Package 'WARDEN'

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Title Workflows for Health Technology Assessments in R using Discrete EveNts

Version 1.2.0

Description Toolkit to support and perform discrete event simulations without resource constraints in the context of health technology assessments (HTA). The package focuses on cost-effectiveness modelling and aims to be submission-ready to relevant HTA bodies in alignment with 'NICE TSD 15' <https://www.sheffield.ac.uk/nice-dsu/tsds/patient-level-simulation>. More details an examples can be found in the package website <https://jsanchezalv.github.io/WARDEN/>.

License GPL (>= 3)

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LazyData true

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Imports purrr, data.table, foreach, future, doFuture, stats, utils, flexsurv, MASS, zoo, progressr, magrittr, rlang, tidyr

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URL https://jsanchezalv.github.io/WARDEN/

NeedsCompilation no

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Contents

`add_item` *Define parameters that may be used in model calculations (list)*

Description

Define parameters that may be used in model calculations (list)

Usage

```
add_item(.data = NULL, ...)
```

Arguments

`.data`	Existing data
`...`	Items to define for the simulation

Details

The functions to add/modify events/inputs use lists. Whenever several inputs/events are added or modified, it's recommended to group them within one function, as it reduces the computation cost. So rather than use two `add_item` with a list of one element, it's better to group them into a single `add_item` with a list of two elements.

Whenever a function is directly implemented which must be evaluated later and that has no object name attached (e.g., `pick_val_v`), it should be implemented after a first `add_item()` (empty or with content) to avoid confusing the `.data` argument, or wrapping the function within `substitute()`

Value

A list of items

Examples

```
library(magrittr)

add_item(fl.idfs = 0)
add_item(util_idfs = if(psa_bool){rnorm(1,0.8,0.2)} else{0.8}, util.mbc = 0.6, cost_idfs = 2500)
common_inputs <- add_item() %>%
add_item(pick_val_v(
  base      = l_statics[["base"]],
```

```
  psa       = pick_psa(
    l_statics[["function"]],
    l_statics[["n"]],
    l_statics[["a"]],
    l_statics[["b"]]
  ),
  sens      = l_statics[[sens_name_used]],
  psa_ind   = psa_bool,
  sens_ind  = sensitivity_bool,
  indicator = indicators_statics,
  names_out = l_statics[["parameter_name"]]
)
)
```

`add_item2` *Define parameters that may be used in model calculations (uses expressions)*

Description

Define parameters that may be used in model calculations (uses expressions)

Usage

```
add_item2(.data = NULL, input)
```

Arguments

`.data`	Existing data
`input`	Items to define for the simulation as an expression (i.e., using)

Details

The functions to add/modify events/inputs use lists. If chaining together add_item2, it will just append the expressions together in the order established.

If using `pick_val_v`, note it should be used with the `deploy_env = TRUE` argument so that add_item2 process it correctly.

Value

A substituted expression to be evaluated by engine

Examples

```
library(magrittr)

add_item2(input = {fl.idfs <-  0})
add_item2(input = {
 util_idfs <- if(psa_bool){rnorm(1,0.8,0.2)} else{0.8}
 util.mbc <- 0.6
 cost_idfs <- 2500})
common_inputs <- add_item2(input = {
pick_val_v(
  base      = l_statics[["base"]],
  psa       = pick_psa(
    l_statics[["function"]],
    l_statics[["n"]],
    l_statics[["a"]],
    l_statics[["b"]]
  ),
  sens      = l_statics[[sens_name_used]],
  psa_ind   = psa_bool,
  sens_ind  = sensitivity_bool,
  indicator = indicators_statics,
  names_out = l_statics[["parameter_name"]],
  deploy_env = TRUE #Note this option must be active if using it at add_item2
)
}
)
```

`add_reactevt` *Define the modifications to other events, costs, utilities, or other items affected by the occurrence of the event*

Description

Define the modifications to other events, costs, utilities, or other items affected by the occurrence of the event

Usage

```
add_reactevt(.data = NULL, name_evt, input)
```

Arguments

`.data`	Existing data for event reactions
`name_evt`	Name of the event for which reactions are defined.
`input`	Expressions that define what happens at the event, using functions as defined in the Details section

Details

There are a series of objects that can be used in this context to help define the event reactions.

