

# Package ‘survstan’

September 21, 2023

**Title** Fitting Survival Regression Models via 'Stan'

**Version** 0.0.4

**Description** Parametric survival regression models under the maximum likelihood approach via 'Stan'. Implemented regression models include accelerated failure time models, proportional hazards models, proportional odds models, accelerated hazard models, and Yang and Prentice models. Available baseline survival distributions include exponential, Weibull, log-normal, log-logistic, and fatigue (Birnbaum-Saunders) distributions. References: Lawless (2002) <ISBN:9780471372158>; Bennett (1982) <doi:10.1002/sim.4780020223>; Chen and Wang(2000) <doi:10.1080/01621459.2000.10474236>; Demarqui and Mayrink (2021) <doi:10.1214/20-BJPS471>.

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**SystemRequirements** GNU make

**URL** <https://github.com/fndemarqui/survstan>,  
<https://fndemarqui.github.io/survstan/>

**BugReports** <https://github.com/fndemarqui/survstan/issues>

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**Author** Fabio Demarqui [aut, cre, cph]  
(<https://orcid.org/0000-0001-9236-1986>)

**Maintainer** Fabio Demarqui <fndemarqui@est.ufmg.br>

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survstan-package	<i>The 'survstan' package.</i>
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## Description

The aim of the R package `survstan` is to provide a toolkit for fitting survival models using Stan. The R package `survstan` can be used to fit right-censored survival data under independent censoring. The implemented models allow the fitting of survival data in the presence/absence of covariates. All inferential procedures are currently based on the maximum likelihood (ML) approach.

## References

- Stan Development Team (2023). “RStan: the R interface to Stan.” R package version 2.21.8, <https://mc-stan.org/>.
- Lawless JF (2002). *Statistical Models and Methods for Lifetime Data*, Wiley Series in Probability and Statistics, 2nd Edition edition. John Wiley and Sons. ISBN 9780471372158.
- Bennett S (1983). “Analysis of survival data by the proportional odds model.” *Statistics in Medicine*, **2**(2), 273-277. doi:10.1002/sim.4780020223.
- Chen YQ, Wang M (2000). “Analysis of Accelerated Hazards Models.” *Journal of the American Statistical Association*, **95**(450), 608-618. doi:10.1080/01621459.2000.10474236.
- Demarqui FN, Mayrink VD (2021). “Yang and Prentice model with piecewise exponential baseline distribution for modeling lifetime data with crossing survival curves.” *Brazilian Journal of Probability and Statistics*, **35**(1), 172 – 186. doi:10.1214/20BJPS471.

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aftreg	<i>Fitting Accelerated Failure Time Models</i>
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---

## Description

Function to fit accelerated failure time (AFT) models.

## Usage

```
aftreg(formula, data, baseline = "weibull", dist = NULL, init = 0, ...)
```

## Arguments

- |         |   |
|---------|---|
| formula | an object of class "formula" (or one that can be coerced to that class): a symbolic description of the model to be fitted.  |
| data    | data an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which function is called. |

baseline	the chosen baseline distribution; options currently available are: exponential, weibull, lognormal, loglogistic and Birnbaum-Saunders (fatigue) distributions.
dist	alternative way to specify the baseline distribution (for compability with the <a href="#">survreg</a> function); default is NULL.
init	initial values specification (default value is 0); see the detailed documentation for <code>init</code> in <a href="#">optimizing</a> .
...	further arguments passed to other methods.

**Value**

ahreg returns an object of class "aftreg" containing the fitted model.

**Examples**

```
library(survstan)
fit <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull")
summary(fit)
```

---

ahreg

*Fitting Accelerated Hazard Models*


---

**Description**

Function to fit accelerated hazard (AH) models.

**Usage**

```
ahreg(formula, data, baseline = "weibull", dist = NULL, init = 0, ...)
```

**Arguments**

formula	an object of class "formula" (or one that can be coerced to that class): a symbolic description of the model to be fitted.
data	data an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which function is called.
baseline	the chosen baseline distribution; options currently available are: exponential, weibull, lognormal, loglogistic and Birnbaum-Saunders (fatigue) distributions.
dist	alternative way to specify the baseline distribution (for compability with the <a href="#">survreg</a> function); default is NULL.
init	initial values specification (default value is 0); see the detailed documentation for <code>init</code> in <a href="#">optimizing</a> .
...	further arguments passed to other methods.

**Value**

ahreg returns an object of class "ahreg" containing the fitted model.

