

# Package ‘biostat3’

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**Type** Package

**Title** Utility Functions, Datasets and Extended Examples for Survival Analysis

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**Description** Utility functions, datasets and extended examples for survival analysis. This extends a range of other packages, some simple wrappers for time-to-event analyses, datasets, and extensive examples in HTML with R scripts. The package also supports the course Biostatistics III entitled “Survival analysis for epidemiologists in R”.

**Depends** survival, R (>= 3.5), MASS, methods

**Imports** graphics, stats

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biostat3-package	<i>Utility Functions, Datasets and Extended Examples for Survival Analysis</i>
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## Description

Utility functions, datasets and extended examples for survival analysis. This extends a range of other packages, some simple wrappers for time-to-event analyses, datasets, and extensive examples in HTML with R scripts. The package also supports the course Biostatistics III entitled "Survival analysis for epidemiologists in R".

## Author(s)

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## Examples

```
plot(muhaz2(Surv(surv_mm, status == "Dead: cancer")~1, melanoma))
```

---

addIndicators                      *Utility to add indicators from a data-frame based on a formula.*

---

**Description**

Column-bind a model matrix to the source data-frame

**Usage**

```
addIndicators(data, formula, drop.intercept = TRUE)
```

**Arguments**

data                      source data-frame or matrix.  
formula                    model formula used to add columns.  
drop.intercept            logical as to whether to drop the column named '(Intercept)'.

**Details**

This function calls `model.matrix`, conditionally checks for and removes '(Intercept)', and binds with the original data-frame (or matrix).

**Value**

data-frame or matrix.

**Examples**

```
addIndicators(data.frame(f = c("a","a","b")), ~f+0)
```

---

as.data.frame.bshazard  
*Functions to work with bshazard objects.*

---

**Description**

Convert a bshazard object to a data-frame.

**Usage**

```
## S3 method for class 'bshazard'  
as.data.frame(x, ...)
```

**Arguments**

x                    bshazard object  
 ...                  other arguments

**Value**

Returns a data-frame with names time, hazard, conf.low and conf.high (cf. lower.ci and upper.ci provided in the object).

**Examples**

```
##---- Should be DIRECTLY executable !! ----
##-- ==> Define data, use random,
##--or do help(data=index) for the standard data sets.

## The function is currently defined as
function (x, ...)
{
  with(x, data.frame(time, hazard, conf.low = lower.ci, conf.high = upper.ci))
}
```

brv

*Bereavement dataset***Description**

Bereavement dataset

**Usage**

```
data("brv")
```

**Format**

A data frame with 399 observations on the following 11 variables.

id a numeric vector the id of a subject  
 couple a numeric vector for the id of a couple  
 dob a Date for the date of birth  
 doe a Date for the date of entry into study  
 dox a Date for the date of exit from study  
 dosp a Date for the date of bereavement  
 fail a numeric vector for status at study exit 0=alive 1=died  
 group a numeric vector for Group  
 disab a numeric vector for disability level  
 health a numeric vector for perceived health status  
 sex a numeric vector for sex 1=M 2=F

**Examples**

```
data(brv)
## maybe str(brv) ; plot(brv) ...
```

---

colon	<i>Colon cancer dataset</i>
-------	-----------------------------

---

**Description**

Colon cancer dataset

**Usage**

```
data("colon")
```

**Format**

A data frame with 15564 observations on the following 18 variables.

sex a factor with levels Male Female

age a numeric vector

stage a factor with levels Unknown Localised Regional Distant

mmdx a numeric vector

yydx a numeric vector

surv\_mm a numeric vector

surv\_yy a numeric vector

status a factor with levels Alive Dead: cancer Dead: other Lost to follow-up

subsite a factor with levels Coecum and ascending Transverse Descending and sigmoid Other and NOS

year8594 a factor with levels Diagnosed 75-84 Diagnosed 85-94

agegrp a factor with levels 0-44 45-59 60-74 75+

dx a Date

exit a Date

id a numeric vector

ydx a numeric vector for continuous year of diagnosis

yexit a numeric vector for continuous year of exit

**Examples**

```
data(colon)
## maybe str(colon) ; plot(colon) ...
```

---

colon_sample	<i>Sample from the <code>colon</code> dataset used for teaching.</i>
--------------	--

---

**Description**

Sample from the `colon` dataset used for teaching.

