

Package ‘denvax’

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Type Package

Title Simple Dengue Test and Vaccinate Cost Thresholds

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Description

Provides the mathematical model described by “Serostatus Testing & Dengue Vaccine Cost-Benefit Thresholds” in [doi:10.1098/rsif.2019.0234](https://doi.org/10.1098/rsif.2019.0234). Using the functions in the package, that analysis can be repeated using sample life histories, either synthesized from local seroprevalence data using other functions in this package (as in the manuscript) or from some other source. The package provides a vignette which walks through the analysis in the publication, as well as a function to generate a project skeleton for such an analysis.

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build.project	<i>Creates an ROI estimation project.</i>
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Description

Creates an ROI estimation project.

Usage

build.project(targetdir, overwrite = FALSE, copy_pub = TRUE)

Arguments

- targetdir path to enclosing directory. If this directory does not exist, will attempt to create it (recursively)
- overwrite overwrite existing files corresponding to the project skeleton elements?
- copy_pub copy the ‘/pub’ folder (which contains the analyses from the publication)

Details

This function sets up the skeleton of an analysis to go from seroprevalence data to the ROI estimation surface. That skeleton uses a series of separate scripts for each analytical step (fitting, simulation, analysis, and application), connected via the command line build tool make. This approach allows clean substitution for various stages (e.g., using a different model to generate life histories). The following files are created:

- Makefile** the dependencies for various analysis stages
- README.md** brief notes about project parts

fit.R script for fitting seroprevalence data

synthesize.R script for generating synthetic populations

digest.R script for converting life histories into probability coefficients for ROI calculation

simple.R a quick example start-to-finish analysis

Value

logical, indicating error free creation of the project skeleton; there may still be other warnings

Examples

```
require(denvax)
tardir <- tempdir() # replace with desired target
build.project(tardir)
list.files(tardir, recursive = TRUE)
```

denvax

denvax: Simple Dengue Test and Vaccinate Cost Thresholds

Description

Provides the mathematical model described by "Serostatus Testing & Dengue Vaccine Cost-Benefit Thresholds" in [doi:10.1098/rsif.2019.0234](https://doi.org/10.1098/rsif.2019.0234). Using the functions in the package, that analysis can be repeated using sample life histories, either synthesized from local seroprevalence data using other functions in this package (as in the manuscript) or from some other source. The package provides a vignette which walks through the analysis in the publication, as well as a function to generate a project skeleton for such an analysis.

denvax functions

serofit fits serosurvey data against two-risk model

synthetic.pop using parameter fit data, generate a sample population

nPxA estimate dengue infection outcome probabilities based on a synthetic population

ROIcoeffs using population outcome probabilities, compute ROI equation coefficients

ROI compute ROIs from setting coefficients and cost scenarios

build.project create a template project for estimating ROIs

lazou2016

*The serosurvey data in L'Azou 2016***Description**

From "Symptomatic Dengue in Children in 10 Asian and Latin American Countries", Table 4.

Usage

lazou2016

Format

a data.frame (data.table, if installed) with 20 rows and 4 columns:

Country character, common country name (all Peru for this data)

Age character, the bounding ages for the sample; format: lower age '-' upper age

Number integer, the number of samples

Seropositive integer, the number of seropositive samples

Source

<https://doi.org/10.1056/NEJMoa1503877>

Examples

```
require(denvax); require(ggplot2)
data(lazou2016)
ggplot(lazou2016) + aes(Age, Seropositive/Number*100, color = Country) +
  geom_point() + labs(y="Seropositive %", x="Age Group") + lims(y=c(0,100)) +
  theme_minimal()
```

morrison2010

*The serosurvey data in Morrison 2010***Description**

From "Epidemiology of Dengue Virus in Iquitos, Peru 1999 to 2005: Interepidemic and Epidemic Patterns of Transmission", combining information from Fig. 2 and Fig. 3. The data from Fig. 3 were extracted using <https://automeris.io/WebPlotDigitizer/>

Usage

morrison2010

Format

a data.frame (data.table, if installed) with 13 rows and 4 columns:

Country character, common country name (all Peru for this data)

Age integer, the age category

Number integer, the number of samples

Seropositive integer, the number of seropositive samples

Source

<https://doi.org/10.1371/journal.pntd.0000670>

Examples

```
require(denvax)
data(morrison2010)
with(morrison2010, plot(Age, Seropositive/Number*100, ylab="% Seropositive", ylim=c(0,100)))
```

nPxA

Compute the $nPx(A)$, $C(A)$ proportions from a population of life histories

Description

Compute the $nPx(A)$, $C(A)$ proportions from a population of life histories

Usage

```
nPxA(lifehistory)
```

Arguments

lifehistory a matrix with rows (sample individuals) and columns (outcome in year of life);
see [synthetic.pop](#) return value

