Package ‘MSRDT’

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Type Package

Title Multi-State Reliability Demonstration Tests (MSRDT)

Version 0.1.0

Maintainer Suiyao Chen <csycsy12377@gmail.com>

Description This is a implementation of design methods for multi-state reliability demonstration tests (MSRDT) with failure count data, which is associated with the work from the published paper “Multi-state Reliability Demonstration Tests” by Suiyao Chen et al. (2017) <doi:10.1080/08982112.2017.1314493>. It implements two types of MSRDT, multiple periods (MP) and multiple failure modes (MFM). For MP, two different scenarios with criteria on cumulative periods (Cum) or separate periods (Sep) are implemented respectively. It also provides the implementation of conventional design method, namely binomial tests for failure count data.

Depends R (>= 3.3.0)

License GPL-3

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Imports gtools, stats, reshape2, dplyr, utils

Suggests tidyverse, knitr, rmarkdown

URL https://github.com/ericchen12377/MSRDT

BugReports https://github.com/ericchen12377/MSRDT/issues

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Author Suiyao Chen [aut, cre]

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Description

Define the consumer's risk function which gets the probability of passing the test when the lower level reliability requirement is not satisfied (for binomial RDT).

Usage

\[ \text{bconsumerrisk}(n, c, \pi, R) \]

Arguments

- **n**: RDT sample size.
- **c**: Maximum allowable failures.
- **\pi**: Failure probability.
- **R**: Lower level reliability requirement.

Value

Probability of consumer's risk
See Also

- `bcore` for getting the core probability of passing the test; `boptimal_n` for getting the optimal test sample size; `bIndicator` for getting the binary indicator;
- Other Binomial RDT functions: `bIndicator()`, `bcore()`, `boptimal_n()`

Examples

```r
pi <- pi_MCSim_beta(M = 1000, seed = 10, a = 1, b = 1)
bconsumerrisk(n = 10, c = 2, pi = pi, R = 0.8);
```

**bcore**  
*Probability Core for Binomial RDT*

**Description**

Define the summed core function inside of the integration which gets the probability of passing the test given specific failure probabilities (for binomial RDT).

**Usage**

```r
bcore(n, c, pi)
```

**Arguments**

- `n`: RDT sample size.
- `c`: Maximum allowable failures.
- `pi`: Failure probability.

**Value**

Core probability of passing the test given specific failure probabilities.

**See Also**

- `boptimal_n` for getting the optimal test sample size; `bconsumerrisk` for getting the consumer's risk; `bIndicator` for getting the binary indicator;
- Other Binomial RDT functions: `bIndicator()`, `bconsumerrisk()`, `boptimal_n()`

**Examples**

```r
bcore(n = 10, c = 2, pi = 0.2)
```
**bIndicator**  
*Binary Indicator for Binomial RDT*

**Description**

Define the binary indicator function to check whether the failure probability satisfies the lower level reliability requirement (for binomial RDT).

**Usage**

\[ \text{bIndicator}(\pi, R) \]

**Arguments**

- \( \pi \)  
  Failure probability.
- \( R \)  
  Lower Level reliability requirement.

**Value**

\( 0 \) – No; \( 1 \) – Yes.

**See Also**

- `bcore` for getting the core probability of passing the test;  
- `boptimal_n` for getting the optimal test sample size;  
- `bconsumerrisk` for getting the consumer's risk;  

Other Binomial RDT functions: `bconsumerrisk()`, `bcore()`, `boptimal_n()`

**Examples**

\[ \text{bIndicator}(\pi = 0.05, R = 0.9) \]
\[ \text{bIndicator}(\pi = 0.2, R = 0.9) \]

---

**boptimal_n**  
*Optimal Test Sample Size for Binomial RDT*

**Description**

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer's risk (for binomial RDT).

**Usage**

\[ \text{boptimal_n}(c, \pi, R, \text{thres\_CR}) \]

**Description**

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer's risk (for binomial RDT).