**Usage**

```
data("colon_sample")
```

**Format**

A data frame with 35 observations on the following 9 variables.

`sex` a factor with levels Male Female

`age` a numeric vector

`stage` a factor with levels Unknown Localised Regional Distant

`mmdx` a numeric vector

`yydx` a numeric vector

`surv_mm` a numeric vector

`surv_yy` a numeric vector

`status` a factor with levels Alive Dead: cancer Dead: other Lost to follow-up

`subsite` a factor with levels Coecum and ascending Transverse Descending and sigmoid Other and NOS

**Examples**

```
data(colon_sample)
## maybe str(colon_sample) ; plot(colon_sample) ...
```

---

coxphHaz	<i>Smoothed hazard estimates for coxph</i>
----------	--

---

**Description**

Smoothed hazard estimates for coxph

**Usage**

```

coxphHaz(object, newdata, n.grid = 300, kernel = "epanechnikov", from,
to, ...)
## S3 method for class 'coxphHaz'
print(x, digits=NULL, ...)
## S3 method for class 'coxphHaz'
plot(x, xlab="Time", ylab="Hazard", type="l", ...)
## S3 method for class 'coxphHazList'
plot(x, xlab="Time", ylab="Hazard", type="l",
      col=1:length(x), lty=1, legend.args=list(), ...)
## S3 method for class 'coxphHazList'
lines(x, ...)
## S3 method for class 'coxphHaz'
as.data.frame(x, row.names=NULL, optional=FALSE, level=0.95, ...)
## S3 method for class 'coxphHazList'
as.data.frame(x, row.names=NULL, optional=FALSE, ...)

```

**Arguments**

object	coxph object
newdata	data-frame with covariates for prediction
n.grid	the number of grid values for which the hazard is calculated
kernel	the kernel used for smoothing
from	argument for density. Defaults to the minimum time.
to	argument for density. Defaults to the maximum time.
x	object
digits	argument passed to print.density
col	graphics argument
lty	graphics argument
xlab	graphics argument
ylab	graphics argument
type	graphics argument
level	level for confidence intervals (default=0.95)
row.names	NULL or a character vector giving the row names for the data frame. Missing values are not allowed.
optional	logical. If TRUE, setting row names and converting column names (to syntactic names: see make.names) is optional. Note that all of R's base package as.data.frame() methods use optional only for column names treatment, basically with the meaning of data.frame(*, check.names = !optional). See also the make.names argument of the matrix method.
legend.args	a list of options that are passed to the legend call. Defaults are list(x="topright", legend=strata(at
...	other arguments. For coxphHaz, these arguments are passed to density. For the plot and lines methods, these are passed to the relevant plot, matplot and matlines functions.

**Details**

Smooth hazard estimates from a Cox model using kernel smoothing of the Nelson-Aalen estimator.

**Value**

The `coxphHaz` function returns either a class of type `c("coxphHaz", "density")` when `newdata` has one row or, for multiple rows in `newdata`, a class of type `"coxphHazList"`, which is a list of type `c("coxphHaz", "density")`.

**See Also**

[coxph](#), [survfit](#), [density](#)

**Examples**

```
fit <- coxph(Surv(surv_mm/12, status=="Dead: cancer")~agegrp, data=colon)
newdata <- data.frame(agegrp=levels(colon$agegrp))
haz <- suppressWarnings(coxphHaz(fit, newdata))
plot(haz, xlab="Time since diagnosis (years)")
```

---

diet

*Diet data set*

---

**Description**

Diet data set

**Usage**

```
data("diet")
```

**Format**

A data frame with 337 observations on the following 15 variables.

