, or `m2()` option is specified. `cluster` is required to compute the numbers of clusters when `nspec` is used to specify sample sizes instead of `mspec` for cluster sizes.

`alpha()`, `power()`, `beta()`; see [PSS] [power](#).

`k1(numlist)` specifies the number of clusters in the control group.

`k2(numlist)` specifies the number of clusters in the experimental group.

`kratio(numlist)` specifies the ratio of the numbers of clusters of the experimental group relative to the control group,  $K2/K1$ . The default is `kratio(1)`, meaning equal numbers of clusters in the two groups.

`m1(numlist)` specifies the cluster size of the control group. `m1()` may contain noninteger values.

`m2(numlist)` specifies the cluster size of the experimental group. `m2()` may contain noninteger values.

`mratio(numlist)` specifies the ratio of cluster sizes of the experimental group relative to the control group,  $M2/M1$ . The default is `mratio(1)`, meaning equal cluster sizes in the two groups.

`n1()`, `n2()`, `nratio()`; see [PSS] [power](#).

`nfractional`; see [PSS] [power](#). The `nfractional` option displays fractional (without rounding) values of the numbers of clusters, cluster sizes, and sample sizes.

`hratio()`, `lnhratio()`; see [PSS] [power logrank](#).

`rho(numlist)` specifies the intraclass correlation. The default is `rho(0.5)`.

`cvcluster(numlist)` specifies the coefficient of variation for cluster sizes. This option is used with varying cluster sizes.

`direction()`, `onesided`, `parallel`; see [PSS] [power](#). `direction(lower)` is the default.

### Table

`table`, `table()`, `notable`; see [PSS] [power, table](#).

`saving()`; see [PSS] [power](#).

### Graph

`graph`, `graph()`; see [PSS] [power, graph](#). Also see the *column* table for a list of symbols used by the graphs.

Iteration

`init(#)` specifies the initial value for the hazard ratio.

`iterate()`, `tolerance()`, `ftolerance()`, `log`, `nolog`, `dots`, `nodots`; see [PSS] **power**.

The following option is available with `power logrank`, `cluster` but is not shown in the dialog box:

`notitle`; see [PSS] **power**.

## Remarks and examples

[stata.com](http://www.stata.com)

Remarks are presented under the following headings:

*Using power logrank, cluster*

*Computing numbers of clusters*

*Computing cluster sizes*

*Computing power*

*Computing effect size*

*Compare two survivor functions with clustered data*

`power logrank`, `cluster` requests that computations for the `power logrank` command be done for a CRD. In a CRD, groups of subjects or clusters are randomized instead of individual subjects, so the sample size is determined by the numbers of clusters and the cluster sizes. The sample-size determination thus consists of the determination of the numbers of clusters given cluster sizes or the determination of cluster sizes given the numbers of clusters. For a general discussion of using `power logrank`, see [PSS] **power logrank**. The discussion below is specific to the CRD.

## Using power logrank, cluster

If you specify the `cluster` option, include `k1()` or `k2()` to specify the number of clusters or include `m1()` or `m2()` to specify the cluster size, the `power logrank` command will perform computations for the log-rank test in a CRD. The computations for a CRD are based on the Freedman method; see *Introduction* in [PSS] **power logrank** for details.

All computations are performed for a two-sided hypothesis test where, by default, the significance level is set to 0.05. You may change the significance level by specifying the `alpha()` option. You can specify the `onesided` option to request a one-sided test. By default, all computations assume a balanced or equal-allocation design, meaning equal numbers of clusters and cluster sizes in both groups; see [PSS] **unbalanced designs** for a description of how to specify an unbalanced design.

To compute the number of clusters in both groups, you must provide cluster sizes for both groups. There are multiple ways to supply cluster sizes, but the most common is to specify the cluster size of the control group in the `m1()` option and the cluster size of the experimental group in the `m2()` option. See *mspec* and *nspec* under *Syntax* for other specifications. When *nspec* is specified, the `cluster` option is also required to request that `power logrank` perform computations for a CRD. The number of clusters is assumed to be equal in the two groups, but you can change this by specifying the ratio of the numbers of clusters in the experimental to the control group in the `kratio()` option. Other parameters are specified as described in *Using power logrank* in [PSS] **power logrank**.