**Usage**

\[ \text{boptimal_n}(c, \pi, R, \text{thres\_CR}) \]
**MFM_consumerrisk**

**Arguments**
- `c`: Maximum allowable failures
- `pi`: Failure probability
- `R`: Lower level reliability requirement
- `thres_CR`: Threshold (acceptable level) of consumer’s risk

**Value**
Minimum test sample size

**See Also**
- `bcore` for getting the core probability of passing the test; `bconsumerrisk` for getting the consumer’s risk; `bIndicator` for getting the binary indicator;
Other Binomial RDT functions: `bIndicator()`, `bconsumerrisk()`, `bcore()`

**Examples**

```r
pi <- pi_MCSim_beta(M = 5000, seed = 10, a = 1, b = 1)
boptimal_n(c = 2, pi = pi, R = 0.8, thres_CR = 0.05)
```

---

**MFM_consumerrisk**  
Consumer’s Risk for Multi-state RDT with Multiple Failure Modes (MFM)

---

**Description**
Define the consumer risk function which gets the probability of passing the test when the lower level reliability requirements are not satisfied under different failure modes (for Multi-state RDT, Multiple Failure Modes).

**Usage**

```r
MFM_consumerrisk(n, cvec, pivec, Rvec)
```

**Arguments**
- `n`: RDT sample size
- `cvec`: Maximum allowable failures for each separate period
- `pivec`: Failure probability for each separate period
- `Rvec`: Lower level reliability requirements for each cumulative period from the beginning of the test.
MFM_core

Value

Probability for consumer’s risk

See Also

MFM_core for getting the core probability of passing the test; MFM_Indicator for getting the binary indicator; MFM_optimal_n for getting the optimal test sample size;

Other MSRDT for MFM functions: MFM_Indicator(), MFM_core(), MFM_optimal_n()

Examples

pi1 <- pi_MCSim_beta(M = 1000, seed = 10, a = 1, b = 1)
pi2 <- pi_MCSim_beta(M = 1000, seed = 10, a = 2, b = 18)
MFM_consumerrisk(n = 10, cvec = c(1, 1), pivec = cbind(pi1, pi2), Rvec = c(0.8, 0.7))

MFM_core

Probability Core for Multi-state RDT with Multiple Failure Modes (MFM)

Description

Define the summed core function inside of the integration which gets the probability of passing the test given specific failure probabilities under different failure modes (for Multi-state RDT, Multiple Failure Modes).

Usage

MFM_core(n, cvec, pivec)

Arguments

n RDT sample size
cvec Maximum allowable failures for each separate period
pivec Failure probability for each separate period

Value

Core probability of passing the test given specific failure probabilities

See Also

MFM_consumerrisk for getting the consumer’s risk; MFM_Indicator for getting the binary indicator; MFM_optimal_n for getting the optimal test sample size;

Other MSRDT for MFM functions: MFM_Indicator(), MFM_consumerrisk(), MFM_optimal_n()
Examples

Example for two failure modes
pi1 <- pi_MCSim_beta(M = 1000, seed = 10, a = 1, b = 1)
pi2 <- pi_MCSim_beta(M = 1000, seed = 10, a = 2, b = 18)
MFM_core(n = 10, cvec = c(1, 1), pivec = c(pi1[1], pi2[1]));
# The function also works for more than two failure modes.
# However, the computation cost may increase.
# Example for three failure modes
MFM_core(n = 10, cvec = c(1, 1, 1), pivec = c(0.8, 0.9, 0.8));

MFM_Indicator

Binary Indicator for Multi-state RDT with Multiple Failure Modes (MFM)

Description

Define the binary indicator function to check whether the failure probability satisfies the lower level reliability requirements for each failure mode (for Multi-state RDT, Multiple Failure Models)

Usage

MFM_Indicator(pivec, Rvec)

Arguments

pivec Failure probability for each separate period.
Rvec Lower level reliability requirements for each cumulative period from the beginning of the test.

Value

0 – No; 1 – Yes.

See Also

MFM_core for getting the core probability of passing the test; MFM_consumerrisk for getting the consumer’s risk; MFM_optimal_n for getting the optimal test sample size;

Other MSRDT for MFM functions: MFM_consumerrisk(), MFM_core(), MFM_optimal_n()

Examples

MFM_Indicator(pivec = c(0.1, 0.2), Rvec = c(0.8, 0.6))
MFM_Indicator(pivec = c(0.1, 0.2, 0.1), Rvec = c(0.8, 0.6, 0.4))
MFM_Indicator(pivec = c(0.1, 0.4), Rvec = c(0.8, 0.7))
**MFM_optimal_n**  
*Optimal Test Sample Size for Multi-state RDT with Multiple Failure Modes (MFM)*

**Description**

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer’s risk (for Multi-state RDT, Multiple Failure Modes).

