

Package ‘lillies’

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Title Estimation of Life Years Lost

Version 0.2.5

Description Estimation of life expectancy and Life Years Lost (LYL, or lillies for short) for a given population, for example those with a given disease or condition. In addition, the package can be used to compare estimates from different populations, or to estimate confidence intervals. Technical details of the method are available in Andersen (2017) <doi:10.1002/sim.7357>.

Depends R (>= 3.5.0)

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LazyData true

RoxygenNote 6.1.1

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Suggests ggplot2

NeedsCompilation no

Author Oleguer Plana-Ripoll [aut, cre]
(<<https://orcid.org/0000-0002-6470-7465>>)

Maintainer Oleguer Plana-Ripoll <opr@econ.au.dk>

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aggreg_data	<i>Simulated aggregated data for Life Years Lost estimation.</i>
-------------	--

Description

A dataset containing age-specific number of new cases, number of deaths and mortality rates for a simulated disease with onset after age 40 years. Data is available for ages 40-90 years.

Usage

```
aggreg_data
```

Format

A data frame with 50 rows and 4 variables:

age age

new_cases number of new cases diagnosed at that specific age

deaths number of deaths among the diagnosed at that specific age

rate age-specific mortality rates among the diagnosed

Source

Simulated data

lyl *Life Years Lost at one specific age.*

Description

lyl estimates remaining life expectancy and Life Years Lost for a given population after a specific age `age_specific` and restricted to a maximum theoretical age τ .

Usage

```
lyl(data, t0 = NULL, t, status, age_specific,
     censoring_label = "Alive", death_labels = "Dead", tau = 100)
```

Arguments

<code>data</code>	A dataframe, where each row represents a person. The dataframe will have a time-to-event format with at least two variables: age at end of follow-up (<code>t</code>) and status indicator with death/censoring (<code>status</code>).
<code>t0</code>	Age at start of the follow-up time. Default is NULL, which means all subjects are followed from birth. For delayed entry, <code>t0</code> indicates age at beginning of follow-up.
<code>t</code>	Age at the end of the follow-up time (death or censoring).
<code>status</code>	Status indicator, normally 0=alive, 1=dead. Other choices are TRUE/FALSE (TRUE = death) or 1/2 (2=death). For multiple causes of death (competing risks analysis), the status variable will be a factor, whose first level is treated as censoring; or a numeric variable, whose lowest level is treated as censoring. In the latter case, the label for censoring is <code>censoring_label</code> ("Alive" by default).
<code>age_specific</code>	Specific age at which the Life Years Lost have to be estimated.
<code>censoring_label</code>	Label for censoring status ("Alive" by default).
<code>death_labels</code>	Label for event status. For only one cause of death, "Dead" is the default. For multiple causes, the default are the values given in variable <code>status</code> .
<code>tau</code>	Remaining life expectancy and Life Years Lost are estimated restricted to a maximum theoretical age τ ($\tau=100$ years by default).

Value

A list with class "lyl" containing the following components:

- `data`: Data frame with 3 variables and as many observations as the original data provided to estimate Life Years Lost: `t0`, `t`, and `status`
- `LYL`: Data frame with 1 observation and at least 3 variables: `age` which corresponds to `age_specific`; `life_exp` which is the estimated remaining life expectancy at age `age_specific` years and before age `tau` years; and one variable corresponding to the estimated Life Years Lost for each specific cause of death. If only one cause of death is considered (no competing risks), this variable is `Dead` and includes the total overall Life Years Lost

- tau: Maximum theoretical age τ
- age_specific: Specific age at which the Life Years Lost have been estimated
- data_plot: A data frame in long format with 3 variables time, cause, and cip used to create a Figure of Life Years Lost with function `plot`.
- censoring_label: Label for censoring status
- death_labels: Label(s) for death status
- competing_risks: Logical value (TRUE = more than one cause of death (competing risks))
- type: Whether the estimation is at "age_specific" or "age_range".

References

- Andersen PK. Life years lost among patients with a given disease. *Statistics in Medicine*. 2017;36(22):3573- 3582.
- Andersen PK. Decomposition of number of life years lost according to causes of death. *Statistics in Medicine*. 2013;32(30):5278-5285.

See Also

- `lyl_range` for estimation of Life Years Lost for a range of different ages.
- `lyl_ci` to estimate bootstrapped confidence intervals.
- `lyl_diff` to compare Life Years Lost for two populations.
- `summary.lyl` to summarize objects obtained with function `lyl`.
- `plot.lyl` to plot objects obtained with function `lyl`.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after age 45 years and before age 95 years
lyl_estimation <- lyl(data = simu_data, t = age_death, status = death,
                    age_specific = 45, tau = 95)

# Summarize and plot the data
summary(lyl_estimation)
plot(lyl_estimation)

# Estimate remaining life expectancy and Life Years
# Lost due to specific causes of death after age 45
# years and before age 95 years

lyl_estimation2 <- lyl(data = simu_data, t = age_death, status = cause_death,
                    age_specific = 45, tau = 95)

# Summarize and plot the data
summary(lyl_estimation2)
plot(lyl_estimation2)
```

lyl_2plot

Plot Life Years Lost at one specific age for two different populations

Description

lyl_2plot creates a figure of Life Years Lost at one specific age for two different populations.

Usage