`id` a numeric vector

`chd` a numeric vector

`y` a numeric vector

`hieng` a factor with levels low high

`energy` a numeric vector

`job` a factor with levels driver conductor bank

`month` a numeric vector

`height` a numeric vector

`weight` a numeric vector

`doe` a Date for date of study entry



dox a Date for date of study exit  
 dob a Date for date of birth  
 yob a numeric vector for continuous year of birth  
 yoe a numeric vector for continuous year of entry  
 yox a numeric vector for continuous year of exit

### Examples

```
data(diet)
## maybe str(diet) ; plot(diet) ...
```

---

eform	<i>Calculate the exponential form for coefficients and their confidence intervals using either profile likelihood-based or Wald-based confidence intervals.</i>
-------	---

---

### Description

irr and or use eform with a different name for the estimator.

### Usage

```
eform(object, ...)
## Default S3 method:
eform(object, parm, level = 0.95, method =
c("Delta","Profile"), name = "exp(beta)", ...)
irr(..., name = "IRR")
or(..., name = "OR")
```

### Arguments

object	A fitted model object with coef and confint methods
parm	a specification of which parameters are to be given confidence intervals, either a vector of numbers or a vector of names. If missing, all parameters are considered.
level	the confidence level required
method	string to determine method to use the delta method (stats::confint.default), which assumes that the parameters are asymptotically normal, or profile likelihood-based confidence intervals (MASS::confint.glm), respectively.
name	name of the estimator.
...	arguments to pass from irr or or to eform.

### Value

A matrix (or vector) with columns giving lower and upper confidence limits for each parameter. These will be labelled as (1-level)/2 and 1 - (1-level)/2 in

**Examples**

```
## from example(glm)
counts <- c(18,17,15,20,10,20,25,13,12)
outcome <- gl(3, 1, 9); treatment <- gl(3, 3)
glm.D93 <- glm(counts ~ outcome + treatment, family = poisson())
eform(glm.D93)
eform(glm.D93, method="Profile")
```

---

lifetab	<i>Create cohort life table</i>
---------	---------------------------------

---

**Description**

Create cohort life table.

**Usage**

```
lifetab(tis, ninit, nlost, nevent)
```

**Arguments**

tis	a vector of end points of time intervals, whose length is 1 greater than nlost and nevent.
ninit	the number of subjects initially entering the study.
nlost	a vector of the number of individuals lost follow or withdrawn alive for whatever reason.
nevent	a vector of the number of individuals who experienced the event

**Details**

This is a minor update of the `lifetab` function from the **KMsurv** package, where the start and stop times of the intervals are now included in the return value.

**Value**

A data.frame with the following columns:

tstart	interval start time.
tstop	interval end time.
nsubs	the number of subject entering the intervals who have not experienced the event.
nlost	the number of individuals lost follow or withdrawn alive for whatever reason.
nrisk	the estimated number of individuals at risk of experiencing the event.
nevent	the number of individuals who experienced the event.
surv	the estimated survival function at the start of the intervals.
pdf	the estimated probability density function at the midpoint of the intervals.

hazard	the estimated hazard rate at the midpoint of the intervals.
se.surv	the estimated standard deviation of survival at the beginning of the intervals.
se.pdf	the estimated standard deviation of the probability density function at the midpoint of the intervals.
se.hazard	the estimated standard deviation of the hazard function at the midpoint of the intervals

The row.names are the intervals.

### Author(s)

Jun Yan <jyan@stat.uconn.edu>

### Examples

```
tis <- c(0, 2, 3, 5, 7, 11, 17, 25, 37, 53, NA)
nsubs <- c(927, 848, 774, 649, 565, 449, 296, 186, 112, 27)
nlost <- c(2, 3, 6, 9, 7, 5, 3, rep(0, 3))
nevent <- c(77, 71, 119, 75, 109, 148, 107, 74, 85, 27)

lifetab(tis, nsubs[1], nlost, nevent)
```

---

lifetab2

*Formula wrapper for [lifetab](#) from the [KMsurv](#) package.*

---

### Description

Calculate a life table using the actuarial method using a formula and a data-frame with optional breaks.

