Package ‘crt2power’

March 13, 2025

Type Package

Title Designing Cluster-Randomized Trials with Two Continuous Co-Primary Outcomes

Version 1.2.0

Description Provides methods for powering cluster-randomized trials with two continuous co-primary outcomes using five key design techniques. Includes functions for calculating required sample size and statistical power. For more details on methodology, see Owen et al. (2025) <doi:10.1002/sim.70015>, Yang et al. (2022) <doi:10.1111/biom.13692>, Pocock et al. (1987) <
erstaff et al. (2019) <doi:10.1186/s12874-019-0754-4>, and Li et al. (2020) <doi:10.1111/biom.13212>.

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Encoding UTF-8

URL `https://github.com/melodyaowen/crt2power`

Depends R (>= 4.3)

Imports devtools (>= 2.4.5), knitr (>= 1.43), rootSolve (>= 1.8.2.3), tidyverse (>= 2.0.0), tableone (>= 0.13.2), foreach (>= 1.5.2), mvtnorm (>= 1.2), tibble (>= 3.2.1), dplyr (>= 1.1.4), tidyr (>= 1.3.0), stats (>= 3.6.2)

RoxygenNote 7.3.2

Suggests testthat (>= 3.0.0)

Config/testthat/edition 3

NeedsCompilation no

Author Melody Owen [aut, cre]

Maintainer Melody Owen <`melody.owen@yale.edu`>

Repository CRAN

Date/Publication 2025-03-13 07:00:02 UTC

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`calc_K_comb_outcome` *Calculate required number of clusters per treatment group for a cluster-randomized trial with co-primary endpoints using a combined outcomes approach.*

Description

Allows user to calculate the number of clusters per treatment arm of a cluster-randomized trial with two co-primary outcomes given a set of study design input values, including the number of clusters in each trial arm, and cluster size. Uses a combined outcomes approach where the two outcome effects are summed together.

Usage

```
calc_K_comb_outcome(
  dist = "Chi2",
  power,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
```

```
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A data frame of numerical values.

Examples

```
calc_K_comb_outcome(power = 0.8, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_K_conj_test`	*Calculate required number of clusters per treatment group for a cluster-randomized trial with co-primary endpoints using the conjunctive intersection-union test approach.*

Description

Allows user to calculate the required number of clusters per treatment group of a cluster-randomized trial with two co-primary outcomes given a set of study design input values, including the statistical power, and cluster size. Uses the conjunctive intersection-union test approach.Code is adapted from "calSampleSize_ttestIU()" from https://github.com/siyunyang/coprimary_CRT written by Siyun Yang.

Usage

```
calc_K_conj_test(
  dist = "T",
  power,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1,
  cv = 0,
  deltas = c(0, 0),
  two_sided = FALSE
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'T' for T-Distribution or 'MVN' for Multivariate Normal Distribution. Default is T-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.

`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.
`cv`	Cluster variation parameter, set to 0 if assuming all cluster sizes are equal; numeric.
`deltas`	Vector of non-inferiority margins, set to delta_1 = delta_2 = 0; numeric vector.
`two_sided`	Specification of whether to conduct two 2-sided tests, 'TRUE', or two 1-sided tests, 'FALSE', default is FALSE; boolean.

Value

A data frame of numerical values.

Examples

```
calc_K_conj_test(power = 0.8, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_K_disj_2dftest` *Calculate required number of clusters per treatment group for a cluster-randomized trial with co-primary endpoints using a disjunctive 2-DF test approach.*

Description

Allows user to calculate the number of clusters per treatment arm of a cluster-randomized trial with two co-primary outcomes given a set of study design input values, including the statistical power, and cluster size. Uses the disjunctive 2-DF test approach. Code is adapted from "calSampleSize_omnibus()" from https://github.com/siyunyang/coprimary_CRT.

Usage

```
calc_K_disj_2dftest(
  dist = "Chi2",
  power,
  m,
  alpha = 0.05,
```

```
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A data frame of numerical values.

Examples

```
calc_K_disj_2dftest(power = 0.8, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_K_pval_adj` *Calculate required number of clusters per treatment group for a cluster-randomized trial with co-primary endpoints using three common p-value adjustment methods*

Description

Allows user to calculate the number of clusters per treatment arm of a cluster-randomized trial with two co-primary endpoints given a set of study design input values, including the statistical power, and cluster size. Uses three common p-value adjustment methods.

Usage

```
calc_K_pval_adj(
  dist = "Chi2",
  power,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.

`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A data frame of numerical values.

Examples

```
calc_K_pval_adj(power = 0.8, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho2  = 0.05)
```

`calc_K_single_1dftest` *Calculate required number of clusters per treatment group for a cluster-randomized trial with co-primary endpoints using the single 1-DF combined test approach.*

Description

Allows user to calculate the number of clusters per treatment arm of a cluster-randomized trial with two co-primary endpoints given a set of study design input values, including the statistical power, and cluster size. Uses the single 1-DF combined test approach for clustered data and two outcomes.

Usage

```
calc_K_single_1dftest(
  dist = "Chi2",
  power,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A data frame of numerical values.