```
lyl_2plot(x, y, colors = NA, labels = c("Population of interest",
  "Reference population"), ...)
```

Arguments

x	An object of class lyl (obtained with function lyl).
y	An object of class lyl (obtained with function lyl).
colors	Vector with one color for each cause of death. Default is NA, and default colors are used.
labels	Vector with labels for the two populations (default are "Population of interest" for x, and "Reference population" for y)
...	Additional arguments affecting the plot produced.

Value

A plot with survival function and stacked cause-specific cumulative incidences for two populations side by side.

See Also

- [lyl](#) for estimation of Life Years Lost at one specific age.
- [lyl_diff](#) to compare Life Years Lost for two populations.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after age 45 years and before age 95 years
lyl_estimation <- lyl(data = simu_data, t = age_death, status = cause_death,
  age_specific = 45, tau = 95)

# Same estimate for those with a specific disease
diseased <- simu_data[!is.na(simu_data$age_disease), ]

lyl_estimation1 <- lyl(data = diseased, t0 = age_disease,
  t = age_death, status = cause_death,
```

```

age_specific = 45, tau = 95)

# Plot the data
lyl_2plot(lyl_estimation1, lyl_estimation)
lyl_2plot(lyl_estimation1, lyl_estimation,
          labels = c("Population with a disease", "General population"))

# The plot can be modified with a usual ggplot2 format
lyl_2plot(lyl_estimation1, lyl_estimation) +
  ggplot2::xlab("Age [in years]") +
  ggplot2::ggtitle("Differences in Life Years Lost at age 45 years")

```

lyl_aggregated	<i>Life Years Lost at one specific age using aggregated data.</i>
----------------	---

Description

lyl estimates differences in remaining life expectancy and Life Years Lost for two given life tables data and data0 after a specific age `age_specific` and restricted to a maximum theoretical age τ .

Usage

```

lyl_aggregated(data, age, rates, surv, data0, age0, rates0, surv0,
               age_specific, censoring_label = "Alive", death_labels = "Dead",
               tau = 100)

```

Arguments

<code>data</code>	A dataframe, where each row represents an age, for the population of interest. The dataframe will contain information on age-specific mortality rates or survival probability (if both parameters are provided, rates will be used).
<code>age</code>	Variable in <code>data</code> containing information on age.
<code>rates</code>	Variable in <code>data</code> containing information on age-specific mortality rates.
<code>surv</code>	Variable in <code>data</code> containing information on age-specific survival probability.
<code>data0</code>	A dataframe, where each row represents an age, for the population of reference. The dataframe will contain information on age-specific mortality rates or survival probability (if both parameters are provided, rates will be used).
<code>age0</code>	Variable in <code>data0</code> containing information on age.
<code>rates0</code>	Variable in <code>data0</code> containing information on age-specific mortality rates.
<code>surv0</code>	Variable in <code>data0</code> containing information on age-specific survival probability.
<code>age_specific</code>	Specific age at which the Life Years Lost have to be estimated.
<code>censoring_label</code>	Label for censoring status ("Alive" by default).
<code>death_labels</code>	Label for event status ("Dead" by default).
<code>tau</code>	Remaining life expectancy and Life Years Lost are estimated restricted to a maximum theoretical age τ ($\tau=100$ years by default).

Value

A list with class "lyl_aggregated" containing the following components:

- data: Name of the dataset provided in parameter data
- data0: Name of the dataset provided in parameter data0
- LYL: Data frame with 1 observation and 3 variables: age which corresponds to age_spefific; and life_exp and life_exp0 which are the estimated remaining life expectancies at age age_specific years and before age tau years for the population provided in data and data0, respectively
- tau: Maximum theoretical age τ
- age_specific: Specific age at which the Life Years Lost have been estimated
- data_plot: A data frame in long format with 3 variables time, cause, and cip used to create a Figure of Life Years Lost with function [plot](#).
- censoring_label: Label for censoring status
- death_labels: Label(s) for death status
- type: Whether the estimation is at "age_specific" or "age_range"

References

- Andersen PK. Life years lost among patients with a given disease. *Statistics in Medicine*. 2017;36(22):3573- 3582.
- Andersen PK. Decomposition of number of life years lost according to causes of death. *Statistics in Medicine*. 2013;32(30):5278-5285.

See Also

- [lyl_aggregated_range](#) for estimation of Life Years Lost for a range of different ages.
- [summary.lyl_aggregated](#) to summarize objects obtained with function lyl_aggregated.
- [plot.lyl_aggregated](#) to plot objects obtained with function lyl_aggregated.

Examples

```
# Load simulated data as example
data(aggreg_data)
data(pop_ref)

# Estimate remaining life expectancy and Life Years
# Lost after age 70 years and before age 90 years
lyl_summary_data70 <- lyl_aggregated(data = aggre_data, age = age, rates = rate,
                                   data0 = pop_ref, age0 = age, surv0 = survival,
                                   age_specific = 70, tau = 90)

# Summarize and plot the data
summary(lyl_summary_data70)
plot(lyl_summary_data70)
```

lyl_aggregated_range *Life Years Lost at a range of different ages using aggregated data.*

Description

lyl estimates differences in remaining life expectancy and Life Years Lost for two given life tables `data` and `data0` after a range of specific ages (`age_begin` to `age_end`) and restricted to a maximum theoretical age τ .