### Usage

```
lifetab2(formula, data, subset, breaks = NULL)
## S3 method for class 'lifetab2'
plot(x, y=NULL, ...)
## S3 method for class 'lifetab2'
lines(x, y=NULL, ...)
```

### Arguments

formula	formula with the left-hand side being a Surv object, including a time and event indicator, and the right-hand side indicated stratification.
data	optional data.frame for the Surv object. If this is not provided, then the parent frame is used for the Surv object.
subset	optional subset statement
breaks	optional numeric vector of breaks. If this is not provided, then the unique time values from the Surv object are used together with Inf.

x	lifetab2 object
y	unused argument (part of the generic function)
...	other arguments

### Details

See `lifetab` for details. This wrapper is meant to make life easier.

A copy of the `lifetab` function has been included in the **biostat3** package to reduce dependencies.

### Value

A `data.frame` as per `lifetab`.

### Author(s)

Mark Clements for the wrapper.

### Examples

```
## we can use unique transformed times (colon_sample)
lifetab2(Surv(floor(surv_yy),status=="Dead: cancer")~1, colon_sample)

## we can also use the breaks argument (colon)
lifetab2(Surv(surv_yy,status=="Dead: cancer")~1, colon, breaks=0:10)
```

---

lincom

*Linear combination of regression parameters.*

---

### Description

Using results calculated by the `linearHypothesis` function in the `car` package, calculate a linear combination of regression parameters.

### Usage

```
lincom(model, specification, level = 0.95, eform = FALSE, ...)
```

### Arguments

model	regression model object (as per the <code>model</code> argument in <code>linearHypothesis</code> )
specification	specification of the linear combination. This is the same as a single component of the <code>hypothesis.matrix</code> argument in <code>linearHypothesis</code> .
level	the confidence level required
eform	logical for whether to exponentiate the confidence interval (default=FALSE)
...	other arguments to the <code>linearHypothesis</code> function.

**Details**

Multiple specifications of linear combinations are called individually.

**Value**

A matrix with columns including the estimate, a normal-based confidence interval, test statistic and p-values.

**See Also**

See Also `linearHypothesis`.

**Examples**

```
fit <- glm(chd ~ hieng*job + offset(log(y)), data=diet, family=poisson)
lincom(fit, c("hienghigh+hienghigh:jobconductor",
             "hienghigh+hienghigh:jobbank"),
       eform=TRUE)
```

---

melanoma

*Melanoma cancer dataset*

---

**Description**

Melanoma cancer dataset

**Usage**

```
data("melanoma")
```

**Format**

A data frame with 7775 observations on the following 18 variables.

`sex` a factor with levels Male Female

`age` a numeric vector

`stage` a factor with levels Unknown Localised Regional Distant

`mmdx` a numeric vector

`yydx` a numeric vector

`surv_mm` a numeric vector

`surv_yy` a numeric vector

`status` a factor with levels Alive Dead: cancer Dead: other Lost to follow-up

`subsite` a factor with levels Head and Neck Trunk Limbs Multiple and NOS

`year8594` a factor with levels Diagnosed 75-84 Diagnosed 85-94

`dx` a Date

exit a Date  
 agegrp a factor with levels 0-44 45-59 60-74 75+  
 id a numeric vector  
 ydx a numeric vector for continuous year of diagnosis  
 yexit a numeric vector for continuous year of exit

### Examples

```
data(melanoma)
## maybe str(melanoma) ; plot(melanoma) ...
```

---

muhaz2

*Formula wrapper for the [muhaz](#) function from the [muhaz](#) package.*

---

### Description

Formula wrapper for the [muhaz](#) function from the [muhaz](#) package.