To compute the cluster sizes in both groups, you must provide the numbers of clusters in both groups. There are several ways to supply the numbers of clusters; see *kspec* under *Syntax*. The most common is to specify the numbers of clusters in the control group and the experimental group in the `k1()` and `k2()` options, respectively. Equal cluster sizes are assumed in the two groups, but you can change this by specifying the ratio of the cluster sizes in the experimental to that of the control group in the `mratio()` option. Other parameters are specified as described in *Using power logrank* in [PSS] **power logrank**.

The power and effect-size determination is the same as described in *Using power logrank* in [PSS] **power logrank**, but the sample-size information is supplied as the numbers of clusters *kspec* and either cluster sizes using *mspec* or, less commonly, sample sizes using *nspec*.

All computations assume an intraclass correlation of 0.5. You can change this by specifying the `rho()` option. Also, all clusters are assumed to be of the same size unless the coefficient of variation for cluster sizes is specified in the `cvcluster()` option.

By default, the computed numbers of clusters, cluster sizes, and sample sizes are rounded up. However, you can specify the `nfractional` option to see the corresponding fractional values; see *Fractional sample sizes* in [PSS] **unbalanced designs** for an example. If the `cvcluster()` option is specified when computing cluster sizes, then cluster sizes represent average cluster sizes and are thus not rounded. When sample sizes are specified using *nspec*, fractional cluster sizes may be reported to accommodate the specified numbers of clusters and sample sizes.

Some of **power logrank**, **cluster**'s computations require iteration; see *Methods and formulas* for details and [PSS] **power** for the descriptions of options that control the iteration procedure.

## Computing numbers of clusters

To compute the numbers of clusters in each group, you must either provide the cluster size for each group using *mspec* or specify the `cluster` option and provide the sample sizes of both groups using *nspec*. The most common method is to use *mspec* of `m1()` and `m2()`. A hazard ratio of 0.5 is assumed but may be changed by specifying the `hratio()` option. If there is censoring, the control-group survival probability  $surv_1$  must be specified, and the experimental-group survival probability  $surv_2$  may be specified instead of the hazard ratio.

### ► Example 1: Numbers of clusters for the log-rank test with no censoring in a CRD

Consider an example from [Xie and Waksman \(2003\)](#). A researcher would like to study the time it takes diabetic foot ulcers to heal completely (the event of interest). Patients enrolled in the study may have multiple ulcers, and all existing ulcers will be treated. Suppose that at the end of the study, all ulcers are expected to be healed. Patients, the clustering unit, are randomly assigned equally to the control group with the usual treatment and the experimental group with the new treatment. The researcher is interested in detecting a hazard ratio, experimental group to control group, of 1.79 for healing. For the planned study, the researcher assumes about 3 ulcers per patient in each group with an intraclass correlation of 0.3.

To compute the numbers of patients in each group required to detect a hazard ratio of 1.79 with 80% power using a 5%-level two-sided test, we type

```
. power logrank, hratio(1.79) m1(3) m2(3) rho(0.3)
Estimated numbers of clusters for two-sample comparison of survivor functions
Cluster randomized design, log-rank test, Freedman method
Ho: HR = 1 versus Ha: HR != 1
Study parameters:
    alpha =    0.0500
    power =    0.8000
    delta =    1.7900 (hazard ratio)
    hratio =    1.7900
Cluster design:
    M1 =        3
    M2 =        3
    rho =    0.3000
Number of events and censoring:
    E =        157
    Pr_E =    1.0000
Estimated numbers of clusters and sample sizes:
    K1 =        27
    K2 =        27
    N1 =        81
    N2 =        81
```

We find that 27 patients per group are required to detect a hazard ratio of 1.79 with 80% power using a 5%-level two-sided test.