Usage

```
lyl_aggregated_range(data, age, rates, surv, weights, data0, age0, rates0,
  surv0, age_begin, age_end, censoring_label = "Alive",
  death_labels = "Dead", tau = 100)
```

Arguments

<code>data</code>	A dataframe, where each row represents an age, for the population of interest. The dataframe will contain information on age-specific mortality rates or survival probability (if both parameters are provided, rates will be used).
<code>age</code>	Variable in <code>data</code> containing information on age.
<code>rates</code>	Variable in <code>data</code> containing information on age-specific mortality rates.
<code>surv</code>	Variable in <code>data</code> containing information on age-specific survival probability.
<code>weights</code>	Variable in <code>data</code> containing information on number of new cases per age. A weighted average is provided using these weights.
<code>data0</code>	A dataframe, where each row represents an age, for the population of reference. The dataframe will contain information on age-specific mortality rates or survival probability (if both parameters are provided, rates will be used).
<code>age0</code>	Variable in <code>data0</code> containing information on age.
<code>rates0</code>	Variable in <code>data0</code> containing information on age-specific mortality rates.
<code>surv0</code>	Variable in <code>data0</code> containing information on age-specific survival probability.
<code>age_begin</code>	Specific starting age at which the Life Years Lost have to be estimated.
<code>age_end</code>	Specific ending age at which the Life Years Lost have to be estimated.
<code>censoring_label</code>	Label for censoring status ("Alive" by default).
<code>death_labels</code>	Label for event status ("Dead" by default).
<code>tau</code>	Remaining life expectancy and Life Years Lost are estimated restricted to a maximum theoretical age τ ($\tau=100$ years by default).

Value

A list with class "lyl_aggregated" containing the following components:

- data: Name of the dataset provided in parameter data
- data0: Name of the dataset provided in parameter data0
- LYL: Data frame with 1 observation and 2 variables: life_exp and life_exp0 which are the estimated remaining life expectancies averaged over the age range and before age tau years for the population provided in data and data0, respectively
- tau: Maximum theoretical age τ
- age_begin: Specific starting age at which the Life Years Lost have been estimated
- age_end: Specific ending age at which the Life Years Lost have been estimated
- data_plot: A data frame in long format with 3 variables time, cause, and cip used to create a Figure of Life Years Lost with function [plot](#).
- censoring_label: Label for censoring status
- death_labels: Label(s) for death status
- type: Whether the estimation is at "age_specific" or "age_range".

References

- Andersen PK. Life years lost among patients with a given disease. *Statistics in Medicine*. 2017;36(22):3573- 3582.
- Andersen PK. Decomposition of number of life years lost according to causes of death. *Statistics in Medicine*. 2013;32(30):5278-5285.

See Also

- [lyl_aggregated](#) for estimation of Life Years Lost at one specific age.
- [summary.lyl_aggregated](#) to summarize objects obtained with function `lyl_aggregated_range`.

Examples

```
# Load simulated data as example
data(aggreg_data)
data(pop_ref)

# Estimate remaining life expectancy and Life Years
# Lost after each age from 40 to 89 years and before age 90 years
lyl_summary_data <- lyl_aggregated_range(data = aggreg_data, age = age,
                                       rates = rate, weights = new_cases,
                                       data0 = pop_ref, age0 = age, surv0 = survival,
                                       age_begin = 40, age_end = 89, tau = 90)

# Summarize the data
summary(lyl_summary_data)
```

`lyl_checkplot`*Plot number of persons at risk at each specific age.*

Description

Given a `lyl_range`-class object, `lyl_checkplot` draws numbers of persons at risk of dying at each specific age from `age_begin` until age τ .

Usage

```
lyl_checkplot(x)
```

Arguments

`x` An object of class `lyl_range` obtained with the `lyl_range` function.

Value

A plot with the number of persons at risk at each specific age.

See Also

[lyl_range](#) for estimation of Life Years Lost for a range of different ages.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after each age from 0 to 94 years and before age 95 years
lyl_estimation <- lyl_range(data = simu_data, t = age_death, status = death,
                           age_begin = 45, age_end = 50, tau = 95)

# Check whether small numbers could compromise the results
lyl_checkplot(lyl_estimation)

# The plot can be modified with a usual ggplot2 format
lyl_checkplot(lyl_estimation) +
  ggplot2::geom_hline(yintercept = 10, linetype = "dashed", color = "red") +
  ggplot2::xlab("Age [in years]") +
  ggplot2::ggtitle("Persons at risk of dying at each age 0-94 years")
```

lyl_ci	<i>Confidence intervals for Life Years Lost.</i>
--------	--

Description

lyl_ci estimates confidence intervals for Life Years Lost using non-parametric bootstrap. The confidence level can be specified when summarizing the results with the function [summary.lyl_ci](#).

Usage

