

# Package ‘bellreg’

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**Title** Count Regression Models Based on the Bell Distribution

**Version** 0.0.1

**Description** Bell regression models for count data with overdispersion. The implemented models account for ordinary and zero-inflated regression models under both frequentist and Bayesian approaches. Theoretical details regarding the models implemented in the package can be found in Castella et al. (2018) <[doi:10.1016/j.apm.2017.12.014](https://doi.org/10.1016/j.apm.2017.12.014)> and Lemonte et al. (2020) <[doi:10.1080/02664763.2019.1636940](https://doi.org/10.1080/02664763.2019.1636940)>.

**License** GPL (>= 2)

**URL** <https://github.com/fndemarqui/bellreg>

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

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**Biarch** true

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**Author** Fabio Demarqui [aut, cre] (<<https://orcid.org/0000-0001-9236-1986>>),  
Marcos Prates [ctb] (<<https://orcid.org/0000-0001-8077-4898>>),  
Fredy Caceres [ctb] (<<https://orcid.org/0000-0001-8077-4898>>)

**Maintainer** Fabio Demarqui <[fndemarqui@est.ufmg.br](mailto:fndemarqui@est.ufmg.br)>

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bellreg-package	<i>The 'bellreg' package.</i>
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**Description**

Bell Regression models for count data with overdispersion. The implemented models account for ordinary and zero-inflated regression models under both frequentist and Bayesian approaches. Theoretical details regarding the models implemented in the package can be found in (Castellares et al. 2018) and (Lemonte et al. 2020)

**References**

- Stan Development Team (2020). RStan: the R interface to Stan. R package version 2.19.3. <https://mc-stan.org>
- Castellares F, Ferrari SL, Lemonte AJ (2018). “On the Bell distribution and its associated regression model for count data.” *Applied Mathematical Modelling*, **56**, 172 - 185. doi: [10.1016/j.apm.2017.12.014](https://doi.org/10.1016/j.apm.2017.12.014).
- Lemonte AJ, Moreno-Arenas G, Castellares F (2020). “Zero-inflated Bell regression models for count data.” *Journal of Applied Statistics*, **47**(2), 265-286. doi: [10.1080/02664763.2019.1636940](https://doi.org/10.1080/02664763.2019.1636940).

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Bell	<i>Probability function, distribution function, quantile function and random generation for the Bell distribution with parameter theta.</i>
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### Description

Probability function, distribution function, quantile function and random generation for the Bell distribution with parameter theta.

### Usage

```
dbell(x, theta, log = FALSE)
```

```
pbell(q, theta, lower.tail = TRUE, log.p = FALSE)
```

```
qbell(p, theta, log.p = FALSE)
```

```
rbell(n, theta)
```

### Arguments

x	vector of (non-negative integer) quantiles.
theta	parameter of the Bell distribution (theta > 0).
log, log.p	logical; if TRUE, probabilities p are given as log(p).
q	vector of quantiles.
lower.tail	logical; if TRUE (default), probabilities are $P[X \leq x]$ ; otherwise, $P[X > x]$ .
p	vector of probabilities.
n	number of random values to return.

### Details

Probability mass function

$$f(x) = \frac{\theta^x e^{e^\theta + 1} B_x}{x!},$$

where  $B_x$  is the Bell number, and  $x = 0, 1, \dots$

### Value

dbell gives the (log) probability function, pbell gives the (log) distribution function, qbell gives the quantile function, and rbell generates random deviates.

bellreg

*Bell regression model***Description**

Fits the Bell regression model to overdispersed count data.

**Usage**

```
bellreg(
  formula,
  data,
  approach = c("mle", "bayes"),
  hessian = TRUE,
  hyperpars = list(mu_beta = 0, sigma_beta = 10),
  ...
)
```

**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	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 <code>ypbp</code> is called.
approach	approach to be used to fit the model (mle: maximum likelihood; bayes: Bayesian approach).
hessian	hessian logical; If TRUE (default), the hessian matrix is returned when <code>approach="mle"</code> .
hyperpars	a list containing the hyperparameters associated with the prior distribution of the regression coefficients; if not specified then default choice is <code>hyperpars = c(mu_beta = 0, sigma_beta = 10)</code> .
...	further arguments passed to either <code>'rstan::optimizing'</code> or <code>'rstan::sampling'</code> .

**Value**

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

**Examples**

```
# ML approach:
mle <- bellreg(nf ~ lroll, data = faults, approach = "mle")
summary(mle)
```

```
# Bayesian approach:
bayes <- bellreg(nf ~ lroll, data = faults, approach = "bayes")
summary(bayes)
```

---

cells

*Cells data set*


---

### Description

Data set taken from (Crawley 2012) and posteriorly analyzed by (Lemonte et al. 2020). The data includes the count of infected blood cells per square millimetre on microscope slides prepared from  $n = 511$  randomly selected individuals.

### Format

A data frame with 511 rows and 5 variables:

- cells: count of infected blood cells per square millimetre on microscope slides
- smoker: smoking status of the subject (0: smoker; 1: non smoker)
- gender: subject's gender (1: male; 0: female).
- age: subject's age categorized into three levels: young ( $\leq 20$ ), mid (21 to 59), and old ( $\geq 60$ ).
- weight: body mass score categorized into three levels: normal, overweight, obese.

### References

Crawley MJ (2012). *The R Book*, 2nd edition. Wiley Publishing. ISBN 0470973927.

Lemonte AJ, Moreno-Arenas G, Castellares F (2020). "Zero-inflated Bell regression models for count data." *Journal of Applied Statistics*, **47**(2), 265-286. doi: [10.1080/02664763.2019.1636940](https://doi.org/10.1080/02664763.2019.1636940).

