Package 'hce'

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Type Package

Title Design and Analysis of Hierarchical Composite Endpoints

Version 0.5.0

Description Simulate and analyze hierarchical composite endpoints. Win odds is the main analysis method. See Gasparyan SB et al (2022) <doi:10.1007/s43441-022-00420-1>.

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R topics documented:

`calcWINS` *A generic function for calculating win statistics*

Description

A generic function for calculating win statistics

Usage

```
calcWINS(x, ...)
```

Arguments

`x`	an object used to select a method.
`...`	further arguments passed to or from other methods.

Value

a data frame containing calculated values.

See Also

calcWINS.hce(), calcWINS.formula(), calcWINS.data.frame() methods.

---

calcWINS.data.frame *Win statistics calculation using a data frame*

Description

Win statistics calculation using a data frame

Usage

```
## S3 method for class 'data.frame'
calcWINS(x, AVAL, TRTP, ref, alpha = 0.05, WOnull = 1, ...)
```

Arguments

x	a data frame containing subject-level data.
AVAL	variable in the data with ordinal analysis values.
TRTP	the treatment variable in the data.
ref	the reference treatment group.
alpha	2-sided significance level. The default is 0.05.
WOnull	the null hypothesis. The default is 1.
...	additional parameters.

Value

a list containing win statistics and their confidence intervals. It contains the following named data frames:

- summary a data frame containing number of wins, losses, and ties of the active treatment group and the overall number of comparisons.
- WP a data frame containing the win probability and its confidence interval.
- NetBenefit a data frame containing the net benefit and its confidence interval. This is just a 2x-1 transformation of WP and its CI.
- WO a data frame containing the win odds and its confidence interval.
- WR1 a data frame containing the win ratio and its confidence interval, using the transformed standard error of the gamma statistic.
- WR2 a data frame containing the win ratio and its confidence interval, using the standard error calculated using Pties.
- gamma a data frame containing Goodman Kruskal's gamma and its confidence interval.
- SE a data frame containing standard errors used to calculed the Confidence intervals for win statistics.

References

The theory of win statistics is covered in the following papers.

- For the win proportion CI calculation see

  Gasparyan, Samvel B., et al. "Adjusted win ratio with stratification: calculation methods and interpretation." Statistical Methods in Medical Research 30.2 (2021): 580-611 doi:10.1177/0962280220942558.

- The win odds CI is calculated using the formula in

  Gasparyan, Samvel B., et al. "Power and sample size calculation for the win odds test: application to an ordinal endpoint in COVID-19 trials." Journal of Biopharmaceutical Statistics 31.6 (2021): 765-787 doi:10.1080/10543406.2021.1968893.

- The win ratio the first CI uses the standard error derived from the standard error of the gamma statistic.

- The win ratio the second CI uses the standard error presented in

  Yu RX, Ganju J. Sample size formula for a win ratio endpoint. Statistics in medicine. 2022 Mar 15;41(6):950-63 doi:10.1002/sim.9297.

- The Goodman Kruskal's gamma and its CI match those in DescTools::GoodmanKruskalGamma() and are based on

  Agresti, A. (2002) Categorical Data Analysis. John Wiley & Sons, pp. 57-59.

  Brown, M.B., Benedetti, J.K.(1977) Sampling Behavior of Tests for Correlation in Two-Way Contingency Tables, Journal of the American Statistical Association, 72, 309-315.

  Goodman, L. A., & Kruskal, W. H. (1954) Measures of association for cross classifications. Journal of the American Statistical Association, 49, 732-764.

  Goodman, L. A., & Kruskal, W. H. (1963) Measures of association for cross classifications III: Approximate sampling theory. Journal of the American Statistical Association, 58, 310-364.

See Also

calcWINS(), calcWINS.hce(), calcWINS.formula().

Examples

```
calcWINS(x = COVID19b, AVAL = "GROUP", TRTP = "TRTP", ref = "Placebo")
```

`calcWINS.formula` *Win statistics calculation using formula syntax*

Description

Win statistics calculation using formula syntax

Usage

```
## S3 method for class 'formula'
calcWINS(x, data, ...)
```

Arguments

`x`	an object of class formula.
`data`	a data frame.
`...`	additional parameters.

Value

a list containing win statistics and their confidence intervals. It contains the following named data frames:

- summary a data frame containing number of wins, losses, and ties of the active treatment group and the overall number of comparisons.
- WP a data frame containing the win probability and its confidence interval.
- NetBenefit a data frame containing the net benefit and its confidence interval. This is just a `2x-1` transformation of WP and its CI.
- WO a data frame containing the win odds and its confidence interval.
- WR1 a data frame containing the win ratio and its confidence interval, using the transformed standard error of the `gamma` statistic.
- WR2 a data frame containing the win ratio and its confidence interval, using the standard error calculated using `Pties`.
- gamma a data frame containing Goodman Kruskal's `gamma` and its confidence interval.
- SE a data frame containing standard errors used to calculed the Confidence intervals for win statistics.