```
lyl_ci(lyl_estimation, niter = 1000)
```

Arguments

lyl_estimation An object of class lyl or lyl_range.
 niter Number of iterations for the bootstrap (default is 1,000).

Value

A list with class "lyl_ci" containing the following components:

- LYL: Data frame with one observation per age and at least 3 variables: age; life_exp which is the estimated remaining life expectancy at age age_specific years and before age tau years; and one variable corresponding to the estimated Life Years Lost for each specific cause of death. If only one cause of death is considered (no competing risks), this variable is Dead and includes the total overall Life Years Lost
- LYL_ci: Data frame with one observation per age-iteration and at least 4 variables: age; iteration, which correspond to each specific iteration; life_exp which is the estimated remaining life expectancy at age age_specific years and before age tau years; and one variable corresponding to the estimated Life Years Lost for each specific cause of death. If only one cause of death is considered (no competing risks), this variable is Dead and includes the total overall Life Years Lost
- tau: Maximum theoretical age τ
- age_specific: Specific age at which the Life Years Lost have been estimated
- age_begin: Specific starting age at which the Life Years Lost have been estimated
- age_end: Specific ending age at which the Life Years Lost have been estimated
- death_labels: Label(s) for death status
- competing_risks: Logical value (TRUE = more than one cause of death (competing risks))
- type: Whether the estimation is at "age_specific" or "age_range".
- niter: Number of iterations used to estimate the confidence intervals

See Also

- [lyl](#) for estimation of Life Years Lost at one specific age.
- [lyl_range](#) for estimation of Life Years Lost for a range of different ages.
- [lyl_diff](#) to compare Life Years Lost for two populations.
- [summary.lyl_ci](#) to summarize objects obtained with function `lyl_ci`.
- [plot.lyl_ci](#) to plot objects obtained with function `lyl_ci`.

[lyl_range](#) for estimation of Life Years Lost for a range of different ages.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after age 45 years and before age 95 years
lyl_estimation <- lyl(data = simu_data, t = age_death, status = death,
                    age_specific = 45, tau = 95)

# Calculate bootstrapped confidence interval (3 iterations to test; more are necessary)
lyl_estimation_ci <- lyl_ci(lyl_estimation, niter = 3)
summary(lyl_estimation_ci)
plot(lyl_estimation_ci)

# Estimate remaining life expectancy and Life Years
# Lost after each age from 0 to 94 years and before age 95 years
lyl_estimation2 <- lyl_range(data = simu_data, t = age_death, status = death,
                          age_begin = 0, age_end = 94, tau = 95)

# Calculate bootstrapped confidence interval
lyl_estimation_ci2 <- lyl_ci(lyl_estimation2, niter = 10)
summary(lyl_estimation_ci2, weights = simu_data$age_disease)
plot(lyl_estimation_ci2, weights = simu_data$age_disease)
```

lyl_diff

Summarize differences in Life Years Lost.

Description

`lyl_diff` summarizes differences in estimated Life Years Lost in two different populations: `lyl_estimation` compared to `lyl_estimation0`.

Usage

```
lyl_diff(lyl_population1, lyl_population0, decimals = 2, level = 0.95,
        weights = NA)
```

Arguments

lyl_population1	Population of interest: An object of class <code>lyl</code> or <code>lyl_range</code> (obtained with functions <code>lyl</code> or <code>lyl_range</code>). Alternatively, an object of class <code>lyl_ci</code> can be provided for bootstrapped confidence intervals.
lyl_population0	Reference population: An object of class <code>lyl</code> or <code>lyl_range</code> (obtained with functions <code>lyl</code> or <code>lyl_range</code>). Alternatively, an object of class <code>lyl_ci</code> can be provided for bootstrapped confidence intervals.
decimals	Number of decimals to be reported (default is 2).
level	Confidence level if <code>lyl_population1</code> or <code>lyl_population0</code> is obtained with the <code>lyl_ci</code> function (default is 0.95 for 95% confidence intervals)
weights	Vector with age distribution of disease/condition onset to be used when Life Years Lost are estimated over a range of ages (with <code>lyl_range</code> function). If weights are not provided (default is <code>weights = NA</code>), then the differences in Life Years Lost at each age is provided. If weights are provided, then a weighted average is provided.

Value

A table with the summary of the differences between two populations.

See Also

- [lyl](#) for estimation of Life Years Lost at one specific age.
- [lyl_range](#) for estimation of Life Years Lost for a range of different ages.