**Examples**

```
library(survstan)
fit <- ahreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull")
summary(fit)
```

---

AIC.survstan	<i>Akaike information criterion</i>
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---

**Description**

Akaike information criterion

**Usage**

```
## S3 method for class 'survstan'
AIC(object, ..., k = 2)
```

**Arguments**

object	an object of the class survstan.
...	further arguments passed to or from other methods.
k	numeric, the penalty per parameter to be used; the default k = 2 is the classical AIC.

**Value**

the Akaike information criterion value when a single model is passed to the function; otherwise, a data.frame with the Akaike information criterion values and the number of parameters is returned.

**Examples**

```
library(survstan)
fit1 <- aftreg(Surv(futime, fustat) ~ 1, data = ovarian, baseline = "weibull", init = 0)
fit2 <- aftreg(Surv(futime, fustat) ~ rx, data = ovarian, baseline = "weibull", init = 0)
fit3 <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
AIC(fit1, fit2, fit3)
```

---

anova.survstan	<i>anova method for survstan models</i>
----------------	---

---

**Description**

Compute analysis of variance (or deviance) tables for one or more fitted model objects.

**Usage**

```
## S3 method for class 'survstan'
anova(...)
```

**Arguments**

... further arguments passed to or from other methods.

**Value**

the ANOVA table.

**Examples**

```
library(survstan)
fit1 <- aftreg(Surv(futime, fustat) ~ 1, data = ovarian, baseline = "weibull", init = 0)
fit2 <- aftreg(Surv(futime, fustat) ~ rx, data = ovarian, baseline = "weibull", init = 0)
fit3 <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
anova(fit1, fit2, fit3)
```

---

coef.survstan	<i>Estimated regression coefficients</i>
---------------	--

---

**Description**

Estimated regression coefficients

**Usage**

```
## S3 method for class 'survstan'
coef(object, ...)
```

**Arguments**

object an object of the class survstan  
 ... further arguments passed to or from other methods

**Value**

the estimated regression coefficients

**Examples**

```
library(survstan)
fit <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
coef(fit)
```

---

confint.survstan	<i>Confidence intervals for the regression coefficients</i>
------------------	---

---

**Description**

Confidence intervals for the regression coefficients

**Usage**

```
## S3 method for class 'survstan'
confint(object, parm = NULL, level = 0.95, ...)
```

**Arguments**

object	an object of the class survstan.
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.
...	further arguments passed to or from other methods.

**Value**

100(1-alpha) confidence intervals for the regression coefficients.

**Examples**

```
library(survstan)
fit <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
confint(fit)
```

---

cross_time	<i>Generic S3 method cross_time</i>
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---

**Description**

Generic S3 method cross\_time

**Usage**

```
cross_time(object, ...)
```

**Arguments**

object	a fitted model object
...	further arguments passed to or from other methods.

**Value**

the crossing survival time

---

cross_time.ypreg	<i>Computes the crossing survival times</i>
------------------	---

---

**Description**

Computes the crossing survival times

**Usage**

```
## S3 method for class 'ypreg'
cross_time(object, newdata1, newdata2, conf.level = 0.95, nboot = 1000, ...)
```

**Arguments**

object	an object of class ypreg
newdata1	a data frame containing the first set of explanatory variables
newdata2	a data frame containing the second set of explanatory variables
conf.level	level of the confidence/credible intervals
nboot	number of bootstrap samples (default nboot=1000).
...	further arguments passed to or from other methods.

**Value**

the crossing survival time



## Examples

```
library(survstan)
data(ipass)
fit <- ypreg(Surv(time, status)~arm, data=ipass, baseline = "weibull")
summary(fit)
newdata1 <- data.frame(arm=0)
newdata2 <- data.frame(arm=1)
tcross <- cross_time(fit, newdata1, newdata2, nboot = 10)
tcross
```

---

estimates

*Parameters estimates of a survstan model*

---

## Description

Parameters estimates of a survstan model

## Usage

```
estimates(object, ...)
```

## Arguments

**object**            an object of the class survstan.  
**...**             further arguments passed to or from other methods.

## Value

the parameters estimates of a given survstan model.

## Examples

```
library(survstan)
fit <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
estimates(fit)
```

---

extractAIC.survstan    *Extract AIC from a Fitted Model*

---

### Description

Computes the (generalized) Akaike An Information Criterion for a fitted parametric model.