References

The theory of win statistics is covered in the following papers.

- For the win proportion CI calculation see

  Gasparyan, Samvel B., et al. "Adjusted win ratio with stratification: calculation methods and interpretation." Statistical Methods in Medical Research 30.2 (2021): 580-611 doi:10.1177/0962280220942558.

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  Yu RX, Ganju J. Sample size formula for a win ratio endpoint. Statistics in medicine. 2022 Mar 15;41(6):950-63 doi:10.1002/sim.9297.
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  Brown, M.B., Benedetti, J.K.(1977) Sampling Behavior of Tests for Correlation in Two-Way Contingency Tables, Journal of the American Statistical Association, 72, 309-315.

  Goodman, L. A., & Kruskal, W. H. (1954) Measures of association for cross classifications. Journal of the American Statistical Association, 49, 732-764.

  Goodman, L. A., & Kruskal, W. H. (1963) Measures of association for cross classifications III: Approximate sampling theory. Journal of the American Statistical Association, 58, 310-364.

See Also

calcWINS(), calcWINS.hce(), calcWINS.data.frame().

Examples

```
# Example 1
calcWINS(x = GROUP ~ TRTP, data = COVID19b)
# Example 2
calcWINS(x = GROUP ~ TRTP, data = COVID19, ref = "Placebo", alpha = 0.01, WOnull = 1.2)
```

---

calcWINS.hce *Win statistics calculation for* hce *objects*

Description

Win statistics calculation for hce objects

Usage

```
## S3 method for class 'hce'
calcWINS(x, ...)
```

Arguments

x	an hce object.
...	additional parameters.

Value

a list containing win statistics and their confidence intervals. It contains the following named data frames:

- summary a data frame containing number of wins, losses, and ties of the active treatment group and the overall number of comparisons.
- WP a data frame containing the win probability and its confidence interval.
- NetBenefit a data frame containing the net benefit and its confidence interval. This is just a 2x-1 transformation of WP and its CI.
- WO a data frame containing the win odds and its confidence interval.
- WR1 a data frame containing the win ratio and its confidence interval, using the transformed standard error of the gamma statistic.
- WR2 a data frame containing the win ratio and its confidence interval, using the standard error calculated using Pties.
- gamma a data frame containing Goodman Kruskal's gamma and its confidence interval.
- SE a data frame containing standard errors used to calculed the Confidence intervals for win statistics.

References

The theory of win statistics is covered in the following papers.

- For the win proportion CI calculation see

  Gasparyan, Samvel B., et al. "Adjusted win ratio with stratification: calculation methods and interpretation." Statistical Methods in Medical Research 30.2 (2021): 580-611 doi:10.1177/0962280220942558.

- The win odds CI is calculated using the formula in

  Gasparyan, Samvel B., et al. "Power and sample size calculation for the win odds test: application to an ordinal endpoint in COVID-19 trials." Journal of Biopharmaceutical Statistics 31.6 (2021): 765-787 doi:10.1080/10543406.2021.1968893.

- The win ratio the first CI uses the standard error derived from the standard error of the gamma statistic.

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  Agresti, A. (2002) Categorical Data Analysis. John Wiley & Sons, pp. 57-59.

  Brown, M.B., Benedetti, J.K.(1977) Sampling Behavior of Tests for Correlation in Two-Way Contingency Tables, Journal of the American Statistical Association, 72, 309-315.

  Goodman, L. A., & Kruskal, W. H. (1954) Measures of association for cross classifications. Journal of the American Statistical Association, 49, 732-764.

  Goodman, L. A., & Kruskal, W. H. (1963) Measures of association for cross classifications III: Approximate sampling theory. Journal of the American Statistical Association, 58, 310-364.

See Also

calcWINS(), calcWINS.formula(), calcWINS.data.frame().

Examples

```
# Example 1
COVID19HCE <- hce(GROUP = COVID19$GROUP, TRTP = COVID19$TRTP)
calcWINS(COVID19HCE)
# Example 2
COVID19bHCE <- hce(GROUP = COVID19b$GROUP, TRTP = COVID19b$TRTP)
calcWINS(COVID19bHCE, ref = "Placebo", WOnull = 1.1, alpha = 0.01)
```

---

calcWO *A generic function for calculating win odds*

Description

A generic function for calculating win odds

Usage

```
calcWO(x, ...)
```

Arguments

x	an object used to select a method.
...	further arguments passed to or from other methods.

