

# Package ‘Barnard’

May 6, 2026

**Type** Package

**Title** Barnard's Unconditional Test

**Version** 1.8

**Date** 2016-10-20

**Author** Kamil Erguler

**Maintainer** Kamil Erguler <k.erguler@cyi.ac.cy>

**Description** Barnard's unconditional test for 2x2 contingency tables.

**License** GPL-2

**URL** <https://github.com/kerguler/Barnard>

**LazyLoad** yes

**NeedsCompilation** yes

**Repository** CRAN

**Date/Publication** 2016-10-20 22:09:29

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## Description

This package implements the `barnard.test` function for performing Barnard's unconditional test of superiority. This is a more powerful alternative of Fisher's exact test for 2x2 contingency tables. The test, in its current implementation, uses Wald statistics as a measure of difference between two binomial proportions.

**Author(s)**

1. Kamil Erguler, Post-doctoral Fellow, EEWRC, The Cyprus Institute <k.erguler@cyi.ac.cy>

**References**

1. Barnard, G.A. (1945) A new test for 2x2 tables. *Nature*, 156:177.
2. Barnard, G.A. (1947) Significance tests for 2x2 tables. *Biometrika*, 34:123-138.

barnard.test

*Barnard's Unconditional Test***Description**

Barnard's unconditional test for superiority applied to 2x2 contingency tables using Score or Wald statistics for the difference between two binomial proportions.

**Usage**

```
barnard.test(n1, n2, n3, n4, dp = 0.001, pooled = TRUE)
```

**Arguments**

n1, n2, n3, n4	Elements of the 2x2 contingency table
dp	The resolution to search for the nuisance parameter
pooled	Z statistic with pooled (Score) or unpooled (Wald) variance

**Details**

For a 2x2 contingency table, such as  $X = [n_1, n_2; n_3, n_4]$ , the normalized difference in proportions between the two categories, given in each column, can be written with pooled variance (Score statistic) as

$$T(X) = \frac{\hat{p}_2 - \hat{p}_1}{\sqrt{\hat{p}(1-\hat{p})\left(\frac{1}{c_1} + \frac{1}{c_2}\right)}},$$

where  $\hat{p} = (n_1 + n_3)/(n_1 + n_2 + n_3 + n_4)$ ,  $\hat{p}_2 = n_2/(n_2 + n_4)$ ,  $\hat{p}_1 = n_1/(n_1 + n_3)$ ,  $c_1 = n_1 + n_3$  and  $c_2 = n_2 + n_4$ . Alternatively, with unpooled variance (Wald statistic), the difference in proportions can be written as

$$T(X) = \frac{\hat{p}_2 - \hat{p}_1}{\sqrt{\frac{\hat{p}_1(1-\hat{p}_1)}{c_1} + \frac{\hat{p}_2(1-\hat{p}_2)}{c_2}}}.$$

The probability of observing  $X$  is

$$P(X) = \frac{c_1!c_2!}{n_1!n_2!n_3!n_4!} p^{n_1+n_2} (1-p)^{n_3+n_4},$$

where  $p$  is the unknown nuisance parameter.

Barnard's test considers all tables with category sizes  $c_1$  and  $c_2$  for a given  $p$ . The p-value is the sum of probabilities of the tables having a score in the rejection region, e.g. having significantly large difference in proportions for a two-sided test. The p-value of the test is the maximum p-value calculated over all  $p$  between 0 and 1.

**Value**

statistic.table	The contingency tables considered in the analysis represented by 'n1' and 'n2', their scores, and whether they are included in the one-sided (1), two-sided (2) tests, or not included at all (0)
nuisance.matrix	Nuisance parameters, $p$ , and the corresponding p-values for both one- and two-sided tests
dp	The resolution of the search space for the nuisance parameter
contingency.matrix	The observed 2x2 contingency table
alternative	One sided or two sided test
statistic	The standardized difference between the observed proportions
nuisance.parameter	The nuisance parameter where the p-value is maximized
p.value	The p-value for the observed contingency table
pooled	Variance estimator of the Z statistic

**Note**

I am indebted to Peter Calhoun for helping to test the performance and the accuracy of the code. I also thank Rodrigo Duprat, Long Qu, and Nicolas Sounac for their valuable comments. The accuracy has been tested with respect to the existing MATLAB and R implementations as well as the results of StatXact. I have largely been influenced by the works of Trujillo-Ortiz et al. (2004), Cardillo G. (2009), and Galili T. (2010).

**Author(s)**

Kamil Erguler, Post-doctoral Fellow, EEWRRC, The Cyprus Institute <k.erguler@cyi.ac.cy>

**References**

1. Barnard, G.A. (1945) A new test for 2x2 tables. *Nature*, 156:177.
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4. Cardillo G. (2009) MyBarnard: a very compact routine for Barnard's exact test on 2x2 matrix. URL <http://www.mathworks.com/matlabcentral/fileexchange/25760>
5. Galili T. (2010) URL <http://www.r-statistics.com/2010/02/barnards-exact-test-a-powerful-alternativ>
6. Lin C.Y., Yang M.C. (2009) Improved p-value tests for comparing two independent binomial proportions. *Communications in Statistics-Simulation and Computation*, 38(1):78-91.
7. Trujillo-Ortiz, A., R. Hernandez-Walls, A. Castro-Perez, L. Rodriguez-Cardozo N.A. Ramos-Delgado and R. Garcia-Sanchez. (2004). Barnardexact:Barnard's Exact Probability Test. A MATLAB file. [WWW document]. URL <http://www.mathworks.com/>

**Examples**

```

barnard.test(8,14,1,3)

## Plotting the search for the nuisance parameter for a one-sided test
bt<-barnard.test(8,14,1,3)
plot(bt$nuisance.matrix[,1:2],
     t="1",xlab="nuisance parameter",ylab="p-value")

## Plotting the tables included in the p-value
bt<-barnard.test(40,14,10,30)
bts<-bt$statistic.table
plot(bts[,1],bts[,2],
     col=HSV(bts[,4]/4,1,1),
     t="p",xlab="n1",ylab="n2")

## Plotting the difference between pooled and unpooled tests
bts<-barnard.test(40,14,10,30,pooled=TRUE)$statistic.table
btw<-barnard.test(40,14,10,30,pooled=FALSE)$statistic.table
plot(bts[,1],bts[,2],
     col=c("black","white")[1+as.numeric(bts[,4]==btw[,4])],
     t="p",xlab="n1",ylab="n2")

```

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barnardw.test

*Barnard's Unconditional Test with Wald Statistics (obsolete)*


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**Description**

Previous version of Barnard's unconditional test for superiority which used Z-statistic with pooled variance for the difference between two binomial proportions in a 2x2 contingency table. Please use the 'barnard.test' instead.

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