### Usage

```
## S3 method for class 'survstan'  
extractAIC(fit, scale, k = 2, ...)
```

### Arguments

fit	a fitted model of the class survstan
scale	optional numeric specifying the scale parameter of the model. Currently only used in the "lm" method, where scale specifies the estimate of the error variance, and scale = 0 indicates that it is to be estimated by maximum likelihood.
k	numeric specifying the 'weight' of the equivalent degrees of freedom part in the AIC formula.
...	further arguments passed to or from other methods.

### Value

the ANOVA table.

### Examples

```
library(survstan)  
fit1 <- aftreg(Surv(futime, fustat) ~ 1, data = ovarian, baseline = "weibull", init = 0)  
fit2 <- aftreg(Surv(futime, fustat) ~ rx, data = ovarian, baseline = "weibull", init = 0)  
fit3 <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)  
extractAIC(fit1)  
extractAIC(fit2)  
extractAIC(fit3)
```

---

gastric

*Gastric cancer data set*

---

### Description

Data set from a clinical trial conducted by the Gastrointestinal Tumor Study Group (GTSG) in 1982. The data set refers to the survival times of patients with locally nonresectable gastric cancer. Patients were either treated with chemotherapy combined with radiation or chemotherapy alone.

### Format

A data frame with 90 rows and 3 variables:

- time: survival times (in days)
- status: failure indicator (1 - failure; 0 - otherwise)
- trt: treatments (1 - chemotherapy + radiation; 0 - chemotherapy alone)

### Author(s)

Fabio N. Demarqui <fndemarqui@est.ufmg.br>

### References

Gastrointestinal Tumor Study Group. (1982) A Comparison of Combination Chemotherapy and Combined Modality Therapy for Locally Advanced Gastric Carcinoma. *Cancer* 49:1771-7.

---

ggresiduals

*Generic S3 method ggresiduals*

---

### Description

Generic S3 method ggresiduals

### Usage

```
ggresiduals(object, ...)
```

### Arguments

object	a fitted model object.
...	further arguments passed to or from other methods.

### Details

Generic method to plot residuals of survival models.

**Value**

the desired residual plot.

---

ggresiduals.survstan *ggresiduals method for survstan models*

---

**Description**

ggresiduals method for survstan models

**Usage**

```
## S3 method for class 'survstan'  
ggresiduals(object, type = c("coxsnell", "martingale", "deviance"), ...)
```

**Arguments**

object	a fitted model object of the class survstan.
type	type of residuals used in the plot: coxsnell (default), martingale and deviance.
...	further arguments passed to or from other methods.

**Details**

This function produces residuals plots of Cox-Snell residuals, martingale residuals and deviance residuals.

**Value**

the desired residual plot.

**Examples**

```
library(survstan)  
ovarian$rx <- as.factor(ovarian$rx)  
fit <- aftreg(Surv(futime, fustat) ~ age + rx, data = ovarian, baseline = "weibull", init = 0)  
ggresiduals(fit, type = "coxsnell")  
ggresiduals(fit, type = "martingale")  
ggresiduals(fit, type = "deviance")
```

---

ipass

*IRESSA Pan-Asia Study (IPASS) data set*

---

### Description

Reconstructed IPASS clinical trial data reported in Argyropoulos and Unruh (2015). Although reconstructed, this data set preserves all features exhibited in references with full access to the observations from this clinical trial. The data base is related to the period of March 2006 to April 2008. The main purpose of the study is to compare the drug gefitinib against carboplatin/paclitaxel doublet chemotherapy as first line treatment, in terms of progression free survival (in months), to be applied to selected non-small-cell lung cancer (NSCLC) patients.

### Format

A data frame with 1217 rows and 3 variables:

- time: progression free survival (in months)
- status: failure indicator (1 - failure; 0 - otherwise)
- arm: (1 - gefitinib; 0 - carboplatin/paclitaxel doublet chemotherapy)

### Author(s)

Fabio N. Demarqui <fndemarqui@est.ufmg.br>

### References

Argyropoulos, C. and Unruh, M. L. (2015). Analysis of time to event outcomes in randomized controlled trials by generalized additive models. PLOS One 10, 1-33.

---

logLik.survstan

*Extract Log-Likelihood from a Fitted Model*

---

### Description

Extracts the log-likelihood function for a fitted parametric model.

### Usage

```
## S3 method for class 'survstan'  
logLik(object, ...)
```

### Arguments

object            a fitted model of the class survstan  
...                further arguments passed to or from other methods.

**Value**

the log-likelihood value when a single model is passed to the function; otherwise, a data.frame with the log-likelihood values and the number of parameters is returned.