Value

a data frame containing calculated values.

See Also

`calcWO.hce()`, `calcWO.formula()`, `calcWO.data.frame()` methods.

`calcWO.data.frame` *Win odds calculation using a data frame*

Description

Win odds calculation using a data frame

Usage

```
## S3 method for class 'data.frame'
calcWO(x, AVAL, TRTP, ref, alpha = 0.05, WOnull = 1, ...)
```

Arguments

`x`	a data frame containing subject-level data.
`AVAL`	variable in the data with ordinal analysis values.
`TRTP`	the treatment variable in the data.
`ref`	the reference treatment group.
`alpha`	significance level. The default is 0.05.
`WOnull`	the null hypothesis. The default is 1.
`...`	additional parameters.

Value

a data frame containing the win odds and its confidence interval. It contains the following columns:

- WO calculated win odds.
- LCL lower confidence limit.
- UCL upper confidence limit.
- SE standard error of the win odds.
- WOnull win odds of the null hypothesis (specified in the `WOnull` argument).
- alpha two-sided significance level for calculating the confidence interval (specified in the `alpha` argument).
- Pvalue p-value associated with testing the null hypothesis.
- WP calculated win probability.
- WP_SE standard error of the win probability.
- WP_SD standard deviation of the win probability, calculated as `WP_SE` multiplied by `sqrt(N)`.
- N total number of patients in the analysis.

References

Gasparyan, Samvel B., et al. "Adjusted win ratio with stratification: calculation methods and interpretation." Statistical Methods in Medical Research 30.2 (2021): 580-611. doi:10.1177/0962280220942558

See Also

calcWO(), calcWO.hce(), calcWO.formula().

Examples

```
data(HCE4)
calcWO(x = HCE4, AVAL = "AVAL", TRTP = "TRTP", ref = "P")
```

---

calcWO.formula *Win odds calculation using formula syntax*

Description

Win odds calculation using formula syntax

Usage

```
## S3 method for class 'formula'
calcWO(x, data, ...)
```

Arguments

x	an object of class formula.
data	a data frame.
...	additional parameters.

Value

a data frame containing the win odds and its confidence interval. It contains the following columns:

- WO calculated win odds.
- LCL lower confidence limit.
- UCL upper confidence limit.
- SE standard error of the win odds.
- WOnull win odds of the null hypothesis (specified in the WOnull argument).
- alpha two-sided significance level for calculating the confidence interval (specified in the alpha argument).
- Pvalue p-value associated with testing the null hypothesis.
- WP calculated win probability.

- WP_SE standard error of the win probability.
- WP_SD standard deviation of the win probability, calculated as `WP_SE` multiplied by `sqrt(N)`.
- N total number of patients in the analysis.
- formula returning the specified formula in the `x` argument.
- ref showing how the reference group was selected. Can be modifying by specifying the `ref` argument.

See Also

`calcWO()`, `calcWO.hce()`, `calcWO.data.frame()`.

Examples

```
#Example 1
data(HCE1)
calcWO(AVAL ~ TRTP, data = HCE1)

#Example 2
calcWO(data = COVID19, GROUP ~ TRTP, ref = "Placebo")
```

---

calcWO.hce *Win odds calculation for* hce *objects*

Description

Win odds calculation for hce objects

Usage

```
## S3 method for class 'hce'
calcWO(x, ...)
```

Arguments

x	an hce object.
...	additional parameters.

Value

a data frame containing the win odds and its confidence interval. It contains the following columns:

- WO calculated win odds.
- LCL lower confidence limit.
- UCL upper confidence limit.
- SE standard error of the win odds.

- WOnull win odds of the null hypothesis (specified in the `WOnull` argument).
- alpha two-sided significance level for calculating the confidence interval (specified in the `alpha` argument).
- Pvalue p-value associated with testing the null hypothesis.
- WP calculated win probability.
- WP_SE standard error of the win probability.
- WP_SD standard deviation of the win probability, calculated as `WP_SE` multiplied by `sqrt(N)`.
- N total number of patients in the analysis.

See Also

`calcWO()`, `calcWO.formula()`, `calcWO.data.frame()`.

Examples

```
Rates_A <- c(1, 1.5)
Rates_P <- c(2, 2)
dat <- simHCE(n = 500, TTE_A = Rates_A, TTE_P = Rates_P, CM_A = 1.25, CM_P = 1)
calcWO(dat)
calcWO(dat, ref = "A", WOnull = 1, alpha = 0.01)
```

COVID19 *COVID-19 ordinal scale dataset (full report).*

Description

A dataset containing dataset with COVID-19 ordinal scale outcomes for 1062 patients.

