

# Package ‘EL2Surv’

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**Title** Empirical Likelihood (EL) for Comparing Two Survival Functions

**Version** 1.1

**Description**

Functions for computing critical values and implementing the one-sided/two-sided EL tests.

**Depends** R ( $\geq 2.13.0$ )

**Imports** survival, stats

**License** GPL ( $\geq 2$ )

**LazyData** true

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hazardcross

*Simulated Survival with Crossing Hazard Functions*

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### Description

The data frame `hazardcross` is simulated from two groups of piecewise exponential lifetime distributions with crossing hazard functions. The estimated survival functions remain ordered even when the estimated hazard functions are crossed. See [supELtest](#) for the application.

### Usage

```
hazardcross
```

### Format

The `hazardcross` is a data frame with 100 simulated observations of 3 variables, and has the following columns:

- `time` the survival time
- `sensor` the censoring indicator
- `group` the grouping variable

### See Also

[supELtest](#)

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hepatitis

*Survival from Severe Alcoholic Hepatitis*

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### Description

The data frame `hepatitis` is obtained by digitizing the published Kaplan-Meier curves in Nguyen-Khac et al (2011). The method of digitizing is described in Guyot et al. (2012). See [intELtest](#) and [ptwiseELtest](#) for the application.

### Usage

```
hepatitis
```

### Format

The `hepatitis` is a data frame with 174 observations of 3 variables, and has the following columns:

- `time` the survival time
- `sensor` the censoring indicator
- `group` the grouping variable

**Source**

Nguyen-Khac et al., "Glucocorticoids plus N-Acetylcysteine in Severe Alcoholic Hepatitis," *The New England Journal of Medicine*, Vol. 365, No. 19, pp. 1781-1789 (2011). <http://www.nejm.org/doi/full/10.1056/NEJMoa1101214#t=article>

**References**

P. Guyot, A. E. Ades, M. J. N. M. Ouwens, and N. J. Welton, "Enhanced secondary analysis of survival data: reconstructing the data from published Kaplan-Meier survival curves," *BMC Medical Research Methodology*, 12(1):9. <http://bmcmedresmethodol.biomedcentral.com/articles/10.1186/1471-2288-12-9>

**See Also**

[intELtest](#), [ptwiseELtest](#)

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intELtest

*The integrated likelihood ratio test*

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**Description**

intELtest gives a class of the weighted likelihood ratio statistics:

$$\sum_{t \in U} w(t) \{-2 \log R(t)\},$$

where  $w(t)$  is an objective weight function, and  $R(t)$  is an empirical likelihood (EL) ratio that compares two survival functions at each time point  $t$  in the set of observed uncensored lifetimes,  $U$ .

**Usage**

```
intELtest(data, g1 = 1, t1 = 0, t2 = Inf, sided = 2,
  nboot = 1000, wt = "p.event", alpha = 0.05, compo = FALSE,
  seed = 1011, nlimit = 200)
```

**Arguments**

data	a data frame/matrix with 3 columns. The first column is the survival time. The second is the censoring indicator. The last is the grouping variable. An example as the input to data provided is <a href="#">hepatitis</a> .
g1	the group with longer survival in one-sided testing with the default value of 1.
t1	pre-specified $t_1$ based on domain knowledge with the default value of 0
t2	pre-specified $t_2$ based on domain knowledge with the default value of $\infty$
sided	2 if two-sided test, and 1 if one-sided test. It assumes the default value of 2.
nboot	number of bootstrap replications in calculating critical values with the default value of 1000.

wt	a string for the integral statistic with a specific weight function. There are four types of integral statistics provided: "p.event", "dF", "dt", and "db". It assumes the default value of "p.event". See 'Details' for more about the integral statistics.
alpha	pre-specified significance level of the test with the default value of 0.05
compo	FALSE if taking the standardized square of the difference as the local statistic for two-sided testing, and TRUE if constructing for one-sided testing, but only the positive part of the difference included. It assumes the default value of <i>FALSE</i> .
seed	the parameter with the default value of 1011 to <code>set.seed</code> for generating bootstrap-based critical values in R. The <code>set.seed</code> is used implicitly in <code>intELtest</code> .
nlimit	the splitting unit with the default value of 200. To deal with large data problems, the bootstrap algorithm is to split the number of bootstrap replicates into <code>nsplit</code> parts. The number <code>nsplit</code> is the smallest integer not less than $\ U\ /nlimit$ .