The following functions may be used to define event reactions within this `add_reactevt()` function: `modify_item()` | Adds & Modifies items/flags/variables for future events (does not consider sequential) `modify_item_seq()` | Adds & Modifies items/flags/variables for future events in a sequential manner `new_event()` | Adds events to the vector of events for that patient `modify_event()` | Modifies existing events by changing their time

Apart from the items defined with add_item(), we can also use standard variables that are always defined within the simulation: `curtime` | Current event time (numeric) `prevtime` | Time of the previous event (numeric) `cur_evtlist` | Named vector of events that is yet to happen for that patient (named numeric vector) `evt` | Current event being processed (character) `i` | Patient being iterated (character) `simulation` | Simulation being iterated (numeric)

The model will run until `curtime` is set to `Inf`, so the event that terminates the model should modify `curtime` and set it to `Inf`.

The user can use `extract_from_reactions` function on the output to obtain a data.frame with all the relationships defined in the reactions in the model.

Value

A named list with the event name, and inside it the substituted expression saved for later evaluation

Examples

```
add_reactevt(name_evt = "start",input = {})
add_reactevt(name_evt = "idfs",input = {modify_item(list("fl.idfs"= 0))})
```

`add_tte` *Define events and the initial event time*

Description

Define events and the initial event time

Usage

```
add_tte(.data = NULL, arm, evts, other_inp = NULL, input)
```

Arguments

`.data`	Existing data for initial event times
`arm`	The intervention for which the events and initial event times are defined
`evts`	A vector of the names of the events
`other_inp`	A vector of other input variables that should be saved during the simulation
`input`	The definition of initial event times for the events listed in the evts argument

Details

Events need to be separately defined for each intervention.

For each event that is defined in this list, the user needs to add a reaction to the event using the `add_reactevt()` function which will determine what calculations will happen at an event.

Value

A list of initial events and event times

Examples

```
add_tte(arm="int",evts = c("start","ttot","idfs","os"),
input={
start <- 0
idfs <- draw_tte(1,'lnorm',coef1=2, coef2=0.5)
ttot <- min(draw_tte(1,'lnorm',coef1=1, coef2=4),idfs)
os <- draw_tte(1,'lnorm',coef1=0.8, coef2=0.2)
})
```

`ast_as_list` *Transform a substituted expression to its Abstract Syntax Tree (AST) as a list*

Description

Transform a substituted expression to its Abstract Syntax Tree (AST) as a list

Usage

```
ast_as_list(ee)
```

Arguments

`ee`	Substituted expression

Value

Nested list with the Abstract Syntax Tree (AST)

Examples

```
expr <- substitute({

a <- sum(5+7)

modify_item(list(afsa=ifelse(TRUE,"asda",NULL)))

modify_item_seq(list(
```

```
  o_other_q_gold1 = if(gold == 1) { utility } else { 0 },

  o_other_q_gold2 = if(gold == 2) { utility } else { 0 },

  o_other_q_gold3 = if(gold == 3) { utility } else { 0 },

  o_other_q_gold4 = if(gold == 4) { utility } else { 0 },

  o_other_q_on_dup = if(on_dup) { utility } else { 0 }

))

if(a==1){
  modify_item(list(a=list(6+b)))

  modify_event(list(e_exn = curtime + 14 / days_in_year + qexp(rnd_exn, r_exn)))
} else{
  modify_event(list(e_exn = curtime + 14 / days_in_year + qexp(rnd_exn, r_exn)))
  if(a>6){
    modify_item(list(a=8))
  }

}


if (sel_resp_incl == 1 & on_dup == 1) {

  modify_event(list(e_response = curtime, z = 6))

}

})


out <- ast_as_list(expr)
```

`ceac_des` *Calculate the cost-effectiveness acceptability curve (CEAC) for a DES model with a PSA result*

Description

Calculate the cost-effectiveness acceptability curve (CEAC) for a DES model with a PSA result

Usage

```
ceac_des(wtp, results, interventions = NULL, sensitivity_used = 1)
```

Arguments

`wtp`	Vector of length >=1 with the willingness to pay
`results`	The list object returned by `run_sim()`
`interventions`	A character vector with the names of the interventions to be used for the analysis
`sensitivity_used`	Integer signaling which sensitivity analysis to use

Value

A data frame with the CEAC results

Examples

```
res <- list(list(list(sensitivity_name = "", arm_list = c("int", "noint"
), total_lys = c(int = 9.04687362556945, noint = 9.04687362556945
), total_qalys = c(int = 6.20743830697466, noint = 6.18115138126336
), total_costs = c(int = 49921.6357486899, noint = 41225.2544659378
), total_lys_undisc = c(int = 10.8986618377039, noint = 10.8986618377039
), total_qalys_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), total_costs_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), c_default = c(int = 49921.6357486899, noint = 41225.2544659378
), c_default_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), q_default = c(int = 6.20743830697466, noint = 6.18115138126336
), q_default_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), merged_df = list(simulation = 1L, sensitivity = 1L))))

ceac_des(seq(from=10000,to=500000,by=10000),res)
```