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coef.bellreg

*Estimated regression coefficients for the bellreg model*


---

### Description

Estimated regression coefficients for the bellreg model

### Usage

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

**Arguments**

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

**Value**

a vector with the estimated regression coefficients.

**Examples**

```
fit <- bellreg(nf ~ lroll, data=faults)
coef(fit)
```

---

coef.zibellreg	<i>Estimated regression coefficients for zibellreg model</i>
----------------	--

---

**Description**

Estimated regression coefficients for zibellreg model

**Usage**

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

**Arguments**

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

**Value**

a list containing the the estimated regression coefficients associated with the degenerated and Bell count distributions, respectively.

**Examples**

```
fit <- zibellreg(cells ~ smoker + gender|smoker + gender, data = cells)
coef(fit)
```

---

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

---

**Description**

Generic S3 method confint

**Usage**

```
confint(object, ...)
```

**Arguments**

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

**Value**

the estimated regression coefficients

---

confint.bellreg	<i>Confidence intervals for the regression coefficients</i>
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**Description**

Confidence intervals for the regression coefficients

**Usage**

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

**Arguments**

object	an object of the class bellreg
level	the confidence level required
...	further arguments passed to or from other methods

**Value**

100(1-alpha)

## Examples

```
fit <- bellreg(nf ~ lroll, data = faults)
confint(fit)
```

---

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

---

## Description

Confidence intervals for the regression coefficients

## Usage

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

## Arguments

object	an object of the class zibellreg
level	the confidence level required
...	further arguments passed to or from other methods

## Value

100(1-alpha)

## Examples

```
fit <- zibellreg(cells ~ smoker+gender|smoker+gender, data = cells, approach = "mle")
confint(fit)
```



---

faults

*Faults data set*

---

### Description

Data set taken from ( ) and posteriorly analyzed by (Castellares et al. 2018). The data contains the number of faults in rolls of fabric of different lengths.

### Format

A data frame with 32 rows and 2 variables:

- nf: number of faults in rolls of fabric of different lengths.
- lroll: length of the roll.

### References

Castellares F, Ferrari SL, Lemonte AJ (2018). “On the Bell distribution and its associated regression model for count data.” *Applied Mathematical Modelling*, **56**, 172 - 185. doi: [10.1016/j.apm.2017.12.014](https://doi.org/10.1016/j.apm.2017.12.014).

Hind J (ed.) (1982). *Compound Poisson Regression Models*, volume 14 of *Lecture Notes in Statistics*. ISBN 978-0-387-90777-2, doi: [10.1007/9781461257714\\_11](https://doi.org/10.1007/9781461257714_11).

---

`print.summary.bellreg` *Print the summary.bellreg output*

---

### Description

Print the summary.bellreg output

### Usage

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

### Arguments

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

### Value

a summary of the fitted model.

---

```
print.summary.zibellreg
```

*Print the summary.zibellreg output*

---

### Description

Print the summary.zibellreg output

### Usage

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

### Arguments

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

### Value

a summary of the fitted model.

---

```
summary.bellreg
```

*Summary for the bellreg model*

---

### Description

Summary for the bellreg model

### Usage

```
## S3 method for class 'bellreg'  
summary(object, ...)
```

### Arguments

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

---

summary.zibellreg      *Summary for the zibellreg model*

---

**Description**

Summary for the zibellreg model

**Usage**

```
## S3 method for class 'zibellreg'  
summary(object, ...)
```

**Arguments**

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

---

vcov.bellreg      *Variance-covariance matrix for a bellreg model*

---

**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 'bellreg'  
vcov(object, ...)
```

**Arguments**

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

**Value**

the variance-covariance matrix associated with the regression coefficients.

**Examples**

```
fit <- bellreg(nf ~ lroll, data = faults)  
vcov(fit)
```

---

vcov.zibellreg	<i>Covariance of the regression coefficients</i>
----------------	--

---

**Description**

Covariance of the regression coefficients

**Usage**

```
## S3 method for class 'zibellreg'
vcov(object, ...)
```

**Arguments**

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

**Value**

the variance-covariance matrix associated with the regression coefficients.

**Examples**

```
fit <- zibellreg(cells ~ smoker + gender|smoker + gender, data = cells)
vcov(fit)
```

---

zibellreg	<i>ZiBell regression model</i>
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---

**Description**

Fits the Bell regression model to overdispersed count data.

**Usage**

```
zibellreg(
  formula,
  data,
  approach = c("mle", "bayes"),
  hessian = TRUE,
  hyperpars = list(mu_psi = 0, sigma_psi = 10, mu_beta = 0, sigma_beta = 10),
  ...
)
```

**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	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 <code>yppb</code> is called.
approach	approach to be used to fit the model (mle: maximum likelihood; bayes: Bayesian approach).
hessian	hessian logical; If TRUE (default), the hessian matrix is returned when <code>approach="mle"</code> .
hyperpars	a list containing the hyperparameters associated with the prior distribution of the regression coefficients; if not specified then default choice is <code>hyperpars = c(mu_psi = 0, sigma_psi = 10, mu_beta = 0, sigma_beta = 10)</code> .
...	further arguments passed to either <code>'rstan::optimizing'</code> or <code>'rstan::sampling'</code> .

**Value**

`zibellreg` returns an object of class "zibellreg" containing the fitted model.

**Examples**

```
# ML approach:
mle <- zibellreg(cells ~ smoker+gender|smoker+gender, data = cells, approach = "mle")
summary(mle)

# Bayesian approach:
bayes <- zibellreg(cells ~ 1|smoker+gender, data = cells, approach = "bayes")
summary(bayes)
```

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