## Details

`intELtest` calculates the weighted likelihood ratio statistics:

$$\sum_{i=1}^h w_i \cdot \{-2 \log R(t_i)\},$$

where  $w_1, \dots, w_h$  are the values of the weight function evaluated at the distinct ordered uncensored times  $t_1, \dots, t_h$  in  $U$ . There are four types of weight functions considered.

- (wt = "p.event")  
This default option is an objective weight,

$$w_i = \frac{d_i}{n}$$

In other words, this  $w_i$  assigns weight proportional to the number of events at each observed uncensored time  $t_i$ .

- (wt = "dF")  
Based on the integral statistic built by Barmi and McKeague (2013), another weight function is

$$w_i = \hat{F}(t_i) - \hat{F}(t_{i-1})$$

for  $i = 1, \dots, m$ , where  $\hat{F}(t) = 1 - \hat{S}(t)$ ,  $\hat{S}(t)$  is the pooled KM estimator, and  $t_0 \equiv 0$ . This reduces to the objective weight when there is no censoring. The resulting  $I_n$  can be seen as an empirical version of  $E(-2 \log \mathcal{R}(T))$ , where  $T$  denotes the lifetime random variable of interest distributed as the common distribution under  $H_0$ .

- (wt = "dt")  
By means of an extension of the integral statistic derived by Pepe and Fleming (1989), another weight function is

$$w_i = t_{i+1} - t_i$$

for  $i = 1, \dots, m$ , where  $t_{m+1} \equiv t_m$ . This gives more weight to the time intervals where there are fewer observed uncensored times, but may be affected by extreme observations.

- (wt = "db")  
According to a weighing method mentioned in Chang and McKeague (2016), the other weight function is

$$w_i = \hat{b}(t_i) - \hat{b}(t_{i-1})$$

where  $\hat{b}(t) = \hat{\sigma}^2(t)/(1 + \hat{\sigma}^2(t))$ , and  $\hat{\sigma}^2(t)$  is given. The  $\hat{b}(t)$  is chosen so that the limiting distribution is the same as the asymptotic null distribution in EL Barmi and McKeague (2013).

## Value

intELtest returns a list with three elements:

- teststat the resulting integrated test statistic
- critval the critical value
- pvalue the p-value based on the integrated statistic

## References

- H.-w. Chang and I. W. McKeague, "Empirical likelihood based tests for stochastic ordering under right censorship," *Electronic Journal of Statistics*, Vol. 10, No. 2, pp. 2511-2536 (2016).
- M. S. Pepe and T. R. Fleming, "Weighted Kaplan-Meier Statistics: A Class of Distance Tests for Censored Survival Data," *Biometrics*, Vol. 45, No. 2, pp. 497-507 (1989). [https://www.jstor.org/stable/2531492?seq=1#page\\_scan\\_tab\\_contents](https://www.jstor.org/stable/2531492?seq=1#page_scan_tab_contents)
- H. Uno, L. Tian, B. Claggett, and L. J. Wei, "A versatile test for equality of two survival functions based on weighted differences of Kaplan-Meier curves," *Statistics in Medicine*, Vol. 34, No. 28, pp. 3680-3695 (2015). <http://onlinelibrary.wiley.com/doi/10.1002/sim.6591/abstract>
- H. E. Barmi and I. W. McKeague, "Empirical likelihood-based tests for stochastic ordering," *Bernoulli*, Vol. 19, No. 1, pp. 295-307 (2013). <https://projecteuclid.org/euclid.bj/1358531751>

## See Also

[hepatitis](#), [supELtest](#), [ptwiseELtest](#)

## Examples

```
library(EL2Surv)
intELtest(hepatitis)

## OUTPUT:
## $teststat
## [1] 1.406016
##
## $critval
## [1] 0.8993514
##
## $pvalue
## [1] 0.012
```

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ptwiseELtest                      *The pointwise likelihood ratio test*

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### Description

ptwiseELtest gives pointwise EL statistic values at uncensored time span. The pointwise statistic considers only the decision on each single time point; thus, it is different from the [integral type](#) and [sup type](#) statistics.