Examples

```
# Load simulated data as example
data(simu_data)

### For the overall population and for those with a disease
diseased <- simu_data[!is.na(simu_data$age_disease), ]

# Estimate remaining life expectancy and Life Years
# Lost due to specific causes of death after age 45
# years and before age 95 years
lyl_estimation0 <- lyl(data = simu_data, t = age_death, status = cause_death,
  age_specific = 45, tau = 95)
lyl_estimation1 <- lyl(data = diseased, t0 = age_disease,
  t = age_death, status = cause_death,
  age_specific = 45, tau = 95)
lyl_diff(lyl_estimation1, lyl_estimation0)

# Calculate bootstrapped confidence interval (3 iterations to test)
lyl_estimation1_ci <- lyl_ci(lyl_estimation1, niter = 3)
```

```

lyl_estimation0_ci <- lyl_ci(lyl_estimation0, niter = 3)
lyl_diff(lyl_estimation1_ci, lyl_estimation0_ci)

# It is also possible to assume no uncertainty for one of the estimates
lyl_diff(lyl_estimation1_ci, lyl_estimation0)

# Estimate remaining life expectancy and Life Years
# Lost due to specific causes of death after each age
# from 0 to 94 years and before age 95 years
lyl_estimation2 <- lyl_range(data = simu_data, t = age_death, status = cause_death,
                           age_begin = 0, age_end = 94, tau = 95)
lyl_estimation3 <- lyl_range(data = diseased, t0 = age_disease,
                           t = age_death, status = cause_death,
                           age_begin = 0, age_end = 94, tau = 95)
lyl_diff(lyl_estimation3, lyl_estimation2)
lyl_diff(lyl_estimation3, lyl_estimation2, weights = diseased$age_disease)

# Calculate bootstrapped confidence interval (3 iterations to test)
lyl_estimation3_ci <- lyl_ci(lyl_estimation3, niter = 3)
lyl_diff(lyl_estimation3_ci, lyl_estimation2, weights = diseased$age_disease)

```

lyl_diff_ref

Summarize differences in Life Years Lost.

Description

lyl_diff summarizes differences in estimated Life Years Lost in two different populations: lyl_estimation1 compared to a life table provided in data_ref.

Usage

```

lyl_diff_ref(lyl_population1, data_ref, age, surv, rates, decimals = 2,
            level = 0.95, weights = NA, lyl_population0)

```

Arguments

lyl_population1	Population of interest: An object of class lyl or lyl_range (obtained with functions lyl or lyl_range). Alternatively, an object of class lyl_ci can be provided for bootstrapped confidence intervals.
data_ref	A dataframe, where each row represents an age, for the population of reference. The dataframe will contain information on age-specific mortality rates or survival probability (if both parameters are provided, rates will be used).
age	Variable in data_ref containing information on age.
surv	Variable in data_ref containing information on age-specific survival probability.
rates	Variable in data_ref containing information on age-specific mortality rates.

decimals	Number of decimals to be reported (default is 2).
level	Confidence level if lyl_population1 or lyl_population0 is obtained with the lyl_ci function (default is 0.95 for 95% confidence intervals)
weights	Vector with age distribution of disease/condition onset to be used when Life Years Lost are estimated over a range of ages (with lyl_range function). If weights are not provided (default is weights = NA), then the differences in Life Years Lost at each age is provided. If weights are provided, then a weighted average is provided.
lyl_population0	Parameter automatically created.

Value

A table with the summary of the differences between two populations.

See Also

- [lyl](#) for estimation of Life Years Lost at one specific age.
- [lyl_range](#) for estimation of Life Years Lost for a range of different ages.

Examples

```
# Load simulated data as example
data(simu_data)
data(pop_ref)

# Estimate remaining life expectancy and Life Years
# Lost due to specific causes of death after age 45
# years and before age 95 years for those with a disease
diseased <- simu_data[!is.na(simu_data$age_disease), ]
lyl_estimation1 <- lyl(data = diseased, t0 = age_disease,
                     t = age_death, status = cause_death,
                     age_specific = 45, tau = 95)
lyl_diff_ref(lyl_estimation1, pop_ref, age = age, surv = survival)
lyl_diff_ref(lyl_estimation1, pop_ref, age = age, rates = mortality_rates)

# Calculate bootstrapped confidence interval (3 iterations to test; more are necessary)
lyl_estimation1_ci <- lyl_ci(lyl_estimation1, niter = 3)
lyl_diff_ref(lyl_estimation1_ci, pop_ref, age = age, surv = survival)

# Estimate remaining life expectancy and Life Years
# Lost due to specific causes of death after each age
# from 0 to 94 years and before age 95 years
lyl_estimation2 <- lyl_range(data = diseased, t0 = age_disease,
                           t = age_death, status = cause_death,
                           age_begin = 0, age_end = 94, tau = 95)
lyl_diff_ref(lyl_estimation2, pop_ref, age = age, surv = survival)
lyl_diff_ref(lyl_estimation2, pop_ref, age = age, surv = survival, weights = diseased$age_disease)
```

lyl_range	<i>Life Years Lost at a range of different ages.</i>
-----------	--

Description

lyl estimates remaining life expectancy and Life Years Lost for a given population after a range of specific ages (age_begin to age_end) and restricted to a maximum theoretical age τ .

Usage

```
lyl_range(data, t0 = NULL, t, status, age_begin, age_end,
          censoring_label = "Alive", death_labels = "Dead", tau = 100)
```

Arguments

data	A dataframe, where each row represents a person. The dataframe will have a time-to-event format with at least two variables: age at end of follow-up (t) and status indicator with death/censoring (status).
t0	Age at start of the follow-up time. Default is NULL, which means all subjects are followed from birth. For delayed entry, t0 indicates beginning of follow-up.
t	Age at the end of the follow-up time (death or censoring).
status	Status indicator, normally 0=alive, 1=dead. Other choices are TRUE/FALSE (TRUE = death) or 1/2 (2=death). For multiple causes of death (competing risks analysis), the status variable will be a factor, whose first level is treated as censoring; or a numeric variable, whose lowest level is treated as censoring. In the latter case, the label for censoring is censoring_label ("Alive" by default).
age_begin	Specific starting age at which the Life Years Lost have to be estimated.
age_end	Specific ending age at which the Life Years Lost have to be estimated.
censoring_label	Label for censoring status ("Alive" by default).
death_labels	Label for event status. For only one cause of death, "Dead" is the default. For multiple causes, the default are the values given in variable status.
tau	Remaining life expectancy and Life Years Lost are estimated restricted to a maximum theoretical age τ ($\tau=100$ years by default).