**Usage**

```r
MFM_optimal_n(cvec, pivec, Rvec, thres_CR)
```

**Arguments**

- `cvec`: Maximum allowable failures for each separate period
- `pivec`: Failure probability for each separate period
- `Rvec`: Lower level reliability requirements for each cumulative period from the beginning of the test.
- `thres_CR`: Threshold (acceptable level) of consumer’s risk

**Value**

Minimum test sample size

**See Also**

- `MFM_core` for getting the core probability of passing the test; `MFM_consumerrisk` for getting the consumer’s risk; `MFM_Indicator` for getting the binary indicator;

**Examples**

```r
pi1 <- pi_MCSim_beta(M = 5000, seed = 10, a = 1, b = 1)  
pi2 <- pi_MCSim_beta(M = 5000, seed = 10, a = 2, b = 18)  
MFM_optimal_n(cvec = c(1, 1), pivec = cbind(pi1, pi2), Rvec = c(0.8, 0.7), thres_CR = 0.05)
```
**MPCum_consumerrisk**  
*Consumer’s Risk for Multi-state RDT with Multiple Periods and Criteria for Cumulative Periods*

**Description**

Define the consumer risk function which gets the probability of passing the test when the lower level reliability requirements are not satisfied for any cumulative periods. The maximum allowable failures for each cumulative period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I).

**Usage**

```
MPCum_consumerrisk(n, cvec, pivec, Rvec)
```

**Arguments**

- `n`: RDT sample size
- `cvec`: Maximum allowable failures for each separate period
- `pivec`: Failure probability for each separate period
- `Rvec`: Lower level reliability requirements for each cumulative period from the beginning of the test.

**Value**

Probability for consumer’s risk

**Examples**

```r
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPCum_consumerrisk(n = 10, cvec = c(1, 1), pivec = pi, Rvec = c(0.8, 0.7))
```

---

**MPCum_core**  
*Probability Core for Multi-state RDT with Multiple Periods and Criteria for Cumulative Periods*

**Description**

Define the summed core function inside of the integration which gets the probability of passing the test given specific failure probabilities. The maximum allowable failures for each cumulative period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I).

**Usage**

```
MPCum_core(n, cvec, pivec)
```

**Examples**

```r
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPCum_core(n = 10, cvec = c(1, 1), pivec = pi)
```
Arguments

- `n`: RDT sample size
- `cvec`: Maximum allowable failures for each separate period
- `pivec`: Failure probability for each separate period

Value

Core probability of passing the test given specific failure probabilities

Examples

# Example for two periods
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPCum_core(n = 10, cvec = c(1, 1), pivec = pi[, 1]);
# The function also works for more than two periods, however, may increase the computation cost.
# Example for three periods
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1, 1))
MPCum_core(n = 10, cvec = c(1, 1, 1), pivec = pi[, 1]);

MPCum_optimal_n

Optimal Test Sample Size for Multi-state RDT with Multiple Periods and Criteria for Cumulative Periods

Description

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer’s risk. The maximum allowable failures for each cumulative period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I)

Usage

MPCum_optimal_n(cvec, pivec, Rvec, thres_CR)

Arguments

- `cvec`: Maximum allowable failures for each separate period
- `pivec`: Failure probability for each separate period
- `Rvec`: Lower level reliability requirements for each cumulative period from the beginning of the test.
- `thres_CR`: Threshold (acceptable level) of consumer’s risk

Value

Minimum test sample size
Examples

```r
pi <- pi_MCSim_dirichlet(M = 5000, seed = 10, par = c(1, 1, 1))
MPCum_optimal_n(cvec = c(1,1), pivec = pi, Rvec = c(0.8, 0.7), thres_CR = 0.05)
```

---

**MPSep_consumerrisk**  
Consumer's Risk for Multi-state RDT with Multiple Periods and Criteria for Separate Periods

**Description**

Define the consumer risk function which gets the probability of passing the test when the lower level reliability requirements are not satisfied for any cumulative periods. The maximum allowable failures for each separate period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I)

**Usage**

```r
MPSep_consumerrisk(n, cvec, pivec, Rvec)
```

**Arguments**

- `n`: RDT sample size
- `cvec`: Maximum allowable failures for each separate period
- `pivec`: Failure probability for each separate period
- `Rvec`: Lower level reliability requirements for each cumulative period from the beginning of the test.