### ► Example 2: Numbers of clusters for the log-rank test with censoring in a CRD

Unlike [example 1](#), suppose that 70% of the ulcers in the control group and 50% in the experimental group are not healed at the end of the study. Because there is censoring, we specify the survival probabilities of 0.7 and 0.5 as command arguments.



```

. power logrank 0.7 0.5, m1(3) m2(3) rho(0.3)
Estimated numbers of clusters for two-sample comparison of survivor functions
Cluster randomized design, log-rank test, Freedman method
Ho: HR = 1 versus Ha: HR != 1
Study parameters:
    alpha =    0.0500
    power =    0.8000
    delta =    1.9434 (hazard ratio)
    hratio =    1.9434
Cluster design:
    M1 =        3
    M2 =        3
    rho =    0.3000
Number of events and censoring:
    E =        123
    s1 =    0.7000
    s2 =    0.5000
    Pr_E =    0.4000
Estimated numbers of clusters and sample sizes:
    K1 =        51
    K2 =        51
    N1 =       153
    N2 =       153

```

We find that 51 patients per group are required to detect a decrease in the survival rate or an increase in the healing rate of ulcers from 0.7 to 0.5 with 80% power using a 5%-level two-sided test. ◀

### ▶ Example 3: Numbers of clusters for the log-rank test in a CRD, varying cluster sizes

Continuing with [example 2](#), we now want to account for the fact that the numbers of ulcers may vary among patients. We assume a coefficient of variation of 0.4. To compute the numbers of clusters when cluster sizes vary, we specify the coefficient of variation of the numbers of ulcers of 0.4 in the `cvcluster()` option.

```

. power logrank 0.7 0.5, m1(3) m2(3) rho(0.3) cvcluster(0.4)
Estimated numbers of clusters for two-sample comparison of survivor functions
Cluster randomized design, log-rank test, Freedman method
Ho: HR = 1 versus Ha: HR != 1
Study parameters:
      alpha = 0.0500
      power = 0.8000
      delta = 1.9434 (hazard ratio)
      hratio = 1.9434
Cluster design:
      Average M1 = 3.0000
      Average M2 = 3.0000
      rho = 0.3000
      CV_cl = 0.4000
Number of events and censoring:
      E = 134
      s1 = 0.7000
      s2 = 0.5000
      Pr_E = 0.4000
Estimated numbers of clusters and sample sizes:
      K1 = 56
      K2 = 56
      N1 = 168
      N2 = 168

```

The required number of patients in each group is 56, which is larger than the required number of patients of 51 in [example 2](#). When the numbers of ulcers vary among patients, we need more patients to achieve the same power.

◀

## Computing cluster sizes

To compute cluster sizes in both groups, you must provide the numbers of clusters in both groups by using *kspec*. The most common method is to specify the numbers of clusters in the control and experimental groups in the `k1()` and `k2()` options, respectively. As for the determination of the numbers of clusters, a hazard ratio of 0.5 is assumed but may be changed by specifying the `hratio()` option. If there is censoring, the control-group survival probability  $surv_1$  must be specified, and the experimental-group survival probability  $surv_2$  may be specified instead of the hazard ratio.

### ► Example 4: Cluster sizes for the log-rank test in a CRD

Continuing with [example 2](#), suppose that we are designing a new study and planning to recruit 100 patients, with 50 patients in each group. Given other study parameters from example 2, we compute the number of ulcers we would expect to see from each patient to achieve the power of 80% by specifying 50 clusters in the `k1()` and `k2()` options.

```

. power logrank 0.7 0.5, k1(50) k2(50) rho(0.3)
Estimated cluster sizes for two-sample comparison of survivor functions
Cluster randomized design, log-rank test, Freedman method
Ho: HR = 1 versus Ha: HR != 1
Study parameters:
      alpha = 0.0500
      power = 0.8000
      delta = 1.9434 (hazard ratio)
      hratio = 1.9434
Cluster design:
      K1 = 50
      K2 = 50
      rho = 0.3000
Number of events and censoring:
      E = 77
      s1 = 0.7000
      s2 = 0.5000
      Pr_E = 0.4000
Estimated cluster sizes and sample sizes:
      M1 = 4
      M2 = 4
      N1 = 200
      N2 = 200

```

To achieve the desired power of 80%, with 100 patients, we will need to observe 4 ulcers per patient.

◀

## Computing power

To compute power in a CRD, you supply the sample-size information as the numbers of clusters by using *kspec* along with either the cluster sizes by using *mspec* or, less commonly, the sample sizes by using *nspec*. The most common method is to specify the `k1()`, `k2()`, `m1()`, and `m2()` options. A hazard ratio of 0.5 is assumed but may be changed by specifying the `hratio()` option. If there is censoring, the control-group survival probability `surv1` must be specified, and the experimental-group survival probability `surv2` may be specified instead of the hazard ratio.