Value

A list with class "lyl_range" containing the following components:

- data: Data frame with 3 variables and as many observations as the original data provided to estimate Life Years Lost: t0, t, and status
- LYL: Data frame with (age_end - age_begin + 1) observations and at least 3 variables: age which corresponds to each specific age from age_begin to age_end; life_exp which is the estimated remaining life expectancy at age specific age and before age tau years; and one variable corresponding to the estimated Life Years Lost for each specific cause of death. If

only one cause of death is considered (no competing risks), this variable is Dead and includes the total overall Life Years Lost

- tau: Maximum theoretical age τ
- age_begin: Specific starting age at which the Life Years Lost have been estimated
- age_end: Specific ending age at which the Life Years Lost have been estimated
- censoring_label: Label for censoring status
- death_labels: Label(s) for death status
- competing_risks: Logical value (TRUE = more than one cause of death (competing risks))
- numbers_at_risk: Data frame with (tau - age_begin + 1) observations and 2 variables: age which corresponds to each specific age from age_begin to tau; and number which is the number of persons at risk of dying at each specific age
- type: Whether the estimation is at "age_specific" or "age_range".

References

- Andersen PK. Life years lost among patients with a given disease. *Statistics in Medicine*. 2017;36(22):3573- 3582.
- Andersen PK. Decomposition of number of life years lost according to causes of death. *Statistics in Medicine*. 2013;32(30):5278-5285.

See Also

- [lyl](#) for estimation of Life Years Lost at one specific age.
- [lyl_diff](#) to compare average Life Years Lost for two populations.
- [lyl_checkplot](#) to check whether small numbers could compromise the estimation.
- [lyl_ci](#) to estimate bootstrapped confidence intervals.
- [summary.lyl_range](#) to summarize objects obtained with function `lyl_range`.
- [plot.lyl_range](#) to plot objects obtained with function `lyl_range`.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after each age from 0 to 94 years and before age 95 years
lyl_estimation <- lyl_range(data = simu_data, t = age_death, status = death,
                           age_begin = 0, age_end = 94, tau = 95)

# Visualize data at each different specific age
summary(lyl_estimation)
plot(lyl_estimation)

# Summarize data over an age distribution
summary(lyl_estimation, weights = simu_data$age_disease)
```

```

# Estimate remaining life expectancy and Life Years
# Lost due to specific causes of death after each age
# from 0 to 94 years and before age 95 years
lyl_estimation2 <- ly1_range(data = simu_data, t = age_death, status = cause_death,
                           age_begin = 0, age_end = 94, tau = 95)

# Visualize data at each different specific age
summary(lyl_estimation2)
plot(lyl_estimation2)

# Summarize data over an age distribution
summary(lyl_estimation2, weights = simu_data$age_disease)

```

plot.lyl

Plot Life Years Lost at one specific age

Description

plot for objects of class ly1 creates a figure of Life Years Lost at one specific age.

Usage

```

## S3 method for class 'ly1'
plot(x, colors = NA, ...)

```

Arguments

x	An object of class ly1 (obtained with function ly1).
colors	Vector with one color for each cause of death. Default is NA, and default colors are used.
...	Additional arguments affecting the plot produced.

Value

A plot with survival function and stacked cause-specific cumulative incidences.

See Also

- [ly1](#) for estimation of Life Years Lost at one specific age.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after age 45 years and before age 95 years
lyl_estimation <- lyl(data = simu_data, t = age_death, status = cause_death,
                    age_specific = 45, tau = 95)

# Summarize and plot the data
plot(lyl_estimation)
plot(lyl_estimation, colors = c("chocolate", "cornflowerblue"))

# The plot can be modified with a usual ggplot2 format
plot(lyl_estimation) +
  ggplot2::xlab("Age [in years]") +
  ggplot2::ggtitle("Life Years Lost at age 45 years")
```

```
plot.lyl_aggregated    Plot Life Years Lost at one specific age for two different populations
                        obtained from aggregated data
```

Description

plot for objects of class `lyl_aggregated` creates a figure of Life Years Lost at one specific age for two different populations.

Usage

```
## S3 method for class 'lyl_aggregated'
plot(x, colors = NA,
     labels = c("Population of interest", "Reference population"), ...)
```

Arguments

<code>x</code>	An object of class <code>lyl_aggregated</code> (obtained with function <code>lyl_aggregated</code>).
<code>colors</code>	Vector with one color for each cause of death. Default is <code>NA</code> , and default colors are used.
<code>labels</code>	Vector with labels for the two populations (default are "Population of interest" for <code>data</code> , and "Reference population" for <code>data@0</code> ; which are provided to function <code>lyl_aggregated</code> .)
<code>...</code>	Additional arguments affecting the plot produced.