Examples

```
calc_K_single_1dftest(power = 0.8, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_m_comb_outcome` *Calculate cluster size for a cluster-randomized trial with co-primary endpoints using a combined outcomes approach.*

Description

Allows user to calculate the cluster size of a cluster-randomized trial with two co-primary endpoints given a set of study design input values, including the number of clusters in each trial arm, and statistical power. Uses a combined outcomes approach where the two outcome effects are summed together.

Usage

```
calc_m_comb_outcome(
  dist = "Chi2",
  power,
  K,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A numerical value.

Examples

```
calc_m_comb_outcome(power = 0.8, K = 15, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_m_conj_test` *Calculate cluster size for a cluster-randomized trial with co-primary endpoints using the conjunctive intersection-union test approach.*

Description

Allows user to calculate the cluster size of a cluster-randomized trial with two co-primary endpoints given a set of study design input values, including the number of clusters in each trial arm, and statistical power. Uses the conjunctive intersection-union test approach.

Usage

```
calc_m_conj_test(
  dist = "T",
  power,
  K,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1,
  cv = 0,
  deltas = c(0, 0),
  two_sided = FALSE
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'T' for T-Distribution or 'MVN' for Multivariate Normal Distribution. Default is T-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.

`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.
`cv`	Cluster variation parameter, set to 0 if assuming all cluster sizes are equal; numeric.
`deltas`	Vector of non-inferiority margins, set to delta_1 = delta_2 = 0; numeric vector.
`two_sided`	Specification of whether to conduct two 2-sided tests, 'TRUE', or two 1-sided tests, 'FALSE', default is FALSE; boolean.

Value

A numerical value.

Examples

```
calc_m_conj_test(power = 0.8, K = 15, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_m_disj_2dftest` *Calculate cluster size for a cluster-randomized trial with co-primary endpoints using a disjunctive 2-DF test approach.*

Description

Allows user to calculate the cluster size of a cluster-randomized trial with two co-primary outcomes given a set of study design input values, including the number of clusters in each trial arm, and statistical power. Uses the disjunctive 2-DF test approach.

Usage

```
calc_m_disj_2dftest(
  dist = "Chi2",
  power,
  K,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A numerical value.

Examples

```
calc_m_disj_2dftest(power = 0.8, K = 15, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_m_pval_adj` *Calculate cluster size for a cluster-randomized trial with co-primary endpoints using three common p-value adjustment methods*

Description

#' @description Allows user to calculate the cluster size of a cluster-randomized trial with two co-primary endpoints given a set of study design input values, including the number of clusters in each trial arm, and statistical power. Uses three common p-value adjustment methods.

Usage

```
calc_m_pval_adj(
  dist = "Chi2",
  power,
  K,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.

`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A data frame of numerical values.

Examples

```
calc_m_pval_adj(power = 0.8, K = 15, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho2  = 0.05)
```

`calc_m_single_1dftest` *Calculate cluster size for a cluster-randomized trial with co-primary endpoints using the single 1-DF combined test approach.*

Description

Allows user to calculate the cluster size of a cluster-randomized trial with two co-primary endpoints given a set of study design input values, including the number of clusters in each trial arm, and statistical power. Uses the single 1-DF combined test approach for clustered data and two outcomes.

Usage

```
calc_m_single_1dftest(
  dist = "Chi2",
  power,
  K,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`power`	Desired statistical power in decimal form; numeric.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A numerical value.

Examples

```
calc_m_single_1dftest(power = 0.8, K = 15, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_ncp_chi2` *Find the non-centrality parameter corresponding to Type I error rate and statistical power*

Description

Allows user to find the corresponding non-centrality parameter for power analysis based on the Type I error rate, statistical power, and degrees of freedom.

Usage

```
calc_ncp_chi2(alpha, power, df = 1)
```

Arguments

`alpha`	Type I error rate; numeric.
`power`	Desired statistical power in decimal form; numeric.
`df`	Degrees of freedom; numeric.

Value

A number.

Examples

```
calc_ncp_chi2(alpha = 0.05, power = 0.8, df = 1)
```

`calc_pwr_comb_outcome` *Calculate statistical power for a cluster-randomized trial with co-primary endpoints using a combined outcomes approach.*

Description

Allows user to calculate the statistical power of a cluster-randomized trial with two co-primary outcomes given a set of study design input values, including the number of clusters in each trial arm, and cluster size. Uses a combined outcomes approach where the two outcome effects are summed together.