**Value**

Probability for consumer's risk

**Examples**

```r
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPSep_consumerrisk(n = 10, cvec = c(1, 1), pi = pi, Rvec = c(0.8, 0.7))
```
MPsep_core

**Probability Core for Multi-state RDT with Multiple Periods and Criteria for Separate Periods**

**Description**

Define the summed core function inside of the integration which gets the probability of passing the test given specific failure probabilities. The maximum allowable failures for each separate period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario II).

**Usage**

```r
MPsep_core(n, cvec, pivec)
```

**Arguments**

- **n**: RDT sample size
- **cvec**: Maximum allowable failures for each separate period
- **pivec**: Failure probability for each separate period

**Value**

Core probability of passing the test given specific failure probabilities

**Examples**

```r
# Example for two periods
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
MPsep_core(n = 10, cvec = c(1, 1), pivec = pi[1,]);
# The function also works for more than two periods, however, may increase the computation cost.
# Example for three periods
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1, 1))
MPsep_core(n = 10, cvec = c(1, 1, 1), pivec = pi[1,]);
```

---

**MPsep_optimal_n**

**Optimal Test Sample Size for Multi-state RDT with Multiple Periods and Criteria for Separate Periods**

**Description**

Define the optimal function to find the optimal test plan with minimum test sample size given an acceptable level of consumer’s risk. The maximum allowable failures for each separate period need to be satisfied to pass the test (for Multi-state RDT, Multiple Periods, Scenario I)
**MP_Indicator**

**Usage**

```r
MPSep_optimal_n(cvec, pivec, Rvec, thres_CR)
```

**Arguments**

- `cvec`: Maximum allowable failures for each separate period.
- `pivec`: Failure probability for each separate period.
- `Rvec`: Lower level reliability requirements for each cumulative period from the beginning of the test.
- `thres_CR`: Threshold (acceptable level) of consumer’s risk.

**Value**

Minimum test sample size.

**Examples**

```r
pi <- pi_MCSim_dirichlet(M = 5000, seed = 10, par = c(1, 1, 1))
MPSep_optimal_n(cvec = c(1, 1), pivec = pi, Rvec = c(0.8, 0.7), thres_CR = 0.05)
```

---

**MP_Indicator**

**Binary Indicator for Multi-state RDT with Multiple Periods**

**Description**

Define the binary indicator function to check whether the failure probability satisfies the lower level reliability requirements for each cumulative period (for Multi-state RDT, Multiple Periods).

**Usage**

```r
MP_Indicator(pivec, Rvec)
```

**Arguments**

- `pivec`: Failure probability for each separate period.
- `Rvec`: Lower level reliability requirements for each cumulative period from the beginning of the test.

**Value**

0 – No; 1 – Yes.

**Examples**

```r
MP_Indicator(pivec = c(0.1, 0.2), Rvec = c(0.8, 0.6))
MP_Indicator(pivec = c(0.1, 0.2, 0.1), Rvec = c(0.8, 0.6, 0.4))
MP_Indicator(pivec = c(0.1, 0.3), Rvec = c(0.8, 0.7))
```
Description

Define the simulation function to generate failure probability with Beta prior distributions as conjugate prior to binomial distributions (for binomial RDT).

Usage

pi_MCSim_beta(M, seed, a, b)

Arguments

M Simulation sample size
seed Random seed for random sample
a Shape parameter 1 for beta distribution
b Shape parameter 2 for beta distribution

Value

Vector of failure probability sample values

See Also

pi_MCSim_dirichlet

Other Prior distribution generation functions: pi_MCSim_dirichlet()

Examples

pi <- pi_MCSim_beta(M = 1000, seed = 10, a = 1, b = 1)

Description

Define the simulation function to generate failure probability with Dirichlet prior distributions as conjugate prior to multinomial distributions (for multi-state RDT).

Usage

pi_MCSim_dirichlet(M, seed, par)
`pi_MCSim_dirichlet`

**Arguments**

- `M` Simulation sample size
- `seed` Random seed for random sample
- `par` Parameters for dirichlet distribution

**Value**

Vector of failure probability sample

**See Also**

- `pi_MCSim_beta`
- Other Prior distribution generation functions: `pi_MCSim_beta()`

**Examples**

```r
pi <- pi_MCSim_dirichlet(M = 1000, seed = 10, par = c(1, 1, 1))
```
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