Value

A plot with survival function and stacked cause-specific cumulative incidences for two populations side by side.

See Also

- [lyl_aggregated](#) for estimation of Life Years Lost at one specific age.

Examples

```
# Load simulated data as example
data(aggreg_data)
data(pop_ref)

# Estimate remaining life expectancy and Life Years
# Lost after age 70 years and before age 90 years
lyl_summary_data70 <- lyl_aggregated(data = aggre_data, age = age, rates = rate,
                                   data0 = pop_ref, age0 = age, surv0 = survival,
                                   age_specific = 70, tau = 90)

# Plot the data
plot(lyl_summary_data70)
```

plot.lyl_ci

Plot evolution of bootstrapped parameters for Life Years Lost

Description

plot for objects of class `lyl_ci` creates a figure of the bootstrapped Life Years Lost to examine if the number of iterations is enough.

Usage

```
## S3 method for class 'lyl_ci'
plot(x, level = 0.95, weights, ...)
```

Arguments

<code>x</code>	An object of class <code>lyl_ci</code> (obtained with function <code>lyl_ci</code>).
<code>level</code>	Confidence level (default is 0.95 for 95% confidence intervals)
<code>weights</code>	Vector with age distribution of disease/condition onset to be used when Life Years Lost are estimated over a range of ages (with <code>lyl_range</code> function).
<code>...</code>	Additional arguments affecting the plot produced.

Value

A plot with the evolution of bootstrapped parameters.

See Also

- [lyl_range](#) for estimation of Life Years Lost for a range of different ages.
- [lyl](#) for estimation of Life Years Lost at one specific age.
- [lyl_ci](#) to estimate bootstrapped confidence intervals.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after age 45 years and before age 95 years
lyl_estimation <- lyl(data = simu_data, t = age_death, status = death,
                    age_specific = 45, tau = 95)

# Calculate bootstrapped confidence interval (10 iterations to test)
lyl_estimation_ci <- lyl_ci(lyl_estimation, niter = 10)
plot(lyl_estimation_ci)

# Estimate remaining life expectancy and Life Years
# Lost after each age from 0 to 94 years and before age 95 years
lyl_estimation2 <- lyl_range(data = simu_data, t = age_death, status = death,
                           age_begin = 0, age_end = 94, tau = 95)

# Calculate bootstrapped confidence interval
lyl_estimation_ci2 <- lyl_ci(lyl_estimation2)
plot(lyl_estimation_ci2, weights = simu_data$age_disease)
```

plot.lyl_range

Plot Life Years Lost at a range of different ages

Description

plot for objects of class `lyl_range` creates a figure of Life Years Lost at a range of different ages.

Usage

```
## S3 method for class 'lyl_range'
plot(x, colors = NA, ...)
```

Arguments

<code>x</code>	An object of class <code>lyl_range</code> (obtained with function <code>lyl_range</code>).
<code>colors</code>	Vector with one color for each cause of death. Default is NA, and default colors are used.
<code>...</code>	Additional arguments affecting the plot produced.

Value

A plot with age-specific life expectancy and life years lost.

See Also

- [lyl_range](#) for estimation of Life Years Lost for a range of different ages.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost due to specific causes of death after each age
# from 30 to 40 years and before age 95 years
lyl_estimation <- lyl_range(data = simu_data, t = age_death, status = cause_death,
                           age_begin = 30, age_end = 40, tau = 95)

# Summarize and plot the data
plot(lyl_estimation)
plot(lyl_estimation, colors = c("chocolate", "cornflowerblue"))

# The plot can be modified with a usual ggplot2 format
plot(lyl_estimation) +
  ggplot2::xlab("Age [in years]") +
  ggplot2::ggtitle("Life Years Lost at ages 30-40 years")
```

pop_ref

Aggregated data for Life Years Lost estimation.

Description

A dataset containing age-specific survival probability and mortality rates for Danish women in years 2017-2018.

Usage

```
pop_ref
```

Format

A data frame with 100 rows and 3 variables:

age age

survival survival probability at that specific age

mortality_rates age-specific mortality rates

Source

Statistics Danmark (<https://www.dst.dk/en/Statistik/emner/befolkning-og-valg/>)

simu_data	<i>Simulated population for Life Years Lost estimation.</i>
-----------	---

Description

A dataset containing age and cause of death, as well as age at disease diagnosis (or start of a condition) for 100,000 simulated persons.

Usage

```
simu_data
```

Format

A data frame with 100000 rows and 6 variables:

id unique identifier of each person

age_start age at start of follow-up (0 for all individuals)

age_death age at end of follow-up (death or censoring)

death logical variable (TRUE = death / FALSE = censoring)

cause_death factor variable with 3 levels: "Alive" (for those censored) and "Natural" and "Unnatural" (for those dying of natural and unnatural causes of death, respectively)

age_disease age at developing a specific disease or condition for those 32,391 individuals that develop the disease (missing for the remaining 67,609)

Source

Simulated data

summary.lyl	<i>Summarize Life Years Lost at one specific age</i>
-------------	--

Description

summary for objects of class lyl summarizes Life Years Lost at one specific age.