`cond_dirichlet` *Calculate conditional dirichlet values*

Description

Calculate conditional dirichlet values

Usage

```
cond_dirichlet(alpha, i, xi, full_output = FALSE)
```

Arguments

`alpha`	mean vector
`i`	index of the known parameter (1-based index)
`xi`	known value of the i-th parameter (should be >0)
`full_output`	boolean indicating whether to return the full list of parameters

Details

Function to compute conditional dirichlet values

Value

List of length 2, one with new mu and other with covariance parameters

Examples

```
alpha <- c(2, 3, 4)
i <- 2  # Index of the known parameter
xi <- 0.5  # Known value of the second parameter

# Compute the conditional alpha parameters with full output
cond_dirichlet(alpha, i, xi, full_output = TRUE)
```

`cond_mvn` *Calculate conditional multivariate normal values*

Description

Calculate conditional multivariate normal values

Usage

```
cond_mvn(mu, Sigma, i, xi, full_output = FALSE)
```

Arguments

`mu`	mean vector
`Sigma`	covariance matrix
`i`	index of the known parameter (1-based index)
`xi`	known value of the i-th parameter
`full_output`	boolean indicating whether to return the full list of parameters

Details

Function to compute conditional multivariate normal values

Value

List of length 2, one with new mu and other with covariance parameters

Examples

```
mu <- c(1, 2, 3)
Sigma <- matrix(c(0.2, 0.05, 0.1,
                  0.05, 0.3, 0.05,
                  0.1, 0.05, 0.4), nrow = 3)

i <- 1:2  # Index of the known parameter
xi <- c(1.2,2.3)  # Known value of the first parameter

cond_mvn(mu, Sigma, i, xi,full_output = TRUE)
```

`create_indicators` *Creates a vector of indicators (0 and 1) for sensitivity/DSA analysis*

Description

Creates a vector of indicators (0 and 1) for sensitivity/DSA analysis

Usage

```
create_indicators(sens, n_sensitivity, elem, n_elem_before = 0)
```

Arguments

`sens`	current analysis iterator
`n_sensitivity`	total number of analyses to be run
`elem`	vector of 0s and 1s of elements to iterate through (1 = parameter is to be included in scenario/DSA)
`n_elem_before`	Sum of 1s (# of parameters to be included in scenario/DSA) that go before elem

Details

n_elem_before is to be used when several indicators want to be used (e.g., for patient level and common level inputs) while facilitating readibility of the code

Value

Numeric vector composed of 0 and 1, where value 1 will be used by `pick_val_v` to pick the corresponding index in its `sens` argument

Examples

```
create_indicators(10,20,c(1,1,1,1))
create_indicators(7,20,c(1,0,0,1,1,1,0,0,1,1),2)
```

`disc_cycle` *Cycle discounting*

Description

Cycle discounting

Usage

```
disc_cycle(
  lcldr = 0.035,
  lclprvtime = 0,
  cyclelength,
  lclcurtime,
  lclval,
  starttime = 0
)
```

Arguments

`lcldr`	The discount rate
`lclprvtime`	The time of the previous event in the simulation
`cyclelength`	The cycle length
`lclcurtime`	The time of the current event in the simulation
`lclval`	The value to be discounted
`starttime`	The start time for accrual of cycle costs (if not 0)

Value

Double based on cycle discounting

Examples

```
disc_cycle(lcldr=0.035, lclprvtime=0, cyclelength=1/12, lclcurtime=2, lclval=500,starttime=0)
```

`disc_cycle_v` *Cycle discounting for vectors*

Description

Cycle discounting for vectors

Usage

```
disc_cycle_v(
  lcldr = 0.035,
  lclprvtime = 0,
  cyclelength,
  lclcurtime,
  lclval,
  starttime = 0
)
```

Arguments

`lcldr`	The discount rate
`lclprvtime`	The time of the previous event in the simulation
`cyclelength`	The cycle length
`lclcurtime`	The time of the current event in the simulation
`lclval`	The value to be discounted
`starttime`	The start time for accrual of cycle costs (if not 0)

Value

Double based on cycle discounting

Examples

```
disc_cycle_v(lcldr=0.035, lclprvtime=0, cyclelength=1/12, lclcurtime=2, lclval=500,starttime=0)
```