### ► Example 5: Power for the log-rank test in a CRD

Continuing with [example 2](#), suppose that we can recruit 100 patients (50 patients per group) and observe 3 ulcers per patient and we want to compute power for this design. Given other study parameters from [example 2](#), we compute power by specifying 50 clusters in the `k1()` and `k2()` options and 3 as the cluster size in the `m1()` and `m2()` options.

```

. power logrank 0.7 0.5, k1(50) k2(50) m1(3) m2(3) rho(0.3)
Estimated power for two-sample comparison of survivor functions
Cluster randomized design, log-rank test, Freedman method
Ho: HR = 1 versus Ha: HR != 1
Study parameters:
      alpha = 0.0500
      delta = 1.9434 (hazard ratio)
      hratio = 1.9434
Cluster design:
      K1 = 50
      K2 = 50
      M1 = 3
      M2 = 3
      N1 = 150
      N2 = 150
      rho = 0.3000
Number of events and censoring:
      E = 120
      s1 = 0.7000
      s2 = 0.5000
      Pr_E = 0.4000
Estimated power:
      power = 0.7927

```

The computed power is about 79%.

◀

### ► Example 6: Multiple values of study parameters

To investigate the effect of the number of clusters in the experimental group on power, we can specify a list of numbers of clusters in the `k2()` option:

```

. power logrank 0.7 0.5, k1(50) k2(10(20)90) m1(3) m2(3) rho(0.3) table(power K2)
Estimated power for two-sample comparison of survivor functions
Cluster randomized design, log-rank test, Freedman method
Ho: HR = 1 versus Ha: HR != 1

```

power	K2
.4603	10
.7157	30
.7927	50
.8276	70
.8472	90

In this example, we also specified the `table(power K2)` option to list only the two columns that vary. As expected, as the number of clusters increases, the power tends to get closer to 1.

For multiple values of parameters, the results are automatically displayed in a table, as we see above. For more examples of tables, see [PSS] [power, table](#). If you wish to produce a power plot, see [PSS] [power, graph](#).

◀

## Computing effect size

Effect size  $\delta$  for the log-rank test is the hazard ratio. To compute effect size in a CRD, you supply the sample-size information as the numbers of clusters by using *kspec* along with either the cluster sizes by using *mspec* or, less commonly, the sample sizes by using *nspec*. The most common method is to specify the `k1()`, `k2()`, `m1()`, and `m2()` options. In addition, power and, in the presence of censoring, control-group survival probability must be specified. You must also decide on the direction of the effect, which is specified in the `direction()` option. For the default, lower, meaning  $\Delta < 1$ , power `logrank, cluster` uses `direction(lower)`. For upper, meaning  $\Delta > 1$ , specify `direction(upper)`.

### ► Example 7: Effect size for the log-rank test in a CRD

Continuing with [example 5](#), we may be interested in finding the minimum value of the hazard ratio that can be detected with a sample of 50 patients per group, with about 3 ulcers per patient, and with 80% power. To compute this, we specify the control-group survival probability of 0.7 as the command argument and required options `k1(50)`, `k2(50)`, `m1(3)`, `m2(3)`, and `power(0.8)`. We continue to use `rho(0.3)`. In this example, we want to detect an effect in the upper direction. That is, we believe the rate of healing in the experimental group is greater than in the control group, so we expect a hazard ratio greater than 1. Therefore, we need to specify the `direction(upper)` option.

```
. power logrank 0.7, k1(50) k2(50) m1(3) m2(3) power(0.8) rho(0.3)
> direction(upper)

Performing iteration ...

Estimated hazard ratio for two-sample comparison of survivor functions
Cluster randomized design, log-rank test, Freedman method
Ho: HR = 1 versus Ha: HR != 1; HR > 1

Study parameters:
      alpha =    0.0500
      power =    0.8000

Cluster design:
      K1 =      50
      K2 =      50
      M1 =       3
      M2 =       3
      N1 =     150
      N2 =     150
      rho =    0.3000

Number of events and censoring:
      E =      121
      s1 =    0.7000
      s2 =    0.4980
      Pr_E =   0.4010

Estimated effect size and hazard ratio:
      delta =   1.9546 (hazard ratio)
      hratio =   1.9546
```

The minimum detectable value of the hazard ratio is about 1.95.