Usage

```
COVID19
```

Format

a data frame with 1062 rows and 2 variables:

GROUP type of the event, ordinal outcomes 1-8, where a higher value means a better outcome

TRTP treatment values, A Active or P Placebo, character

Source

Beigel et al. (2020) doi:10.1056/NEJMoa2007764.

Examples

```
#Frequencies
table(COVID19)
mosaicplot(table(COVID19), col = c(1, 8, 6, 2, 4, 5, 3, 7),
xlab = "Treatment", ylab = "Ordinal Scale", main = "COVID-19 ordinal scale")
# Convert to an hce object
COVID19HCE <- hce(GROUP = COVID19$GROUP, TRTP = COVID19$TRTP)
# Summary wins, losses, and ties with win odds
summaryWO(COVID19HCE)
```

COVID19b *COVID-19 ordinal scale dataset (preliminary report).*

Description

A dataset containing dataset with COVID-19 ordinal scale outcomes for 844 patients.

Usage

```
COVID19b
```

Format

a data frame with 844 rows and 2 variables:

GROUP type of the event, ordinal outcomes 1-8, where a higher value means a better outcome

TRTP treatment values, Active or Placebo, character

Source

Beigel et al. (2020) doi:10.1056/NEJMoa2007764.

Examples

```
#Frequencies
table(COVID19b)
mosaicplot(table(COVID19b), col = c(1, 8, 6, 2, 4, 5, 3, 7),
xlab = "Treatment", ylab = "Ordinal Scale", main = "COVID-19 ordinal scale")
# Calculate win statistics
calcWINS(x = COVID19b, AVAL = "GROUP", TRTP = "TRTP", ref = "Placebo")
```

hce *Helper function for* hce *objects*

Description

Helper function for hce objects

Usage

```
hce(
  GROUP = character(),
  TRTP = character(),
  AVAL0 = 0,
  ORD = sort(unique(GROUP))
)
```

Arguments

GROUP	a character vector of the same length as AVAL containing events.
TRTP	a character vector of the same length as AVAL containing assigned treatment groups.
AVAL0	a numeric vector of analysis values within each category. The default is 0.
ORD	a character vector containing ordered unique values of the GROUP variable for determining the hierarchy of events.

Value

an object of class hce. Its is a subject-level data frame (each row corresponds to one subject), containing the following columns:

- SUBJID subject ID.
- GROUP a character vector specifying the type of the outcome the patient experienced - either a TTE (time-to-event) or C (continuous).
- GROUPN a numeric vector version of the GROUP column.
- AVAL0 original analysis values - time of the time-to-event outcomes or the continuous outcome.
- AVAL derived analysis value AVAL = AVAL0 + GROUPN.
- TRTP assigned treatment groups.

See Also

new_hce(), validate_hce() for the helper and validator functions of hce objects.

Examples

```
# Example 1
set.seed(2022)
d <- hce(GROUP = sample(x = c("A", "B", "C"), size = 10, replace = TRUE),
TRTP = rep(c("Active", "Control"), each = 5),
AVAL0 = c(rnorm(5, mean = 1), rnorm(5)), ORD = c("A", "B", "C"))
calcWO(d, ref = "Control")
```

HCE1 — HCE1, HCE2, HCE3, HCE4 *datasets for 1000 patients with different treatment effects.*

Description

A simulated dataset containing the ordinal values and other attributes for 1000 patients. HCE1

Usage

```
HCE1
```

Format

a data frame with 1000 rows and 6 variables:

SUBJID subject ID, numbers from 1 to 1000

GROUP type of the event, either Time-To-Event (TTE) or Continuous (C), character

GROUPN type of the event, for the ordering of outcomes in the GROUP variable, numeric

AVAL AVAL = AVAL0 + GROUPN, ordinal analysis values for the HCE analysis, numeric, but caution NOT to apply numeric operations; will give meaningless results

AVAL0 original values for each type of the event, time for TTE outcomes, numeric values for Continuous outcomes, numeric

TRTP treatment values, A Active or P Placebo, character

HCE2 — HCE1, HCE2, HCE3, HCE4 *datasets for 1000 patients with different treatment effects.*

Description

A simulated dataset containing the ordinal values and other attributes for 1000 patients. HCE2

Usage

```
HCE2
```

Format

a data frame with 1000 rows and 6 variables:

SUBJID subject ID, numbers from 1 to 1000

GROUP type of the event, either Time-To-Event (TTE) or Continuous (C), character

GROUPN type of the event, for the ordering of outcomes in the GROUP variable, numeric