`disc_instant` *Calculate instantaneous discounted costs or qalys*

Description

Calculate instantaneous discounted costs or qalys

Usage

```
disc_instant(lcldr = 0.035, lclcurtime, lclval)
```

Arguments

`lcldr`	The discount rate
`lclcurtime`	The time of the current event in the simulation
`lclval`	The value to be discounted

Value

Double based on discrete time discounting

Examples

```
disc_instant(lcldr=0.035, lclcurtime=3, lclval=2500)
```

`disc_instant_v` *Calculate instantaneous discounted costs or qalys for vectors*

Description

Calculate instantaneous discounted costs or qalys for vectors

Usage

```
disc_instant_v(lcldr = 0.035, lclcurtime, lclval)
```

Arguments

`lcldr`	The discount rate
`lclcurtime`	The time of the current event in the simulation
`lclval`	The value to be discounted

Value

Double based on discrete time discounting

Examples

```
disc_instant_v(lcldr=0.035, lclcurtime=3, lclval=2500)
```

`disc_ongoing` *Calculate discounted costs and qalys between events*

Description

Calculate discounted costs and qalys between events

Usage

```
disc_ongoing(lcldr = 0.035, lclprvtime, lclcurtime, lclval)
```

Arguments

`lcldr`	The discount rate
`lclprvtime`	The time of the previous event in the simulation
`lclcurtime`	The time of the current event in the simulation
`lclval`	The value to be discounted

Value

Double based on continuous time discounting

Examples

```
disc_ongoing(lcldr=0.035,lclprvtime=0.5, lclcurtime=3, lclval=2500)
```

`disc_ongoing_v` *Calculate discounted costs and qalys between events for vectors*

Description

Calculate discounted costs and qalys between events for vectors

Usage

```
disc_ongoing_v(lcldr = 0.035, lclprvtime, lclcurtime, lclval)
```

Arguments

`lcldr`	The discount rate
`lclprvtime`	The time of the previous event in the simulation
`lclcurtime`	The time of the current event in the simulation
`lclval`	The value to be discounted

Value

Double based on continuous time discounting

Examples

```
disc_ongoing_v(lcldr=0.035,lclprvtime=0.5, lclcurtime=3, lclval=2500)
```

`draw_tte` *Draw a time to event from a list of parametric survival functions*

Description

Draw a time to event from a list of parametric survival functions

Usage

```
draw_tte(
  n_chosen,
  dist,
  coef1 = NULL,
  coef2 = NULL,
  coef3 = NULL,
  ...,
  beta_tx = 1,
  seed = NULL
)
```

Arguments

`n_chosen`	The number of observations to be drawn
`dist`	The distribution; takes values 'lnorm','norm','mvnorm','weibullPH','weibull','llogis','gompertz','gengar
`coef1`	First coefficient of the distribution, defined as in the coef() output on a flexsurvreg object (rate in "rpoisgamma")
`coef2`	Second coefficient of the distribution, defined as in the coef() output on a flexsurvreg object (theta in "rpoisgamma")
`coef3`	Third coefficient of the distribution, defined as in the coef() output on a flexsurvreg object (not used in "rpoisgamma")
`...`	Additional arguments to be used by the specific distribution (e.g., return_ind_rate if dist = "poisgamma")
`beta_tx`	Parameter in natural scale applied in addition to the scale/rate coefficient -e.g., a HR if used in an exponential- (not used in "rpoisgamma" nor "beta")
`seed`	An integer which will be used to set the seed for this draw.

Details

Other arguments relevant to each function can be called directly

Value

A vector of time to event estimates from the given parameters

Examples

```
draw_tte(n_chosen=1,dist='exp',coef1=1,beta_tx=1)
draw_tte(n_chosen=10,"poisgamma",coef1=1,coef2=1,obs_time=1,return_ind_rate=FALSE)
```

`evpi_des` *Calculate the Expected Value of Perfect Information (EVPI) for a DES model with a PSA result*

Description

Calculate the Expected Value of Perfect Information (EVPI) for a DES model with a PSA result

Usage

```
evpi_des(wtp, results, interventions = NULL, sensitivity_used = 1)
```

Arguments

`wtp`	Vector of length >=1 with the willingness to pay
`results`	The list object returned by `run_sim()`
`interventions`	A character vector with the names of the interventions to be used for the analysis
`sensitivity_used`	Integer signaling which sensitivity analysis to use