## Compare two survivor functions with clustered data

To compare two survivor functions nonparametrically, we can use the `sts test` command to perform, for example, the log-rank test. `sts test`, however, assumes independent data. We can compare the survivor functions of the two groups semiparametrically while accounting for correlated observations by using a Cox proportional hazards model with clustered standard errors. The Cox model assumes proportional hazards, so testing the equality of two survivor functions reduces to testing that the ratio of the corresponding hazard functions, the hazard ratio, is equal to one. So we can include an identifier of the two groups in the Cox model as the covariate and test the corresponding hazard ratio against one or, equivalently, the log hazard-ratio (coefficient) against zero.

In this section, we briefly demonstrate the `stcox` command with clustered standard errors to compare two groups with survival-time clustered data.

### ► Example 8: Comparing two survivor functions with clustered data using `stcox`

Consider `eartubes.dta` containing durations of ventilating tubes from [Le and Lindgren \(1996\)](#). To prevent frequent ear infections in infants and young children, a surgical procedure of inserting ventilating tubes in the ears is often recommended. In this study, children with ventilating tubes in both ears were assigned to either a treatment group (receiving a steroid treatment postsurgery) or a control group (receiving no postsurgery intervention). We want to compare the duration of ventilating tubes for children in the two groups. Because durations of ventilating tubes within a child, from the left and right ears, will be correlated, we cluster on the child identifier, `childid`, in our analysis.

We first declare our survival-time data with the `stset` command and then use the `stcox` command with the `vce(cluster childid)` option to fit a Cox model with a treatment variable identifying the two groups as the covariate.

```
. use http://www.stata-press.com/data/r15/eartubes
(Ventilating tubes life data (Le and Lindgren (1996)))
. stset time, failure(status)
      failure event:  status != 0 & status < .
obs. time interval:  (0, time]
exit on or before:  failure
```

---

```
156 total observations
  0 exclusions
```

---

```
156 observations remaining, representing
144 failures in single-record/single-failure data
1,373.8 total analysis time at risk and under observation
              at risk from t =          0
              earliest observed entry t =          0
              last observed exit t =          33
```

```

. stcox i.treatment, vce(cluster childid)
      failure _d: status
      analysis time _t: time
Iteration 0:   log pseudolikelihood = -590.59936
Iteration 1:   log pseudolikelihood = -588.43049
Iteration 2:   log pseudolikelihood = -588.42903
Refining estimates:
Iteration 0:   log pseudolikelihood = -588.42903
Cox regression -- Breslow method for ties
No. of subjects      =           156           Number of obs      =           156
No. of failures      =           144
Time at risk        =           1373.8
Log pseudolikelihood = -588.42903           Wald chi2(1)       =           3.55
                                                    Prob > chi2        =           0.0594
                                                    (Std. Err. adjusted for 78 clusters in childid)

```

_t	Haz. Ratio	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
treatment	.7026351	.1315461	-1.89	0.059	.486821	1.014122

The estimated hazard ratio is 0.7, and the test of log hazard-ratio (or coefficient) of `treatment` against zero has a  $p$ -value = 0.059. We do not have sufficient statistical evidence to conclude that the durations of ventilating tubes of the two groups are different, at least at the 5% significance level.

Suppose that we want to use the results of this study to design a new study. We want to determine how many children we need in the study. To compute the required number of children or clusters, we need the number of observations per cluster in each group and the estimates of the hazard ratio, of the intraclass correlation, and of the survival rate in the control group at the end of the study.

We can use the estimate of 0.7 for the hazard ratio from `stcox`. Suppose that we are planning to stop our new study after 12 months. We can use the `sts list` command to estimate the control-group survival rate at 12 months based on these data,

```

. sts list if treatment==0, at(12 12)
      failure _d: status
      analysis time _t: time

```

Time	Beg. Total	Fail	Survivor Function	Std. Error	[95% Conf. Int.]	
12	15	56	0.2035	0.0484	0.1184	0.3049
12	15	0	0.2035	0.0484	0.1184	0.3049

Note: Survivor function is calculated over full data and evaluated at indicated times; it is not calculated from aggregates shown at left.

The estimated survival rate after 12 months is about 0.2.