**Examples**

```
library(survstan)
fit1 <- aftreg(Surv(futime, fustat) ~ 1, data = ovarian, baseline = "weibull", init = 0)
fit2 <- aftreg(Surv(futime, fustat) ~ rx, data = ovarian, baseline = "weibull", init = 0)
fit3 <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
logLik(fit1, fit2, fit3)
```

---

model.matrix.survstan *Model.matrix method for survstan models*

---

**Description**

Reconstruct the model matrix for a survstan model.

**Usage**

```
## S3 method for class 'survstan'
model.matrix(object, ...)
```

**Arguments**

object            an object of the class survstan.  
...               further arguments passed to or from other methods.

**Value**

The model matrix (or matrices) for the fit.

**Examples**

```
library(survstan)
fit <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
model.matrix(fit)
```

---

phreg

*Fitting Proportional Hazards Models*

---

## Description

Function to fit proportional hazards (PH) models.

## Usage

```
phreg(formula, data, baseline = "weibull", dist = NULL, init = 0, ...)
```

## Arguments

formula	an object of class "formula" (or one that can be coerced to that class): a symbolic description of the model to be fitted.
data	data an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which function is called.
baseline	the chosen baseline distribution; options currently available are: exponential, weibull, lognormal, loglogistic and Birnbaum-Saunders (fatigue) distributions.
dist	alternative way to specify the baseline distribution (for compatibility with the <code>survreg</code> function); default is NULL.
init	initial values specification (default value is 0); see the detailed documentation for <code>init</code> in <code>optimizing</code> .
...	further arguments passed to other methods.

## Value

phreg returns an object of class "phreg" containing the fitted model.

## Examples

```
library(survstan)
fit <- phreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull")
summary(fit)
```

---

poreg

*Fitting Proportional Odds Models*

---

## Description

Function to fit proportional odds (PO) models.

## Usage

```
poreg(formula, data, baseline = "weibull", dist = NULL, init = 0, ...)
```

## Arguments

formula	an object of class "formula" (or one that can be coerced to that class): a symbolic description of the model to be fitted.
data	data an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which function is called.
baseline	the chosen baseline distribution; options currently available are: exponential, weibull, lognormal, loglogistic and Birnbaum-Saunders (fatigue) distributions.
dist	alternative way to specify the baseline distribution (for compatibility with the <a href="#">survreg</a> function); default is NULL.
init	initial values specification (default value is 0); see the detailed documentation for <code>init</code> in <a href="#">optimizing</a> .
...	further arguments passed to other methods.

## Value

poreg returns an object of class "poreg" containing the fitted model.

## Examples

```
library(survstan)
fit <- poreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull")
summary(fit)
```



---

```
print.summary.survstan
```

*Print the summary.survstan output*

---

### Description

Produces a printed summary of a fitted survstan model.

### Usage

```
## S3 method for class 'summary.survstan'
print(x, ...)
```

### Arguments

x                    an object of the class summary.survstan.  
 ...                  further arguments passed to or from other methods.

### Value

No return value, called for side effects.

---

```
rank_models
```

*Rank a collection of survstan models*

---

### Description

Rank a collection of survstan models

### Usage

```
rank_models(formula, data, survreg, baseline, dist = NULL, ...)
```

### Arguments

formula            an object of class "formula" (or one that can be coerced to that class): a symbolic description of the model to be fitted.  
 data                data an optional data frame, list or environment (or object coercible by as.data.frame to a data frame) containing the variables in the model. If not found in data, the variables are taken from environment(formula), typically the environment from which function is called.  
 survreg            survival regression models to be fitted (AFT, AH, PH, PO and YP).  
 baseline           baseline distributions to be fitted; options currently available are: exponential, weibull, lognormal, loglogistic and Birnbaum-Saunders (fatigue) distributions.  
 dist                alternative way to specify the baseline distributions (for compatibility with the [survreg](#) function); default is NULL.  
 ...                further arguments passed to other methods.

**Value**

a tibble containing the fitted models ranked according to their AICs.

**Examples**

```
library(survstan)
library(dplyr)

veteran <- veteran %>%
  mutate(across(c(trt, prior, celltype), as.factor))
fits <- rank_models(
  formula = Surv(time, status) ~ celltype+karno,
  data = veteran,
  survreg = c("aftreg", "ahreg", "phreg", "poreg", "ypreg"),
  baseline = c("exponential", "weibull", "lognormal", "loglogistic", "fatigue")
)
```

---

summary.survstan      *Summary for a survstan object*

---

**Description**

Summary for a survstan object

**Usage**

```
## S3 method for class 'survstan'
summary(object, conf.level = 0.95, ...)
```

**Arguments**

object	the result of a call to summary.survstan
conf.level	the confidence level required.
...	further arguments passed to or from other methods.