Usage

```
## S3 method for class 'lyl'
summary(object, decimals = 2, difference = FALSE, ...)
```

Arguments

object	An object of class lyl (obtained with function lyl).
decimals	Number of decimals to be reported (default is 2).
difference	Parameter automatically created by the package.
...	Additional arguments affecting the summary produced.

Value

A table with the summary of the results.

See Also

- [lyl](#) for estimation of Life Years Lost at one specific age.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after age 45 years and before age 95 years
lyl_estimation <- lyl(data = simu_data, t = age_death, status = death,
                    age_specific = 45, tau = 95)

# Summarize and plot the data
summary(lyl_estimation)
```

```
summary.lyl_aggregated
```

Summarize Life Years Lost at one specific age

Description

summary for objects of class lyl_aggregated summarizes Life Years Lost.

Usage

```
## S3 method for class 'lyl_aggregated'
summary(object, decimals = 2, ...)
```

Arguments

object	An object of class lyl_aggregated (obtained with function lyl_aggregated or lyl_aggregated_range).
decimals	Number of decimals to be reported (default is 2).
...	Additional arguments affecting the summary produced.

Value

A table with the summary of the results.

See Also

- [lyl_aggregated](#) for estimation of Life Years Lost at one specific age.
- [lyl_aggregated_range](#) for estimation of Life Years Lost for a range of different ages.

Examples

```
# Load simulated data as example
data(aggreg_data)
data(pop_ref)

# Estimate remaining life expectancy and Life Years
# Lost after age 70 years and before age 90 years
lyl_summary_data70 <- lyl_aggregated(data = aggre_data, age = age, rates = rate,
                                   data0 = pop_ref, age0 = age, surv0 = survival,
                                   age_specific = 70, tau = 90)

# Summarize and plot the data
summary(lyl_summary_data70)
```

summary.lyl_ci

Summarize Life Years Lost with confidence intervals

Description

summary for objects of class lyl_ci summarizes Life Years Lost at one specific age or over a range of different ages, including bootstrapped confidence intervals

Usage

```
## S3 method for class 'lyl_ci'
summary(object, decimals = 2, level = 0.95,
        weights = NA, difference = FALSE, ...)
```

Arguments

object	An object of class lyl_ci (obtained with function lyl_ci).
decimals	Number of decimals to be reported (default is 2).
level	Confidence level (default is 0.95 for 95% confidence intervals)
weights	Vector with age distribution of disease/condition onset to be used when Life Years Lost are estimated over a range of ages (with lyl_range function). If weights are not provided (default is weights = NA), then the differences in Life Years Lost at each age is provided. If weights are provided, then a weighted average is provided.

difference Parameter automatically created by the package.
 ... Additional arguments affecting the summary produced.

Value

A table with the summary of the results.

See Also

- [lyl](#) for estimation of Life Years Lost at one specific age.
- [lyl_range](#) for estimation of Life Years Lost for a range of different ages.
- [lyl_ci](#) to estimate bootstrapped confidence intervals.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after age 45 years and before age 95 years
lyl_estimation <- lyl(data = simu_data, t = age_death, status = death,
                    age_specific = 45, tau = 95)

# Calculate bootstrapped confidence interval (3 iterations to test)
lyl_estimation_ci <- lyl_ci(lyl_estimation, niter = 3)
summary(lyl_estimation_ci)

# Estimate remaining life expectancy and Life Years
# Lost after each age from 0 to 94 years and before age 95 years
lyl_estimation2 <- lyl_range(data = simu_data, t = age_death, status = death,
                          age_begin = 0, age_end = 94, tau = 95)

# Calculate bootstrapped confidence interval
lyl_estimation_ci2 <- lyl_ci(lyl_estimation2)
summary(lyl_estimation_ci2, weights = simu_data$age_disease)
```

summary.lyl_range *Summarize Life Years Lost over a range of different ages*

Description

summary for objects of class lyl_range summarizes Life Years Lost over a range of different ages.

Usage

```
## S3 method for class 'lyl_range'
summary(object, decimals = 2, weights = NA,
        difference = FALSE, ...)
```

Arguments

object	An object of class <code>lyl_range</code> (obtained with function <code>lyl_range</code>).
decimals	Number of decimals to be reported (default is 2).
weights	Vector with age distribution of disease/condition onset. If weights are not provided (default is <code>weights = NA</code>), then the differences in Life Years Lost at each age are summarized. If weights are provided, then a weighted average is provided.
difference	Parameter automatically created by the package.
...	Additional arguments affecting the summary produced.

Value

A table with the summary of the results.

See Also

- [lyl_range](#) for estimation of Life Years Lost for a range of different ages.

Examples

```
# Load simulated data as example
data(simu_data)

# Estimate remaining life expectancy and Life Years
# Lost after each age from 0 to 94 years and before age 95 years
lyl_estimation <- lyl_range(data = simu_data, t = age_death, status = death,
                           age_begin = 0, age_end = 94, tau = 95)

# Visualize data at each different specific age
summary(lyl_estimation)

# Summarize data over an age distribution
summary(lyl_estimation, weights = simu_data$age_disease)
```

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