Value

A data frame with the EVPI results

Examples

```
res <- list(list(list(sensitivity_name = "", arm_list = c("int", "noint"
), total_lys = c(int = 9.04687362556945, noint = 9.04687362556945
), total_qalys = c(int = 6.20743830697466, noint = 6.18115138126336
), total_costs = c(int = 49921.6357486899, noint = 41225.2544659378
), total_lys_undisc = c(int = 10.8986618377039, noint = 10.8986618377039
), total_qalys_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), total_costs_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), c_default = c(int = 49921.6357486899, noint = 41225.2544659378
), c_default_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), q_default = c(int = 6.20743830697466, noint = 6.18115138126336
), q_default_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), merged_df = list(simulation = 1L, sensitivity = 1L))))

evpi_des(seq(from=10000,to=500000,by=10000),res)
```

`extract_elements_from_list` *Extracts items and events by looking into assignments, modify_item, modify_item_seq, modify_event and new_event*

Description

Extracts items and events by looking into assignments, modify_item, modify_item_seq, modify_event and new_event

Usage

```
extract_elements_from_list(node, conditional_flag = FALSE)
```

Arguments

`node`	Relevant node within the nested AST list
`conditional_flag`	Boolean whether the statement is contained within a conditional statement

Value

A data.frame with the relevant item/event, the event where it's assigned, and whether it's contained within a conditional statement

Examples

```
expr <- substitute({

a <- sum(5+7)

modify_item(list(afsa=ifelse(TRUE,"asda",NULL)))

modify_item_seq(list(

  o_other_q_gold1 = if(gold == 1) { utility } else { 0 },

  o_other_q_gold2 = if(gold == 2) { utility } else { 0 },

  o_other_q_gold3 = if(gold == 3) { utility } else { 0 },

  o_other_q_gold4 = if(gold == 4) { utility } else { 0 },

  o_other_q_on_dup = if(on_dup) { utility } else { 0 }

))

if(a==1){
  modify_item(list(a=list(6+b)))

  modify_event(list(e_exn = curtime + 14 / days_in_year + qexp(rnd_exn, r_exn)))
} else{
  modify_event(list(e_exn = curtime + 14 / days_in_year + qexp(rnd_exn, r_exn)))
  if(a>6){
    modify_item(list(a=8))
  }

}


if (sel_resp_incl == 1 & on_dup == 1) {

  modify_event(list(e_response = curtime, z = 6))

}

})


out <- ast_as_list(expr)

results <- extract_elements_from_list(out)
```

`extract_from_reactions` *Extract all items and events and their interactions from the event reactions list*

Description

Extract all items and events and their interactions from the event reactions list

Usage

```
extract_from_reactions(reactions)
```

Arguments

`reactions`	list generated through `add_reactevt`

Value

A data.frame with the relevant item/event, the event where it's assigned, and whether it's contained within a conditional statement

Examples

```
evt_react_list2 <-
  add_reactevt(name_evt = "sick",
               input = {modify_item(list(a=1+5/3))
                 assign("W", 5 + 3 / 6 )
                 x[5] <- 18
                 for(i in 1:5){
                   assign(paste0("x_",i),5+3)
                 }
                 if(j == TRUE){
                   y[["w"]] <- 612-31+3
                 }#'
                 q_default <- 0
                 c_default <- 0
                 curtime   <- Inf
                 d <- c <- k <- 67
               })

 extract_from_reactions(evt_react_list2)
```

`extract_psa_result` *Extract PSA results from a treatment*

Description

Extract PSA results from a treatment

Usage

```
extract_psa_result(x, element)
```

Arguments

`x`	The output_sim data frame from the list object returned by `run_sim()`
`element`	Variable for which PSA results are being extracted (single string)

Value

A dataframe with PSA results from the specified intervention

Examples

```
res <- list(list(list(sensitivity_name = "", arm_list = c("int", "noint"
), total_lys = c(int = 9.04687362556945, noint = 9.04687362556945
), total_qalys = c(int = 6.20743830697466, noint = 6.18115138126336
), total_costs = c(int = 49921.6357486899, noint = 41225.2544659378
), total_lys_undisc = c(int = 10.8986618377039, noint = 10.8986618377039
), total_qalys_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), total_costs_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), c_default = c(int = 49921.6357486899, noint = 41225.2544659378
), c_default_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), q_default = c(int = 6.20743830697466, noint = 6.18115138126336
), q_default_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), merged_df = list(simulation = 1L, sensitivity = 1L))))


extract_psa_result(res[[1]],"total_costs")
```

`luck_adj` *Perform luck adjustment*

Description

Perform luck adjustment

Usage

```
luck_adj(prevsurv, cursurv, luck, condq = TRUE)
```

Arguments

`prevsurv`	Value of the previous survival
`cursurv`	Value of the current survival
`luck`	Luck used to be adjusted (number between 0 and 1)
`condq`	Conditional quantile approach or standard approach

Details

This function performs the luck adjustment automatically for the user, returning the adjusted luck number. Luck is interpreted in the same fashion as is standard in R (higher luck, higher time to event).