**Value**

an object of the class summary.survstan containing a summary of the fitted model.

---

survfit.survstan	<i>survfit method for survstan models</i>
------------------	---

---

**Description**

Computes the predicted survivor function for a phpe model.

**Usage**

```
## S3 method for class 'survstan'
survfit(formula, newdata, ...)
```

**Arguments**

formula	an object of the class survstan
newdata	a data frame containing the set of explanatory variables.
...	further arguments passed to or from other methods.

**Value**

a list containing the estimated survival probabilities.

**Examples**

```
library(survstan)
library(ggplot2)
data(ipass)
ipass$arm <- as.factor(ipass$arm)
fit <- ypreg(Surv(time, status)~arm, data=ipass, baseline = "weibull")
summary(fit)
newdata <- data.frame(arm=as.factor(0:1))
surv <- survfit(fit, newdata)
ggplot(surv, aes(x=time, y=surv, color = arm)) +
  geom_line()
```

---

tidy	<i>Generic S3 method tidy</i>
------	-------------------------------

---

**Description**

Generic S3 method tidy

**Usage**

```
tidy(object, conf.level = 0.95, ...)
```

**Arguments**

object            a fitted model object.  
 conf.level        the confidence level required.  
 ...               further arguments passed to or from other methods.

**Details**

Convert a fitted model into a tibble.

**Value**

a tibble with a summary of the fit.

---

tidy.survstan	<i>Tidy a survstan object</i>
---------------	-------------------------------

---

**Description**

Tidy a survstan object

**Usage**

```
## S3 method for class 'survstan'  

tidy(object, conf.level = 0.95, ...)
```

**Arguments**

object            a fitted model object.  
 conf.level        the confidence level required.  
 ...               further arguments passed to or from other methods.

**Details**

Convert a fitted model into a tibble.

**Value**

a tibble with a summary of the fit.

## Examples

```
library(survstan)
fit <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
tidy(fit)
```

---

tidy.ypreg

*Tidy a ypreg object*

---

## Description

Tidy a ypreg object

## Usage

```
## S3 method for class 'ypreg'
tidy(object, conf.level = 0.95, ...)
```

## Arguments

object	a fitted model object.
conf.level	the confidence level required.
...	further arguments passed to or from other methods.

## Details

Convert a fitted model into a tibble.

## Value

a tibble with a summary of the fit.

## Examples

```
library(survstan)
fit <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
tidy(fit)
```

---

 vcov.survstan

*Variance-covariance matrix*


---

### Description

This function extracts and returns the variance-covariance matrix associated with the regression coefficients when the maximum likelihood estimation approach is used in the model fitting.

### Usage

```
## S3 method for class 'survstan'
vcov(object, all = FALSE, ...)
```

### Arguments

object	an object of the class survstan.
all	logical; if FALSE (default), only covariance matrix associated with regression coefficients is returned; if TRUE, the full covariance matrix is returned.
...	further arguments passed to or from other methods.

### Value

the variance-covariance matrix associated with the parameters estimators.

### Examples

```
library(survstan)
fit <- aftreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull", init = 0)
vcov(fit)
```

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 ypreg

*Fitting Yang and Prentice Models*


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### Description

Function to fit Yang and Prentice (YP) models.

### Usage

```
ypreg(formula, data, baseline = "weibull", dist = NULL, init = 0, ...)
```

**Arguments**

formula	an object of class "formula" (or one that can be coerced to that class): a symbolic description of the model to be fitted.
data	data an optional data frame, list or environment (or object coercible by <code>as.data.frame</code> to a data frame) containing the variables in the model. If not found in data, the variables are taken from <code>environment(formula)</code> , typically the environment from which function is called.
baseline	the chosen baseline distribution; options currently available are: exponential, weibull, lognormal, loglogistic and Birnbaum-Saunders (fatigue) distributions.
dist	alternative way to specify the baseline distribution (for compability with the <a href="#">survreg</a> function); default is NULL.
init	initial values specification (default value is 0); see the detailed documentation for <code>init</code> in <a href="#">optimizing</a> .
...	further arguments passed to other methods.

**Value**

ypreg returns an object of class "ypreg" containing the fitted model.

**Examples**

```
library(survstan)
fit <- ypreg(Surv(futime, fustat) ~ ecog.ps + rx, data = ovarian, baseline = "weibull")
summary(fit)
```

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