AVAL AVAL = AVAL0 + GROUPN, ordinal analysis values for the HCE analysis, numeric, but caution NOT to apply numeric operations; will give meaningless results

AVAL0 original values for each type of the event, time for TTE outcomes, numeric values for Continuous outcomes, numeric

TRTP treatment values, A Active or P Placebo, character

HCE3 HCE1, HCE2, HCE3, HCE4 *datasets for 1000 patients with different treatment effects.*

Description

A simulated dataset containing the ordinal values and other attributes for 1000 patients. HCE3

Usage

```
HCE3
```

Format

a data frame with 1000 rows and 6 variables:

SUBJID subject ID, numbers from 1 to 1000

GROUP type of the event, either Time-To-Event (TTE) or Continuous (C), character

GROUPN type of the event, for the ordering of outcomes in the GROUP variable, numeric

AVAL AVAL = AVAL0 + GROUPN, ordinal analysis values for the HCE analysis, numeric, but caution NOT to apply numeric operations; will give meaningless results

AVAL0 original values for each type of the event, time for TTE outcomes, numeric values for Continuous outcomes, numeric

TRTP treatment values, A Active or P Placebo, character

HCE4 — HCE1, HCE2, HCE3, HCE4 *datasets for 1000 patients with different treatment effects.*

Description

A simulated dataset containing the ordinal values and other attributes for 1000 patients. HCE4

Usage

```
HCE4
```

Format

a data frame with 1000 rows and 6 variables:

SUBJID subject ID, numbers from 1 to 1000

GROUP type of the event, either Time-To-Event (TTE) or Continuous (C), character

GROUPN type of the event, for the ordering of outcomes in the GROUP variable, numeric

AVAL AVAL = AVAL0 + GROUPN, ordinal analysis values for the HCE analysis, numeric, but caution NOT to apply numeric operations; will give meaningless results

AVAL0 original values for each type of the event, time for TTE outcomes, numeric values for Continuous outcomes, numeric

TRTP treatment values, A Active or P Placebo, character

---

minWO — *Minimum detectable or WO for alternative hypothesis for given power (no ties)*

Description

Minimum detectable or WO for alternative hypothesis for given power (no ties)

Usage

```
minWO(N, power = 0.5, SD = NULL, k = 0.5, alpha = 0.05, WOnull = 1, digits = 2)
```

Arguments

N	a numeric vector of sample size values (two arms combined).
power	the given power. The default is 0.5 corresponding to the minimum detectable win odds. A numeric vector of length 1.
SD	assumed standard deviation of the win proportion. By default uses the conservative SD. A numeric vector of length 1.
k	proportion of active group in the overall sample size. Default is 0.5 (balanced randomization). A numeric vector of length 1.
alpha	the significance level for the 2-sided test. Default is 0.05. A numeric vector of length 1.
WOnull	the win odds value of the null hypothesis (default is 1). A numeric vector of length 1.
digits	precision to use for reporting calculated win odds.

Value

a data frame containing the calculated WO with input values.

References

Gasparyan, Samvel B., et al. "Power and sample size calculation for the win odds test: application to an ordinal endpoint in COVID-19 trials." Journal of Biopharmaceutical Statistics 31.6 (2021): 765-787. doi:10.1080/10543406.2021.1968893

See Also

powerWO(), sizeWO() for WO power and sample size calculation.

Examples

```
minWO(N = 100, digits = 5)
minWO(N = 1200, power = 0.9)
minWO(N = 1200, power = 0.9, k = 0.75)
```

---

new_hce *Constructor function for* hce *objects*

Description

Constructor function for hce objects

Usage

```
new_hce(x = data.frame())
```

Arguments

x	a data frame.

Value

an object of class hce.

See Also

hce(), validate_hce() for the helper and validator functions of hce objects.

Examples

```
data(HCE1)
dat <- new_hce(x = HCE1)
class(dat)
calcWO(dat)
```

---

plot.hce_results *A print method for* hce_results *objects*

Description

A print method for hce_results objects

Usage

```
## S3 method for class 'hce_results'
plot(x, ...)
```

Arguments

x	an object of class hce_results.
...	additional arguments to be passed to base::plot() function.

Value

no return value, called for plotting.

Examples

```
WO <- minWO(N = 100:1000)
plot(WO)
POW <- powerWO(N = 100:1000, WO = 1.2)
plot(POW, ylim = c(0, 1))
```

powerWO *Power calculation for the win odds test (no ties)*

Description

Power calculation for the win odds test (no ties)

Usage

```
powerWO(N, WO, SD = NULL, k = 0.5, alpha = 0.05, WOnull = 1)
```

Arguments

N	a numeric vector of sample size values.
WO	the given win odds for the alternative hypothesis. A numeric vector of length 1.
SD	assumed standard deviation of the win proportion. By default uses the conservative SD. A numeric vector of length 1.
k	proportion of active group in the overall sample size. Default is 0.5 (balanced randomization). A numeric vector of length 1.
alpha	the significance level for the 2-sided test. Default is 0.05. A numeric vector of length 1.
WOnull	the win odds value of the null hypothesis (default is 1). A numeric vector of length 1.