To account for clustered data, we need to specify an intraclass correlation in our PSS computations. We can compute a rough estimate of the intraclass correlation assuming a parametric Weibull model as described by [Canette \(2016\)](#). Also see [Xie and Waksman \(2003\)](#) for a nonparametric estimation of the intraclass correlation. For these data, the two methods provide similar values of 0.12 and 0.14, respectively.

We can compute the required number of clusters for a range of intraclass correlation values between 0.04 and 0.2, for example. We specify this range of intraclass correlation values to straddle the rough estimates of 0.12 and 0.14. We specify the control-group survival rate of 0.2 as the command argument,

the hazard ratio of 0.7 in the `hratio()` option, and because each child has ventilating tubes in both ears, we specify 2 in the `m1()` and `m2()` options in the `power logrank` command below. We also specify the `table(rho K1)` option to list only the columns that vary in the table.

```
. power logrank 0.2, hratio(0.7) m1(2) m2(2) rho(0.04(0.02)0.2) table(rho K1)
Estimated numbers of clusters for two-sample comparison of survivor functions
Cluster randomized design, log-rank test, Freedman method
Ho: HR = 1 versus Ha: HR != 1
```

rho	K1
.04	89
.06	91
.08	93
.1	94
.12	96
.14	98
.16	100
.18	101
.2	103

The required number of clusters varies between 89 and 103, with the values of 96 and 98 corresponding to our rough estimates of the intraclass correlation of 0.12 and 0.14.

◀

## Stored results

`power logrank, cluster` stores the following in `r()`:

### Scalars

<code>r(alpha)</code>	significance level
<code>r(power)</code>	power
<code>r(beta)</code>	probability of a type II error
<code>r(delta)</code>	effect size
<code>r(K1)</code>	number of clusters in the control group
<code>r(K2)</code>	number of clusters in the experimental group
<code>r(kratio)</code>	ratio of numbers of clusters, $K2/K1$
<code>r(M1)</code>	cluster size of the control group
<code>r(M2)</code>	cluster size of the experimental group
<code>r(mratio)</code>	ratio of cluster sizes, $M2/M1$
<code>r(N)</code>	total sample size
<code>r(N1)</code>	sample size of the control group
<code>r(N2)</code>	sample size of the experimental group
<code>r(nratio)</code>	ratio of sample sizes, $N2/N1$
<code>r(nfractional)</code>	1 if <code>nfractional</code> is specified; 0 otherwise
<code>r(onesided)</code>	1 for a one-sided test; 0 otherwise
<code>r(E)</code>	total number of events (failures)
<code>r(hratio)</code>	hazard ratio
<code>r(lnhratio)</code>	log hazard-ratio
<code>r(s1)</code>	survival probability in the control group (if specified)
<code>r(s2)</code>	survival probability in the experimental group (if specified)
<code>r(Pr_E)</code>	probability of an event (failure)
<code>r(rho)</code>	intraclass correlation
<code>r(CV_cluster)</code>	coefficient of variation for cluster sizes
<code>r(init)</code>	initial value for estimated parameter
<code>r(maxiter)</code>	maximum number of iterations
<code>r(iter)</code>	number of iterations performed
<code>r(tolerance)</code>	requested parameter tolerance



r(delta)	final parameter tolerance achieved
r(ftolerance)	requested distance of the objective function from zero
r(function)	final distance of the objective function from zero
r(converged)	1 if iteration algorithm converged; 0 otherwise

#### Macros

r(type)	test
r(method)	logrank
r(design)	CRD
r(test)	Freedman
r(direction)	lower or upper
r(columns)	displayed table columns
r(labels)	table column labels
r(widths)	table column widths
r(formats)	table column formats

#### Matrices

r(pss_table)	table of results
--------------	------------------

## Methods and formulas

The computation in a CRD uses the Freedman method based on the asymptotic distribution of the log-rank test statistic. See *Methods and formulas* in [PSS] **power logrank** for the common notation.