Details

computes the relevant $nPx(A)$ and $C(A)$: the probabilities of the various life trajectories, by age.
See [doi:10.1098/rsif.2019.0234](https://doi.org/10.1098/rsif.2019.0234), SI section II.A (Cost Benefit Equations: Definitions)

Value

a `data.frame` (`data.table`, if available) with columns

A integer; the reference year of life, from 1 to `dim(lifehistory)[2]`

p_0 numeric; probability of 0 lifetime infections

p_1p numeric; probability of 1 or more lifetime infections

p_2p numeric; probability of 2 or more lifetime infections

p0_1 numeric; probability of 0 infections at age A, and 1 lifetime infection

p0_1p numeric; probability of 0 infections at age A, and 1 or more lifetime infections

p0_2p numeric; probability of 0 infections at age A, and 2 or more lifetime infections

p1_A numeric; probability of 1 infection at age A, and 1 or more lifetime infections

p1_2p numeric; probability of 1 infection at age A, and 2 or more lifetime infections

p1p_A numeric; probability of 1 or more infections at age A, and 1 or more lifetime infections

p2p_A numeric; probability of 2 or more infections at age A, and 2 or more lifetime infections

CA numeric; probability of converting from seronegative to seropositive between age A and A+1

Examples

```
require(denvax);
data(morrison2010) # has counts by age
fit <- with(morrison2010, serofit(sero=Seropositive, N=Number, age.min=Age))
m2010pop <- synthetic.pop(fit, runs = 10, popsize = 10) # small sample size for example run time
m2010lh <- nPxA(m2010pop)
m2010lh
with(m2010lh,
  plot(A, p0_2p*100, type="l",
        xlab="Age", ylab="%", ylim = c(0, 100),
        main="Individuals w/ No Infections,\nbut that will have 2"
  )
)
```

ROI

*Compute the ROI surfaces given test and vaccine cost fractions.***Description**

Compute the ROI surfaces given test and vaccine cost fractions.

Usage

```
ROI(rcoeffs, nus = seq(0.3, 0.9, by = 0.05), taus = 10^seq(-2, -0.5, by
  = 0.05))
```

Arguments

<code>rcoeffs</code>	a data.frame with the ROI surface coefficients from ROIcoeffs
<code>nus</code>	the series of normalized vaccine costs to use for ROI calcs
<code>taus</code>	the series of normalized test costs to use for ROI calcs

Details

tabulates ROI

Value

a 'data.frame' ('data.table', if available) with columns:

nu numeric, the normalized vaccine cost used

tau numeric, the normalized test cost used

mechanism character, either "ordinal" or "binary" corresponding to the type of test

A integer; the age when routine test-then-vaccinate strategy starts (from As)

L integer; the maximum number of tests for routine test-then-vaccinate strategy (from Ls)

cost numeric; the intervention cost (as a fraction of second infection cost)

benefit numeric; the difference in health outcome cost (as a fraction of second infection cost) minus 'cost'; positive values indicate positive net benefit

roi numeric; return on investment: 'benefit' over 'cost'

Examples

```
require(denvax);
data(morrison2010) # has counts by age
fit <- with(morrison2010, serofit(sero=Seropositive, N=Number, age.min=Age))
m2010pop <- synthetic.pop(fit, runs = 10, popsize = 10) # small sample size for example run time
m2010lh <- nPxA(m2010pop)
L <- 5
rc <- ROIcoeffs(m2010lh, As=5:10, Ls=L)
rois <- ROI(rc, nus = 0.5, taus = 0.01)
srois <- subset(rois, mechanism == "binary")
mrois <- matrix(srois$roi, nrow = L)
contour(x=unique(srois$L), y=unique(srois$A), z=mrois,
  xlab = "Max # of Tests", ylab = "Initial Age", main="ROI Contour"
)
```

ROIcoeffs	<i>Compute the Return on Investment (ROI) surface coefficients from population probabilities</i>
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Description

Compute the Return on Investment (ROI) surface coefficients from population probabilities

Usage

```
ROIcoeffs(probabilities, As = 5:20, Ls = (diff(range(As)) + 1):1)
```

Arguments

probabilities	a data.frame (or data.table) with the probabilities resulting from nPxA . Rows must correspond to ages, starting with age 1
As	the starting age(s) to consider
Ls	the maximum number of tests for each age; should either be an integer per age or a single integer for all ages. The default behavior computes the number of tests (for each age) that makes the maximum of 'As' the maximum testing age Note: results will also be provided for shorter testing intervals, as the intermediate coefficients are calculated as part of computing the value at the maximum L