Value

a data frame containing the calculated power with input values.

References

Gasparyan, Samvel B., et al. "Power and sample size calculation for the win odds test: application to an ordinal endpoint in COVID-19 trials." Journal of Biopharmaceutical Statistics 31.6 (2021): 765-787. doi:10.1080/10543406.2021.1968893.

See Also

sizeWO(), minWO() for WO sample size or minimum detectable WO calculation.

Examples

```
# Example 1- Use the default standard deviation
powerWO(N = 1000, WO = 1.2)
powerWO(N = seq(500, 1500, 100), WO = 1.2)
# Example 2 - Use data-driven win odds and standard deviation from the COVID19 dataset
res <- calcWO(x = COVID19, AVAL = "GROUP", TRTP = "TRTP", ref = "Placebo")
print(res)
powerWO(N = 500, WO = res$WO, SD = res$SD_WP)
```

```
powerWO(N = 500, WO = res$WO) # power with the default standard deviation for the win proportion.
# Example 3 - Non-balanced 3:1 randomization
powerWO(N = 1000, WO = 1.2, k = 0.75)
```

---

print.hce_results *A print method for* hce_results *objects*

Description

A print method for hce_results objects

Usage

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

Arguments

x	an object of class hce_results.
...	additional arguments to be passed to base::print() function.

Value

no return value, called for printing.

Examples

```
print(powerWO(N = 1000, WO = 1.2))
```

---

propWINS *Proportion of wins/losses/ties given the win odds and the win ratio*

Description

Proportion of wins/losses/ties given the win odds and the win ratio

Usage

```
propWINS(WO, WR, Overall = 1)
```

Arguments

WO	win odds.
WR	win ratio.
Overall	number of comparisons, the sample size of the active treatment multiplied by the sample size of the placebo. The default is 1, hence gives the proportion.

Details

- **Win ratio** defined as $WR = \frac{W}{L}$.
- **Win odds** defined as $WO = \frac{W+0.5T}{L+0.5T} = \frac{WP}{1-WP}$.
- **Net Benefit** defined as $NB = \frac{W-L}{O}$.

Given the overall number of comparisons O, the win proportion WP and the win ratio WR, it is possible to find the total number of wins and losses. Indeed, first the win odds can be found $WO = \frac{WP}{WP+1}$ and

$$
\begin{aligned}
L &= O * \frac{2WP - 1}{WR - 1}, \\
W &= WR * O * \frac{2WP - 1}{WR - 1}, \\
T &= O - W - L.
\end{aligned}
$$

Value

a data frame with a number (or proportion if `Overall = 1`) of wins/losses/ties.

Examples

```
# Example 1
propWINS(WR = 2, WO = 1.5)
# Example 2 - Back-calculation
COVID19HCE <- hce(GROUP = COVID19$GROUP, TRTP = COVID19$TRTP)
res <- calcWINS(COVID19HCE)
WR <- res$WR1$WR
WO <- res$WO$WO
Overall <- res$summary$TOTAL
propWINS(WR = WR, WO = WO, Overall = Overall)
## Verify
res$summary
```

---

regWO *A generic function for win odds regression*

Description

A generic function for win odds regression

Usage

```
regWO(x, ...)
```

Arguments

`x`	an object used to select a method.
`...`	further arguments passed to or from other methods.

Value

a data frame containing calculated values.

See Also

`regWO.data.frame()` methods.

`regWO.data.frame` *Win odds regression using a data frame*

Description

Win odds regression using a data frame

Usage

```
## S3 method for class 'data.frame'
regWO(x, AVAL, TRTP, COVAR, ref, alpha = 0.05, WOnull = 1, ...)
```

Arguments

`x`	a data frame containing subject-level data.
`AVAL`	variable in the data with ordinal analysis values.
`TRTP`	the treatment variable in the data.
`COVAR`	a numeric covariate.
`ref`	the reference treatment group.
`alpha`	significance level. The default is 0.05.
`WOnull`	the null hypothesis. The default is 1.
`...`	additional parameters.