Usage

```
calc_pwr_comb_outcome(
  dist = "Chi2",
  K,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A numerical value.

Examples

```
calc_pwr_comb_outcome(K = 15, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_pwr_conj_test` *Calculate statistical power for a cluster-randomized trial with co-primary endpoints using the conjunctive intersection-union test approach.*

Description

Allows user to calculate the statistical power of a cluster-randomized trial with two co-primary outcomes given a set of study design input values, including the number of clusters in each trial arm, and cluster size. Uses the conjunctive intersection-union test approach. Code is adapted from "calPower_ttestIU()" from https://github.com/siyunyang/coprimary_CRT written by Siyun Yang.

Usage

```
calc_pwr_conj_test(
  dist = "T",
  K,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1,
  cv = 0,
  deltas = c(0, 0),
  two_sided = FALSE
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'T' for T-Distribution or 'MVN' for Multivariate Normal Distribution. Default is T-Distribution.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.
`cv`	Cluster variation parameter, set to 0 if assuming all cluster sizes are equal; numeric.

`deltas`	Vector of non-inferiority margins, set to delta_1 = delta_2 = 0; numeric vector.
`two_sided`	Specification of whether to conduct two 2-sided tests, 'TRUE', or two 1-sided tests, 'FALSE', default is FALSE; boolean.

Value

A numerical value.

Examples

```
calc_pwr_conj_test(K = 15, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_pwr_disj_2dftest` *Calculate statistical power for a cluster-randomized trial with co-primary endpoints using a disjunctive 2-DF test approach.*

Description

Allows user to calculate the statistical power of a cluster-randomized trial with two co-primary outcomes given a set of study design input values, including the number of clusters in each trial arm, and cluster size. Uses the disjunctive 2-DF test approach. Code is adapted from "calPower_omnibus()" from https://github.com/siyunyang/coprimary_CRT written by Siyun Yang.

Usage

```
calc_pwr_disj_2dftest(
  dist = "Chi2",
  K,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A numerical value.

Examples

```
calc_pwr_disj_2dftest(K = 15, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`calc_pwr_pval_adj` *Calculate statistical power for a cluster-randomized trial with co-primary endpoints using three common p-value adjustment methods*

Description

Allows user to calculate the statistical power of a cluster-randomized trial with two co-primary endpoints given a set of study design input values, including the number of clusters in each trial arm, and cluster size. Uses three common p-value adjustment methods.

Usage

```
calc_pwr_pval_adj(
  dist = "Chi2",
  K,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A data frame of numerical values.

Examples

```
calc_pwr_pval_adj(K = 15, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho2  = 0.05)
```

---

calc_pwr_single_1dftest

Calculate statistical power for a cluster-randomized trial with co-primary endpoints using the single 1-DF combined test approach.

Description

Allows user to calculate the statistical power of a cluster-randomized trial with two co-primary endpoints given a set of study design input values, including the number of clusters in each trial arm, and cluster size. Uses the single 1-DF combined test approach for clustered data and two outcomes.

Usage

```
calc_pwr_single_1dftest(
  dist = "Chi2",
  K,
  m,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`dist`	Specification of which distribution to base calculation on, either 'Chi2' for Chi-Squared or 'F' for F-Distribution.
`K`	Number of clusters in treatment arm, and control arm under equal allocation; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.

`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A numerical value.

Examples

```
calc_pwr_single_1dftest(K = 15, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

`run_crt2_design` *Find study design output specifications based on all five CRT co-primary design methods.*

Description

Allows user to calculate either statistical power, number of clusters per treatment group (K), or cluster size (m), given a set of input values for all five study design approaches.

Usage

```
run_crt2_design(
  output,
  power = NA,
  K = NA,
  m = NA,
  alpha = 0.05,
  beta1,
  beta2,
  varY1,
  varY2,
  rho01,
  rho02,
  rho1,
  rho2,
  r = 1
)
```

Arguments

`output`	Parameter to calculate, either "power", "K", or "m"; character.
`power`	Desired statistical power; numeric.
`K`	Number of clusters in each arm; numeric.
`m`	Individuals per cluster; numeric.
`alpha`	Type I error rate; numeric.
`beta1`	Effect size for the first outcome; numeric.
`beta2`	Effect size for the second outcome; numeric.
`varY1`	Total variance for the first outcome; numeric.
`varY2`	Total variance for the second outcome; numeric.
`rho01`	Correlation of the first outcome for two different individuals in the same cluster; numeric.
`rho02`	Correlation of the second outcome for two different individuals in the same cluster; numeric.
`rho1`	Correlation between the first and second outcomes for two individuals in the same cluster; numeric.
`rho2`	Correlation between the first and second outcomes for the same individual; numeric.
`r`	Treatment allocation ratio - K2 = rK1 where K1 is number of clusters in experimental group; numeric.

Value

A data frame of numerical values.

Examples

```
run_crt2_design(output = "power", K = 15, m = 300, alpha = 0.05,
beta1 = 0.1, beta2 = 0.1, varY1 = 0.23, varY2 = 0.25,
rho01 = 0.025, rho02 = 0.025, rho1 = 0.01, rho2  = 0.05)
```

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