Note that if TTE is predicted using a conditional quantile function (e.g., conditional gompertz, conditional quantile weibull...) `prevsurv` and `cursurv` are the unconditional survival using the "previous" parametrization but at the previous time for `presurv` and at the current time for `cursurv`. For other distributions, `presurv` is the survival up to current time using the previous parametrization, and `cursurv` is the survival up to current time using the current parametrization.

Note that the advantage of the conditional quantile function is that it does not need the new parametrization to update the luck, which makes this approach computationally more efficient. This function can also work with vectors, which could allow to update multiple lucks in a single approach, and it can preserve names

Value

Adjusted luck number between 0 and 1

Examples

```
luck_adj(prevsurv = 0.8,
 cursurv = 0.7,
 luck = 0.5,
 condq = TRUE)

luck_adj(prevsurv = c(1,0.8,0.7),
 cursurv = c(0.7,0.6,0.5),
 luck = setNames(c(0.5,0.6,0.7),c("A","B","C")),
 condq = TRUE)

luck_adj(prevsurv = 0.8,
 cursurv = 0.7,
 luck = 0.5,
 condq = FALSE) #different results

#Unconditional approach, timepoint of change is 25,
# parameter goes from 0.02 at time 10 to 0.025 to 0.015 at time 25,
#  starting luck is 0.37
```

```
new_luck <- luck_adj(prevsurv = 1 - pweibull(q=10,3,1/0.02),
 cursurv = 1 - pweibull(q=10,3,1/0.025),
 luck = 0.37,
 condq = FALSE) #time 10 change

new_luck <- luck_adj(prevsurv = 1 - pweibull(q=25,3,1/0.025),
 cursurv = 1 - pweibull(q=25,3,1/0.015),
 luck = new_luck,
 condq = FALSE) #time 25 change

qweibull(new_luck, 3, 1/0.015) #final TTE

#Conditional quantile approach
new_luck <- luck_adj(prevsurv = 1-pweibull(q=0,3,1/0.02),
                      cursurv = 1- pweibull(q=10,3,1/0.02),
                      luck = 0.37,
                   condq = TRUE) #time 10 change, previous time is 0 so prevsurv will be 1

new_luck <- luck_adj(prevsurv = 1-pweibull(q=10,3,1/0.025),
                      cursurv = 1- pweibull(q=25,3,1/0.025),
                      luck = new_luck,
                      condq = TRUE) #time 25 change

qcond_weibull(rnd = new_luck,
                     shape = 3,
                     scale = 1/0.015,
                     lower_bound = 25) + 25 #final TTE
```

`modify_event` *Modify the time of existing events*

Description

Modify the time of existing events

Usage

```
modify_event(evt, create_if_null = TRUE)
```

Arguments

`evt`	A list of events and their times
`create_if_null`	A boolean. If TRUE, it will create non-existing events with the chosen time to event. If FALSE, it will ignore those.

Details

The functions to add/modify events/inputs use lists. Whenever several inputs/events are added or modified, it's recommended to group them within one function, as it reduces the computation cost. So rather than use two `modify_event` with a list of one element, it's better to group them into a single `modify_event` with a list of two elements.

This function does not evaluate sequentially.

This function is intended to be used only within the `add_reactevt` function in its `input` parameter and should not be run elsewhere or it will return an error.

Value

No return value, modifies/adds event to `cur_evtlist` and integrates it with the main list for storage

Examples

```
add_reactevt(name_evt = "idfs",input = {modify_event(list("os"=5))})
```

`modify_item` *Modify the value of existing items*

Description

Modify the value of existing items

Usage

```
modify_item(list_item)
```

Arguments

`list_item`	A list of items and their values or expressions

Details

The functions to add/modify events/inputs use lists. Whenever several inputs/events are added or modified, it's recommended to group them within one function, as it reduces the computation cost. So rather than use two `modify_item` with a list of one element, it's better to group them into a single `modify_item` with a list of two elements.

Note that `modify_item` nor `modify_item_seq` can work on subelements (e.g., `modify_item(list(obj$item = 5))` will not work as intended, for that is better to assign directly using the expression approach, so `obj$item <- 5`).