Value

a data frame containing the win odds and its confidence interval. The data frame has an attribute called "covar_info" giving summary statistics for the covariate used for the calculations. The data frame itselfs contains the following columns:

- WO_beta adjusted win odds.
- LCL lower confidence limit for adjusted WO.
- UCL upper confidence limit for adjusted WO.
- SE standard error of the adjusted win odds.
- WOnull win odds of the null hypothesis (specified in the `WOnull` argument).
- alpha two-sided significance level for calculating the confidence interval (specified in the `alpha` argument).

- Pvalue p-value associated with testing the null hypothesis.
- beta adjusted win probability.
- SE_beta standard error for the adjusted win probability.
- WP (non-adjusted) win probability.
- SE_WP standard error of the non-adjusted win probability.
- WO non-adjusted win odds.

References

Gasparyan, Samvel B., et al. "Adjusted win ratio with stratification: calculation methods and interpretation." Statistical Methods in Medical Research 30.2 (2021): 580-611. doi:10.1177/0962280220942558

See Also

regWO().

Examples

```
# A baseline covariate that is highly correlated with the outcome
set.seed(2023)
dat <- COVID19
n <- nrow(dat)
dat$Severity <- ifelse(dat$GROUP > 4, rexp(n, 1), rexp(n, 10))
res <- regWO(x = dat, AVAL = "GROUP", TRTP = "TRTP", COVAR = "Severity", ref = "Placebo")
res
attr(res, "covar_info")
```

---

simHCE *Simulate* hce *object with given event rates of time-to-event outcomes, mean and SD of the continuous outcome by treatment group*

Description

Simulate hce object with given event rates of time-to-event outcomes, mean and SD of the continuous outcome by treatment group

Usage

```
simHCE(
  n,
  n0 = n,
  TTE_A,
  TTE_P,
  CM_A,
  CM_P,
  CSD_A = 1,
```

```
  CSD_P = 1,
  fixedfy = 1,
  yeardays = 360,
  pat = 100,
  ord = 10000,
  seed = NULL
)
```

Arguments

n	sample size in the active treatment group.
n0	sample size in the placebo group.
TTE_A	event rates per year in the active group for the time-to-event outcomes.
TTE_P	event rates per year in the placebo group for the time-to-event outcomes. Should have the same length as TTE_A.
CM_A	mean value for the continuous outcome of the active group.
CM_P	mean value for the continuous outcome of the placebo group.
CSD_A	standard deviation for the continuous outcome of the active group.
CSD_P	standard deviation for the continuous outcome of the placebo group.
fixedfy	length of follow-up in years.
yeardays	number of days in a year.
pat	scale of provided event rates (per pat-years).
ord	the coefficient for creating ordinal values
seed	the seed for generating random numbers.

Value

an object of class hce.

See Also

hce(), new_hce(), validate_hce() for the helper, constructor, and validator functions of hce.

Examples

```
# Example 1
Rates_A <- c(1.72, 1.74, 0.58, 1.5, 1)
Rates_P <- c(2.47, 2.24, 2.9, 4, 6)
dat <- simHCE(n = 2500, TTE_A = Rates_A, TTE_P = Rates_P,
CM_A = -3, CM_P = -6, CSD_A = 16, CSD_P = 15, fixedfy = 3)
head(dat)

# Example 2
Rates_A <- c(5, 7)
Rates_P <- c(7, 10)
dat <- simHCE(n = 1000, n0 = 500, TTE_A = Rates_A, TTE_P = Rates_P, CM_A = 2, CM_P = 0)
summaryWO(dat)
```

`sizeWO` *Sample size calculation for the win odds test (no ties)*

Description

Sample size calculation for the win odds test (no ties)

Usage

```
sizeWO(WO, power, SD = NULL, k = 0.5, alpha = 0.05, WOnull = 1)
```

Arguments

`WO`	a numeric vector of win odds values.
`power`	the given power. A numeric vector of length 1.
`SD`	assumed standard deviation of the win proportion. By default uses the conservative SD. A numeric vector of length 1.
`k`	proportion of active group in the overall sample size. Default is 0.5 (balanced randomization). A numeric vector of length 1.
`alpha`	the significance level for the 2-sided test. Default is 0.05. A numeric vector of length 1.
`WOnull`	the win odds value of the null hypothesis (default is 1). A numeric vector of length 1.

Value

a data frame containing the sample size with input values.

References

Gasparyan, Samvel B., et al. "Power and sample size calculation for the win odds test: application to an ordinal endpoint in COVID-19 trials." Journal of Biopharmaceutical Statistics 31.6 (2021): 765-787. doi:10.1080/10543406.2021.1968893

See Also

`powerWO()`, `minWO()` for WO power or minimum detectable WO calculation.