Details

computes the coefficients for the economic calculations

Value

a [data.frame](#) ([data.table](#), if available) with columns:

A integer; the age when routine test-then-vaccinate strategy starts (from As)

L integer; the maximum number of tests for routine test-then-vaccinate strategy (from Ls)

vacfrac numeric; the fraction of individuals participating in this strategy that get vaccinated

pri.offset numeric; the (additive) reduction in vacfrac if using the ordinal test

Sfrac numeric; the proportion experiencing second infection costs

Fresp numeric; the F/S cost fraction term, when comparing vaccination with and without testing

Sgain numeric; the S term, when comparing vaccination with and without testing

Examples

```
require(denvax);
data(morrison2010) # has counts by age
fit <- with(morrison2010, serofit(sero=Seropositive, N=Number, age.min=Age))
m2010pop <- synthetic.pop(fit, runs = 10, popsize = 10) # small sample size for example run time
m2010lh <- nPxA(m2010pop)
rc <- ROIcoeffs(m2010lh, As=5:10, Ls=5)
pp <- par()
par(mfrow=c(1, 2))
rcs <- subset(rc, A==10 & L < 11)
with(rcs, plot(
  L, aveTests, type="l",
  xlab="Max # of Tests Allowed",
  ylab="Ave # of Tests Administered",
  main="Starting @ Age 10",
  ylim=c(1, 3)
))
rcs <- subset(rc, A==5 & L < 11)
with(rcs, plot(
  L, aveTests, type="l",
  xlab="Max # of Tests Allowed",
  ylab="",
  main="Starting @ Age 5",
  ylim=c(1, 3)
))
par(pp)
```

serofit

Model fitting for serological data

Description

Model fitting for serological data

Usage

```
serofit(seropositive, N, age.min = use.default(1L:length(seropositive),
  "age.min"), age.max = use.default(age.min, "age.max"))
```

Arguments

seropositive	the number of seropositive samples for each age group; length(seropositive) must be at least 3
N	the total number of samples for each age group; length(N) must equal length(seropositive)
age.min	the low age in age groups; defaults to '1:length(seropositive)', i.e. assumes the seropositive data corresponds to yearly cohorts starting at age 1.
age.max	the upper age in age groups; defaults to 'age.min', i.e. assumes each category corresponds to a single year

Details

Fits a constant force of infection, two-risk category model using seroprevalence survey data. i.e.:

$$P_+(A) = p_H * (1 - (1 - f_H)^A) + (1 - p_H) * (1 - (1 - f_L)^A)$$

This probability is fit to the seroprevalence by age category data, using maximum likelihood and `optim`.

Value

a list of best-fit parameters, all numeric values:

f_H force of infection, for the high risk group

f_L force of infection, for the low risk group

p_H the proportion of the population at high risk

Examples

```
require(denvax);
data(morrison2010) # has counts by age
fit <- with(morrison2010, serofit(sero=Seropositive, N=Number, age.min=Age))
if (requireNamespace("data.table", quietly = TRUE)) {
  data(lazou2016) # has counts by age range, instead of counts for every year
  # this example uses `data.table` functions to simplify processing
  # several groups at once
  lazou2016[,{
    agerange <- data.table::tstrsplit(Age, "-")
    serofit(
      sero      = Seropositive,
      N         = Number,
      age.min   = as.integer(agerange[[1]]),
      age.max   = as.integer(agerange[[2]])
    )
  }, by = Country]
```

synthetic.pop

Compute synthetic population trajectories from model parameters

Description

Compute synthetic population trajectories from model parameters

Usage

```
synthetic.pop(pars, runs = 100, popsize = 1000, maxAge = 70,
  rngseed = NULL)
```

Arguments

<code>pars</code>	a list with elements 'f_H', 'f_L', and 'p_H'; see serofit return value
<code>runs</code>	the number of different serotype timelines to simulate
<code>popsize</code>	the number of individuals to sample for each run
<code>maxAge</code>	the length of each lifetime
<code>rngseed</code>	an optional seed for the random number generator

Details

Using fitted parameters for a two-risk, constant force of infection model, simulate a dengue annual exposures model for the requested number of serotype series ('runs') and individuals ('popsize'). The resulting matrix is a collection of integers, 0-4. 0 indicates no infection, 1-4 infection by the corresponding serotype.

Value

a matrix of integers 0-4, rows 'runs*popsize' x columns 'maxAge'

Examples

```
require(denvax);
data(morrison2010) # has counts by age
fit <- with(morrison2010, serofit(sero=Seropositive, N=Number, age.min=Age))
m2010pop <- synthetic.pop(fit, runs = 10, popsize = 10) # small sample size for example run time
head(m2010pop)
```

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