Costs and utilities can be modified by using the construction `type_name_category`, where type is either "qaly" or "cost", name is the name (e.g., "default") and category is the category used (e.g., "instant"), so one could pass `cost_default_instant` and modify the cost. This will overwrite the value defined in the corresponding cost/utility section.

This function is intended to be used only within the `add_reactevt` function in its `input` parameter and should not be run elsewhere or it will return an error.

Value

No return value, modifies/adds item to the environment and integrates it with the main list for storage

Examples

```
add_reactevt(name_evt = "idfs",input = {modify_item(list("cost.it"=5))})
```

`modify_item_seq` *Modify the value of existing items*

Description

Modify the value of existing items

Usage

```
modify_item_seq(...)
```

Arguments

`...`	A list of items and their values or expressions. Will be evaluated sequentially (so one could have list(a= 1, b = a +2))

Details

The functions to add/modify events/inputs use lists. Whenever several inputs/events are added or modified, it's recommended to group them within one function, as it reduces the computation cost. So rather than use two `modify_item` with a list of one element, it's better to group them into a single `modify_item` with a list of two elements.

Note that `modify_item` nor `modify_item_seq` can work on subelements (e.g., `modify_item_seq(list(obj$item = 5))` will not work as intended, for that is better to assign directly using the expression approach, so `obj$item <- 5`).

Costs and utilities can be modified by using the construction `type_name_category`, where type is either "qaly" or "cost", name is the name (e.g., "default") and category is the category used (e.g., "instant"), so one could pass `cost_default_instant` and modify the cost. This will overwrite the value defined in the corresponding cost/utility section.

The function is different from modify_item in that this function evaluates sequentially the arguments within the list passed. This implies a slower performance relative to modify_item, but it can be more cleaner and convenient in certain instances.

This function is intended to be used only within the `add_reactevt` function in its `input` parameter and should not be run elsewhere or it will return an error.

Value

No return value, modifies/adds items sequentially and deploys to the environment and with the main list for storage

Examples

```
add_reactevt(name_evt = "idfs",input = {
  modify_item_seq(list(cost.idfs = 500, cost.tx = cost.idfs + 4000))
  })
```

`new_event` *Generate new events to be added to existing vector of events*

Description

Generate new events to be added to existing vector of events

Usage

```
new_event(evt)
```

Arguments

`evt`	Event name and event time

Details

The functions to add/modify events/inputs use lists. Whenever several inputs/events are added or modified, it's recommended to group them within one function, as it reduces the computation cost. So rather than use two `new_event` with a list of one element, it's better to group them into a single `new_event` with a list of two elements.

This function is intended to be used only within the `add_reactevt` function in its `input` parameter and should not be run elsewhere or it will return an error.

Value

No return value, adds event to `cur_evtlist` and integrates it with the main list for storage

Examples

```
add_reactevt(name_evt = "idfs",input = {new_event(list("ae"=5))})
```

`pcond_gompertz` *Survival Probaility function for conditional Gompertz distribution (lower bound only)*

Description

Survival Probaility function for conditional Gompertz distribution (lower bound only)

Usage

```
pcond_gompertz(time = 1, shape, rate, lower_bound = 0)
```

Arguments

`time`	Vector of times
`shape`	The shape parameter of the Gompertz distribution, defined as in the coef() output on a flexsurvreg object
`rate`	The rate parameter of the Gompertz distribution, defined as in the coef() output on a flexsurvreg object
`lower_bound`	The lower bound of the conditional distribution

Value

Estimate(s) from the conditional Gompertz distribution based on given parameters

Examples

```
pcond_gompertz(time=1,shape=0.05,rate=0.01,lower_bound = 50)
```

`pick_psa` *Helper function to create a list with random draws or whenever a series of functions needs to be called. Can be implemented within* `pick_val_v`*.*

Description

Helper function to create a list with random draws or whenever a series of functions needs to be called. Can be implemented within `pick_val_v`.

Usage

```
pick_psa(f, ...)
```

Arguments

`f`	A string or vector of strings with the function to be called, e.g., "rnorm"
`...`	parameters to be passed to the function (e.g., if "rnorm", arguments `n`, `mean`, `sd`)

Details

This function can be used to pick values for the PSA within `pick_val_v`.

The function will ignore NA items within the respective parameter (see example below). If an element in f is NA (e.g., a non PSA input) then it will return NA as its value This feature is convenient when mixing distributions with different number of arguments, e.g., `rnorm` and `rgengamma`.