Examples

```
sizeWO(WO = 1.25, power = 0.9)
sizeWO(WO = 1.25, power = 0.9, k = 0.75)
sizeWO(WO = seq(1.05, 1.5, 0.05), power = 0.9)
```

`sizeWR` *Sample size calculation for the win ratio test (with WR = 1 null hypothesis)*

Description

Sample size calculation for the win ratio test (with WR = 1 null hypothesis)

Usage

```
sizeWR(WR, power, WO = NULL, Pties = NULL, k = 0.5, alpha = 0.05)
```

Arguments

`WR`	a numeric vector of win odds values.
`power`	the given power. A numeric vector of length 1.
`WO`	win odds. Should be specified only if `Pties` is not specified. A numeric vector of length 1.
`Pties`	probability of ties. A numeric vector of length 1.
`k`	proportion of active group in the overall sample size. Default is 0.5 (balanced randomization). A numeric vector of length 1.
`alpha`	the significance level for the 2-sided test. Default is 0.05. A numeric vector of length 1.

Value

a data frame containing the sample size with input values.

References

Yu RX, Ganju J. Sample size formula for a win ratio endpoint. Statistics in medicine. 2022 Mar 15;41(6):950-63. doi:10.1002/sim.9297.

See Also

`sizeWO()` for WO sample size calculation.

Examples

```
sizeWR(WR = 1.36, Pties = 0.064, power = 0.9)
sizeWR(WR = 1.36, WO = 1.333, power = 0.9)
```

summaryWO *A generic function for summarizing win odds*

Description

A generic function for summarizing win odds

Usage

```
summaryWO(x, ...)
```

Arguments

x	an object used to select a method.
...	further arguments passed to or from other methods.

Value

a data frame containing calculated values.

See Also

summaryWO.hce(), summaryWO.formula(), summaryWO.data.frame() methods.

summaryWO.data.frame *Win odds summary for a data frame*

Description

Win odds summary for a data frame

Usage

```
## S3 method for class 'data.frame'
summaryWO(x, AVAL, TRTP, ref, GROUP = NULL, ...)
```

Arguments

x	a data frame containing subject-level data.
AVAL	variable in the data with ordinal analysis values.
TRTP	the treatment variable in the data.
ref	the reference treatment group.
GROUP	an optional variable for grouping.
...	additional parameters.

Value

a list containing the summary of wins, losses, and ties. It contains the following named objects:

- summary a data frame containing number of wins, losses, and ties by treatment group and the overall number of comparisons.
- summary_by_GROUP (if GROUP variable is specified) a summary data frame by GROUP.
- WO calculated WO (win odds) and WP (win probability) and their standard errors.

See Also

calcWO(), summaryWO(), summaryWO.data.frame() methods.

Examples

```
summaryWO(x = HCE3, AVAL = "AVAL", TRTP = "TRTP", ref = "P", GROUP = "GROUP")
```

---

summaryWO.formula *Win odds summary using formula syntax*

Description

Win odds summary using formula syntax

Usage

```
## S3 method for class 'formula'
summaryWO(x, data, ...)
```

Arguments

x	an object of class formula.
data	a data frame.
...	additional parameters.

Value

a list containing the summary of wins, losses, and ties. It contains the following named objects:

- summary a data frame containing number of wins, losses, and ties by treatment group and the overall number of comparisons.
- WO calculated WO (win odds) and WP (win probability) and their standard errors.
- formula returning the specified formula in the x argument.
- ref showing how the reference group was selected. Can be modifying by specifying the ref argument.

Examples

```
summaryWO(data = COVID19, GROUP ~ TRTP)
summaryWO(data = COVID19, GROUP ~ TRTP, GROUP = "GROUP", ref = "Placebo")
```

summaryWO.hce *Win odds summary for* hce *objects*

Description

Win odds summary for hce objects

Usage

```
## S3 method for class 'hce'
summaryWO(x, ...)
```

Arguments

x	an hce object.
...	additional parameters.

Value

a list containing the summary of wins, losses, and ties. It contains the following named objects:

- summary a data frame containing number of wins, losses, and ties by treatment group and the overall number of comparisons.
- summary_by_GROUP (if GROUP variable is specified) a summary data frame by GROUP.
- WO calculated WO (win odds) and WP (win probability) and their standard errors.

See Also

calcWO(), summaryWO(), summaryWO.data.frame() methods.

Examples

```
dat <- new_hce(HCE4)
summaryWO(dat, ref = "P")
```

validate_hce *Validator function for* hce *objects*

Description

Validator function for hce objects

Usage

```
validate_hce(x)
```

Arguments

x	an object used for the hce validation.

Value

a validated data frame that can be used for creating an hce object.

See Also

hce(), new_hce() for the helper and constructor functions of hce objects.

Examples

```
data(HCE1)
validate_hce(HCE1)
```

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