### Usage

```
ptwiseELtest(data, g1 = 1, t1 = 0, t2 = Inf, sided = 2,
             nboot = 1000, alpha = 0.05, compo = FALSE, seed = 1011,
             nlimit = 200)
```

### Arguments

data	a data frame/matrix with 3 columns. The first column is the survival time. The second is the censoring indicator. The last is the grouping variable. An example as the input to data provided is <a href="#">hepatitis</a> .
g1	the group with longer survival in one-sided testing with the default value of 1.
t1	pre-specified $t_1$ based on domain knowledge with the default value of 0
t2	pre-specified $t_2$ based on domain knowledge with the default value of $\infty$
sided	2 if two-sided test, and 1 if one-sided test. It assumes the default value of 2.
nboot	number of bootstrap replications in calculating critical values with the default value of 1000.
alpha	pre-specified significance level of the test with the default value of 0.05
compo	FALSE if taking the standardized square of the difference as the local statistic for two-sided testing, and TRUE if constructing for one-sided testing, but only the positive part of the difference included. It assumes the default value of <i>FALSE</i> .
seed	the parameter with the default value of 1011 to <a href="#">set.seed</a> for generating bootstrap-based critical values in R. The <code>set.seed</code> is used implicitly in <code>intELtest</code> .
nlimit	the splitting unit with the default value of 200. To deal with large data problems, the bootstrap algorithm is to split the number of bootstrap replicates into <code>nsplit</code> parts. The number <code>nsplit</code> is the smallest integer not less than $\lceil \ U\  / nlimit \rceil$ .

### Value

ptwiseELtest returns a list with four elements:

- `time_pts` the values of statistics at each uncensored time point
- `decision` logical values. See `stat_ptwise`.
- `stat_ptwise` the decision of the test in which the null hypothesis is rejected at a specific day if the decision exhibits 1 and not rejected if otherwise
- `critval_ptwise` the critical values of the statistic at each uncensored time point

## References

H.-w. Chang and I. W. McKeague, "Empirical likelihood based tests for stochastic ordering under right censorship," *Electronic Journal of Statistics*, Vol. 10, No. 2, pp. 2511-2536 (2016).

## See Also

[hepatitis](#), [intELtest](#), [supELtest](#)

## Examples

```
library(EL2Surv)
ptwiseELtest(hepatitis)
## It produces the estimates on 44 distinct uncensored days
## out of 57 possibly repeated uncensored days.

ptwiseELtest(hepatitis, t1 = 30, t2 = 60)
## It produces the estimates on 12 distinct uncensored days
## on the restricted time interval [30, 60].
```

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supELtest

*The maximally selected likelihood ratio test*

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## Description

supELtest provides a maximal deviation type statistics that is better adapted at detecting local differences:

$$\sup_{t \in U} \{-2 \log R(t)\},$$

where  $R(t)$  is an empirical likelihood (EL) ratio that compares two survival functions at each time point  $t$  in the set of observed uncensored lifetimes,  $U$ .

## Usage

```
supELtest(data, g1 = 1, t1 = 0, t2 = Inf, sided = 2,
  nboot = 1000, alpha = 0.05, compo = FALSE, seed = 1011,
  nlimit = 200)
```

## Arguments

data	a data frame/matrix with 3 columns. The first column is the survival time. The second is the censoring indicator. The last is the grouping variable. An example as the input to data provided is <a href="#">hepatitis</a> .
g1	the group with longer survival in one-sided testing with the default value of 1.
t1	pre-specified $t_1$ based on domain knowledge with the default value of 0
t2	pre-specified $t_2$ based on domain knowledge with the default value of $\infty$
sided	2 if two-sided test, and 1 if one-sided test. It assumes the default value of 2.

nboot	number of bootstrap replications in calculating critical values with the default value of 1000.
alpha	pre-specified significance level of the test with the default value of 0.05
compo	FALSE if taking the standardized square of the difference as the local statistic for two-sided testing, and TRUE if constructing for one-sided testing, but only the positive part of the difference included. It assumes the default value of <i>FALSE</i> .
seed	the parameter with the default value of 1011 to <code>set.seed</code> for generating bootstrap-based critical values in R. The <code>set.seed</code> is used implicitly in <code>intELtest</code> .
nlimit	the splitting unit with the default value of 200. To deal with large data problems, the bootstrap algorithm is to split the number of bootstrap replicates into <code>nsplit</code> parts. The number <code>nsplit</code> is the smallest integer not less than $\ U\ /nlimit$ .

### Value

supELtest returns a list with three elements:

- `teststat` the resulting integrated test statistic
- `critval` the critical value
- `pvalue` the p-value based on the integrated statistic

### References

H.-w. Chang and I. W. McKeague, "Empirical likelihood based tests for stochastic ordering under right censorship," *Electronic Journal of Statistics*, Vol. 10, No. 2, pp. 2511-2536 (2016).

### See Also

[hazardcross](#), [intELtest](#), [ptwiseELtest](#)

### Examples

```
library(EL2Surv)
supELtest(hazardcross)
```

```
## OUTPUT:
## $teststat
## [1] 8.945539
##
## $critval
## [1] 8.738189
##
## $pvalue
## [1] 0.045
```

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