### Usage

```

muhaz2(formula, data, subset, max.time, ...)
## S3 method for class 'muhaz2'
plot(x, haz.scale=1, ylab="Hazard", ylim=NULL, log="", ...)
## S3 method for class 'muhazList'
plot(x, lty=1:5, col=1:length(x), log="", legend.args=list(), ...)
## S3 method for class 'muhaz2'
lines(x, ..., haz.scale = 1)
## S3 method for class 'muhazList'
lines(x, lty=1, col=1:length(x), ...)
## S3 method for class 'muhazList'
summary(object, ...)
## S3 method for class 'muhazList'
ggplot(data, mapping=NULL,
        xlab="Time", ylab="Hazard", ...,
        environment = parent.frame())
## S3 method for class 'muhazList'
as.data.frame(x, row.names, optional, ...)
## S3 method for class 'muhaz'
as.data.frame(x, row.names, optional, ...)
```

### Arguments

formula	formula with the left-hand side being a <code>Surv</code> object, including a time and event indicator, and the right-hand side indicated stratification.
data	optional <code>data.frame</code> for the <code>Surv</code> object. If this is not provided, then the parent frame is used for the <code>Surv</code> object.

subset	subset predicate for the dataset
max.time	maximum follow-up time for the hazards
xlab	graphics argument for xlab (x-axis label)
ylab	graphics argument for ylab (y-axis label)
lty	graphics argument for line type
col	graphics argument for line colour
legend.args	a list of options that are passed to the legend call. Defaults are <code>list(x="topright", legend=names(x), c</code>
haz.scale	scale for the hazard in the plot
row.names	not currently used
object	muhazList object
ylim	graphics argument for the limits of the y axis
log	graphics argument for a log transformation of the x or y axes
x	muhazList or muhaz object
environment	*[Deprecated]* Used prior to tidy evaluation.
optional	not currently used
mapping	Default list of aesthetic mappings to use for plot. If not specified, must be supplied in each layer added to the plot.
...	other arguments

### Value

For a single strata, this is a `muhaz` object. For multiple strata, this is a `muhazList` object, which includes methods for

### Examples

```
plot(muhaz2(Surv(surv_mm, status == "Dead: cancer")~1, melanoma))
```

---

poisson.ci

*Exact Poisson confidence intervals.*

---

### Description

A wrapper for the `poisson.test` that allows for vector values.

### Usage

```
poisson.ci(x, T = 1, alternative = c("two.sided", "less", "greater"), conf.level = 0.95)
```

**Arguments**

x	number of events.
T	time base for event count.
alternative	indicates the type of confidence interval and must be one of "two.sided", "greater" or "less". You can specify just the initial letter.
conf.level	confidence level for the returned confidence interval.

**Details**

This uses a vectorised algorithm based on `stats::poisson.test`.

**Value**

A matrix (or vector) with columns giving lower and upper confidence limits for each parameter. These will be labelled as  $(1-\text{level})/2$  and  $1 - (1-\text{level})/2$  in % (by default 2.5% and 97.5%) for the two-sided alternative.

**See Also**

[poisson.test](#)

**Examples**

```
### These are paraphrased from data sets in the ISwR package

## SMR, Welsh Nickel workers
poisson.ci(137, 24.19893)

## eba1977, compare Fredericia to other three cities for ages 55-59
poisson.ci(c(11, 6+8+7), c(800, 1083+1050+878))
```

---

popmort

*popmort dataset, with population-based mortality rates*

---

**Description**

popmort dataset, with population-based mortality rates

**Usage**

```
data("popmort")
```



**Format**

A data frame with 10600 observations on the following 5 variables.

sex a numeric vector  
 ‘\_year’ a numeric vector  
 ‘\_age’ a numeric vector  
 prob a numeric vector  
 rate a numeric vector

**Examples**

```
data(popmort)
## maybe str(popmort) ; plot(popmort) ...
```

---

smoothHaz	<i>Simple implementation for kernel density smoothing of the Nelson-Aalen estimator.</i>
-----------	--

---

**Description**

Simple implementation for kernel density smoothing of the Nelson-Aalen estimator. Prefer muhaz for right censored data and bshazard for left truncated and right censored data.

