Package ‘facilityepimath’

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Title Analyze Mathematical Models of Healthcare Facility Transmission

Version 0.1.0

Description Calculate useful quantities for a user-defined differential equation model of infectious disease transmission among individuals in a healthcare facility. Input rates of transition between states of individuals with and without the disease-causing organism, distributions of states at facility admission, relative infectivity of transmissible states, and the facility length of stay distribution. Calculate the model equilibrium and the basic facility reproduction number, as described in Toth et al. (2025) <doi:10.1101/2025.02.21.25322698>.

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Encoding UTF-8

RoxygenNote 7.3.2

URL `https://github.com/EpiForeSITE/facilityepimath`

BugReports `https://github.com/EpiForeSITE/facilityepimath/issues`

Imports MASS

Suggests knitr, rmarkdown, testthat (>= 3.0.0)

Config/testthat/edition 3

VignetteBuilder knitr

NeedsCompilation no

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Contents

`equilib` *Calculate the equilibrium of a linear facility model*

Description

Calculate the equilibrium of a linear facility model

Usage

```
equilib(M, init, mgf = NULL)
```

Arguments

`M`	A matrix of state transition rates between facility patient states
`init`	A vector of admission state probabilities to each state
`mgf`	The moment generating function characterizing a time-of-stay-dependent removal hazard

Value

A vector with the proportion of patients in each state at equilibrium

Examples

```
M <- rbind(c(-0.06,0.03,0),c(0.06,-0.08,0),c(0,0.05,0))
init <- c(0.95,0.05,0)
mgf <- function(x, deriv=0) MGFgamma(x, rate = 0.05, shape = 2.5, deriv)
equilib(M, init, mgf)
```

`facilityeq` *Calculate the equilibrium of a facility transmission model*

Description

Calculate the equilibrium of a facility transmission model

Usage

```
facilityeq(S, C, A, R, transm, init, mgf = NULL)
```

Arguments

`S`	A matrix of state transition rates between and removal from the susceptible states in the absence of colonized individuals
`C`	A matrix of state transition rates between and removal from the colonized states
`A`	A matrix describing transitions from susceptible to colonized states at acquisition
`R`	A matrix of recovery rates: state transition rates from colonized to susceptible states
`transm`	A vector of transmission rates from each colonized state
`init`	A vector of admission state probabilities to each state
`mgf`	The moment generating function characterizing a time-of-stay-dependent removal hazard

Value

A vector with the proportion of patients in each state at equilibrium; the vector contains the equilibrium S states followed by C states

Examples

```
S <- 0
C <- rbind(c(-0.38,0),c(0.08,0))
A <- rbind(1,0)
R <- cbind(0.3,0)
transm <- c(0.1,0.05)
init <- c(0.99,0.01,0)
mgf <- function(x, deriv=0) MGFgamma(x, rate=0.2, shape=3, deriv)
facilityeq(S, C, A, R, transm, init, mgf)
```

`facilityR0` *Calculate basic reproduction number R0*

Description

Calculate basic reproduction number R0

Usage

```
facilityR0(S, C, A, transm, initS, mgf = NULL)
```

Arguments

`S`	A matrix of state transition rates between and removal from the susceptible states in the absence of colonized individuals
`C`	A matrix of state transition rates between and removal from the colonized states
`A`	A matrix describing transitions from susceptible to colonized states at acquisition
`transm`	A vector of transmission rates from each colonized state
`initS`	A vector of admission state probabilities to each susceptible state
`mgf`	The moment generating function characterizing the time-of-stay-dependent removal hazard

Value

A number (R0)

Examples

```
S <- rbind(c(-1,2),c(1,-2))
C <- rbind(c(-1.1,0),c(0.1,-0.9))
A <- rbind(c(1,0),c(0,2))
transm <- c(0.4,0.6)
initS <- c(0.9,0.1)
mgf <- function(x, deriv=0) MGFgamma(x, rate=0.01, shape=3.1, deriv)
facilityR0(S,C,A,transm,initS,mgf)
```

`meanlengthofstay` *Calculate the mean length of stay for a linear facility model*

Description

Calculate the mean length of stay for a linear facility model

Usage

```
meanlengthofstay(M, init, mgf)
```

Arguments

`M`	A matrix of state transition rates between facility patient states
`init`	A vector of admission state probabilities to each state
`mgf`	The moment generating function characterizing a time-of-stay-dependent removal hazard

Value

The mean length of stay

Examples

```
M <- rbind(c(-1.1,2),c(1,-2.2))
init <- c(0.9,0.1)
mgf <- function(x, deriv=0) MGFgamma(x, rate=0.2, shape=3, deriv)
meanlengthofstay(M, init, mgf)
```

`MGFexponential` *Evaluate the moment generating function (MGF) of the exponential distribution or a derivative of the MGF*

Description

Evaluate the moment generating function (MGF) of the exponential distribution or a derivative of the MGF

Usage

```
MGFexponential(x, rate, deriv = 0)
```

Arguments

`x`	The value at which to evaluate the MGF
`rate`	The rate parameter value of the exponential distribution
`deriv`	An integer, the number of derivatives of the MGF to apply

Value

The number resulting from the function evaluation

Examples

```
# MGF of an exponential distribution, evaluated at -0.1:
MGFexponential(-0.1, rate = 0.05)
# Second moment of the distribution (second derivative evaluated at zero):
MGFexponential(0, rate = 0.05, deriv = 2)
```

`MGFgamma` *Evaluate the moment generating function (MGF) of the gamma distribution or a derivative of the MGF*

Description

Evaluate the moment generating function (MGF) of the gamma distribution or a derivative of the MGF

Usage

```
MGFgamma(x, rate, shape, deriv = 0)
```

Arguments

`x`	The value at which to evaluate the MGF
`rate`	The rate parameter value of the gamma distribution
`shape`	The shape parameter values of the gamma distribution
`deriv`	An integer, the number of derivatives of the MGF to apply

Value

The number resulting from the function evaluation

Examples

```
# MGF of a gamma distributions, evaluated at -0.1:
MGFgamma(-0.1, rate = 0.7, shape = 3)
# Second moment of the distribution (second derivative evaluated at zero):
MGFgamma(0, rate = 0.7, shape = 3, deriv = 2)
```

`MGFmixedgamma` *Evaluate the moment generating function (MGF) of the mixed gamma distribution or a derivative of the MGF*

Description

Evaluate the moment generating function (MGF) of the mixed gamma distribution or a derivative of the MGF

Usage

```
MGFmixedgamma(x, prob, rate, shape, deriv = 0)
```

Arguments

`x`	The value at which to evaluate the MGF
`prob`	A vector of probabilities of following each gamma distribution in the mixture
`rate`	A vector of rate parameter values for each gamma distribution in the mixture
`shape`	A vector of shape parameter values for each gamma distribution in the mixture
`deriv`	An integer, the number of derivatives of the MGF to apply

Value

The number resulting from the function evaluation

Examples

```
# MGF of a 40/60 mixture of two gamma distributions, evaluated at -0.1:
MGFmixedgamma(-0.1, prob = c(0.4,0.6), rate = c(0.4,0.7), shape = c(0.5,3))
# Second moment of the distribution (second derivative evaluated at zero):
MGFmixedgamma(0, prob = c(0.4,0.6), rate = c(0.4,0.7), shape = c(0.5,3), deriv = 2)
```

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