In a CRD, let  $K_1$  and  $K_2$  be the numbers of clusters in the control and experimental groups, respectively, and  $M_1$  and  $M_2$  be the cluster sizes of the control and experimental groups, respectively. For unequal cluster sizes, we assume that the cluster sizes are independent and identically distributed and are small relative to the number of clusters. We have  $n_1 = K_1 M_1$  and  $n_2 = K_2 M_2$ . Let  $R$  be the ratio of the numbers of observations,  $R_k$  be the ratio of the numbers of clusters,  $K_2/K_1$ , and  $R_m$  be the ratio of the cluster sizes,  $M_2/M_1$ . Let  $n = n_1 + n_2$  be the total number of observations,  $K = K_1 + K_2$  be the total number of clusters,  $\rho$  be the intraclass correlation,  $CV_{cl}$  be the coefficient of variation, and  $\bar{M}$  be the average cluster size

$$\bar{M} = \frac{M_1 K_1 + M_2 K_2}{K}$$

Define  $\psi$  as

$$\psi = (R\Delta + 1)/(\Delta - 1)$$

The total number of events required to be observed in a CRD study to ensure a power of  $\pi = 1 - \beta$  of the log-rank test to detect the hazard ratio  $\Delta$  with significance level  $\alpha$ , according to Xie and Waksman (2003), is

$$E = \frac{1}{R} (z_{1-\alpha/k} + z_{1-\beta})^2 \left( \frac{R\Delta + 1}{\Delta - 1} \right)^2 [1 + \rho\{\bar{M}(1 + CV_{cl}^2) - 1\}] \quad (1)$$

where  $k = 1$  for the one-sided test and  $k = 2$  for the two-sided test.

The required total number of clusters is approximately

$$K = \frac{E}{p_E \bar{M}} \quad (2)$$

where  $p_E = 1 - (S_1 + RS_2)/(1 + R)$  is the event probability with  $S_1$  and  $S_2$  defined as the survival probabilities in the control and the experimental groups at the end of the study. Without censoring,  $p_E = 1$ . Given  $R_k$ , we can compute  $K_1 = K/(1 + R_k)$  and  $K_2 = KR_k/(1 + R_k)$ .

Given  $K_1$  and  $K_2$ , we can compute the average cluster size  $\bar{M}$  as

$$\bar{M} = \frac{1 - \rho}{RKp_E / \{(z_{1-\alpha/k} - z_\beta)\psi\}^2 - \rho(1 + CV_{c1}^2)}$$

We can then compute  $M_1 = K\bar{M}/(K_1 + R_m K_2)$  and  $M_2 = M_1 R_m$ .

The power is estimated using the formula

$$\pi = 1 - \beta = \Phi\{|\psi|^{-1}(Rnp_E/[1 + \rho\{\bar{M}(1 + CV_{c1}^2) - 1\}])^{1/2} - z_{1-\alpha/k}\}$$

where  $\Phi(\cdot)$  is the standard normal cumulative distribution.

Without censoring, the hazard ratio  $\Delta$  is computed as

$$\Delta = \begin{cases} 1 - \frac{R+1}{\sqrt{Rn/(\{z_{1-\alpha/k} - z_\beta\}^2[1 + \rho\{\bar{M}(1 + CV_{c1}^2) - 1\}]) + R}} & \text{when } \Delta < 1 \\ 1 + \frac{R+1}{\sqrt{Rn/(\{z_{1-\alpha/k} - z_\beta\}^2[1 + \rho\{\bar{M}(1 + CV_{c1}^2) - 1\}]) - R}} & \text{when } \Delta > 1 \end{cases}$$

With censoring, the hazard ratio  $\Delta$  is computed iteratively based on (1) and (2).

## References

- Canette, I. 2016. In the spotlight: Intraclass correlations after multilevel survival models. *Stata News*, vol. 31, no. 2. <http://www.stata.com/stata-news/news31-2/intra-class-correlations/>.
- Le, C. T., and B. R. Lindgren. 1996. Duration of ventilating tubes: A test for comparing two clustered samples of censored data. *Biometrics* 52: 328–334.
- Xie, T., and J. Waksman. 2003. Design and sample size estimation in clinical trials with clustered survival times as the primary endpoint. *Statistics in Medicine* 22: 2835–2846.

## Also see

- [PSS] **power logrank** — Power analysis for the log-rank test
- [PSS] **power** — Power and sample-size analysis for hypothesis tests
- [PSS] **power, graph** — Graph results from the power command
- [PSS] **power, table** — Produce table of results from the power command
- [PSS] **Glossary**
- [ST] **stcox** — Cox proportional hazards model
- [ST] **sts test** — Test equality of survivor functions