**Usage**

```
smoothHaz(object, n.grid = 300, kernel = "epanechnikov",
           from = NULL, to = NULL, min.n.risk = 1, ...)
## S3 method for class 'smoothHaz'
plot(x, xlab = "Time", ylab = "Hazard", type = "l", ...)
```

**Arguments**

object	survfit object
n.grid	number of grid points; passed to density
kernel	kernel used; passed to density
from	left boundary; passed to density
to	right boundary; passed to density
min.n.risk	minimum number at risk
x	object of class smoothHaz
xlab	graphics argument
ylab	graphics argument
type	graphics argument
...	Other arguments

---

survPHplot

*Plot to assess non-proportionality*


---

### Description

Plot of  $\log(\text{time})$  versus  $-\log(-\log(\text{survival}))$  to assess non-proportionality. A constant distance between curves suggest proportionality.

### Usage

```
survPHplot(formula, data, subset, contrasts, weights, col = 1:5,
            lty = 1:5, pch = 19, xlab = "Time (log scale)",
            ylab = "-log(-log(Survival))", log = "x",
            legend.args = list(), ...)
```

### Arguments

formula	either (i) formula with a Surv object on the left-hand-side and stratification co- variates on the right-hand-side, or (ii) a survfit object
data	data argument passed to survfit
subset	subset argument passed to survfit
contrasts	contrasts argument passed to survfit
weights	weights argument passed to survfit
col	colours of the curves passed to lines
lty	line type of the curves passed to lines
pch	pch for the curves passed to points
xlab	xlab graphics argument passed to plot.default
ylab	ylab graphics argument passed to plot.default
log	log graphics argument passed to plot.default
legend.args	list of arguments passed to legend. These arguments update the base arguments, which are <code>list(x="topright", legend=names(survfit\$strata), col=col, lty=lty, pch=pch)</code>
...	Other arguments passed to plot.default

### Details

The default plot is to use straight lines between the transformed survival values for each strata, rather than using steps.

### Value

Primary purpose is for plotting (side effect). The return value is initial plot.

**Examples**

```
survPHplot(Surv(surv_mm/12, status == "Dead: cancer") ~ year8594,
           data=colon, subset=(stage=="Localised"),
           legend.args=list(bty="n"))
```

survRate

*Describe rates***Description**

Describe rates using the [Surv](#) function.

**Usage**

```
survRate(formula, data, subset, addvars = TRUE, ci=TRUE, ...)
```

**Arguments**

formula	formula with the left-hand-side being a <a href="#">Surv</a> function and the right-hand-side being any stratification variables.
data	source dataset
subset	subset conditions for the source dataset
addvars	logical for whether to add the stratification variables to the output (default=TRUE). This is useful for subsequent analysis.
ci	logical for whether to calculate the confidence interval (default=TRUE).
...	other arguments to the <a href="#">poisson.test</a> function for calculation of the confidence intervals.

**Value**

data-frame with columns tstop, event, rate, lower and upper. Covariates are appended if addvar=TRUE.

Confidence intervals use `stats::poisson.test`.

**Examples**

```
## incidence rates for CHD for low- or high-energy diets
survRate(Surv(y,chd) ~ hieng, data=diet)
```

---

utilities

*Utility functions for the biostat3 package*

---

### Description

Utility functions for the biostat3 package.

### Usage

```
updateList(object, ...)  
format_perc(probs, digits)
```

### Arguments

object	base object (list)
...	arguments to update
probs	probability to express as a percentage
digits	number of significant digits

### Details

Update the names in the base object list that are specified in the arguments to update.

### Value

list

### Examples

```
updateList(list(a=1,b=2), a=10, c=30)
```

---

year

*Convert a Date vector to a numeric vector*

---

### Description

Convert a Date vector to a numeric vector (either continuous or truncated).

### Usage

```
year(date, trunc = FALSE, year.length = 365.24)
```

**Arguments**

date	Date vector
trunc	logical for whether to truncate the date to a whole year or consider the date as a double (default).
year.length	assumed length of a year

**Details**

For the double calculation, we use  $(\text{truncated year of Date}) + (\text{date} - 1 \text{ Jan of Year})/\text{year.length}$ .

**Value**

numeric vector

**Examples**

```
c(year(as.Date("2001-07-01")), year(as.Date("2001-01-01"), trunc=TRUE))
```

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