While it's slightly lower than individually calling each function, it makes the code easier to read and more transparent

Value

List with length equal to `f` of parameters called

Examples

```
params <- list(
param=list("a","b"),
dist=list("rlnorm","rnorm"),
n=list(4,1),
a=list(c(1,2,3,4),1),
b=list(c(0.5,0.5,0.5,0.5),0.5),
dsa_min=list(c(1,2,3,4),2),
dsa_max=list(c(1,2,3,4),3)
)
pick_psa(params[["dist"]],params[["n"]],params[["a"]],params[["b"]])

#It works with functions that require different number of parameters
params <- list(
 param=list("a","b","c"),
 dist=list("rlnorm","rnorm","rgengamma"),
 n=list(4,1,1),
 a=list(c(1,2,3,4),1,0),
 b=list(c(0.5,0.5,0.5,0.5),0.5,1),
 c=list(NA,NA,0.2),
 dsa_min=list(c(1,2,3,4),2,1),
 dsa_max=list(c(1,2,3,4),3,3)
)

pick_psa(params[["dist"]],params[["n"]],params[["a"]],params[["b"]],params[["c"]])

#Can be combined with multiple type of functions and distributions if parameters are well located

params <- list(
param=list("a","b","c","d"),
dist=list("rlnorm","rnorm","rgengamma","draw_tte"),
n=list(4,1,1,1),
```

```
a=list(c(1,2,3,4),1,0,"norm"),
b=list(c(0.5,0.5,0.5,0.5),0.5,1,1),
c=list(NA,NA,0.2,0.5),
c=list(NA,NA,NA,NA), #NA arguments will be ignored
dsa_min=list(c(1,2,3,4),2,1,0),
dsa_max=list(c(1,2,3,4),3,3,2)
)
```

`pick_val_v` *Select which values should be applied in the corresponding loop for several values (vector or list).*

Description

Select which values should be applied in the corresponding loop for several values (vector or list).

Usage

```
pick_val_v(
  base,
  psa,
  sens,
  psa_ind = psa_bool,
  sens_ind = sens_bool,
  indicator,
  indicator_psa = NULL,
  names_out = NULL,
  indicator_sens_binary = TRUE,
  sens_iterator = NULL,
  distributions = NULL,
  covariances = NULL,
  deploy_env = FALSE
)
```

Arguments

`base`	Value if no PSA/DSA/Scenario
`psa`	Value if PSA
`sens`	Value if DSA/Scenario
`psa_ind`	Boolean whether PSA is active
`sens_ind`	Boolean whether Scenario/DSA is active
`indicator`	Indicator which checks whether the specific parameter/parameters is/are active in the DSA or Scenario loop
`indicator_psa`	Indicator which checks whether the specific parameter/parameters is/are active in the PSA loop. If NULL, it's assumed to be a vector of 1s of length equal to length(indicator)

`names_out`	Names to give the output list
`indicator_sens_binary`	Boolean, TRUE if parameters will be varied fully, FALSE if some elements of the parameters may be changed but not all
`sens_iterator`	Current iterator number of the DSA/scenario being run, e.g., 5 if it corresponds to the 5th DSA parameter being changed
`distributions`	List with length equal to length of base where the distributions are stored
`covariances`	List with length equal to length of base where the variance/covariances are stored (only relevant if multivariate normal are being used)
`deploy_env`	Boolean, if TRUE will deploy all objects in the environment where the function is called for. Must be active if using add_item2 (and FALSE if using add_item)

Details

This function can be used with vectors or lists, but will always return a list. Lists should be used when correlated variables are introduced to make sure the selector knows how to choose among those This function allows to choose between using an approach where only the full parameters are varied, and an approach where subelements of the parameters can be changed

Value

List used for the inputs

Examples

```
pick_val_v(base = list(0,0),
             psa =list(rnorm(1,0,0.1),rnorm(1,0,0.1)),
             sens = list(2,3),
             psa_ind = FALSE,
             sens_ind = TRUE,
             indicator=list(1,2),
             indicator_sens_binary = FALSE,
             sens_iterator = 2,
             distributions = list("rnorm","rnorm")
)

pick_val_v(base = list(2,3,c(1,2)),
             psa =sapply(1:3,
                         function(x) eval(call(
                           c("rnorm","rnorm","mvrnorm")[[x]],
                           1,
                           c(2,3,list(c(1,2)))[[x]],
                           c(0.1,0.1,list(matrix(c(1,0.1,0.1,1),2,2)))[[x]]
                         ))),
             sens = list(4,5,c(1.3,2.3)),
             psa_ind = FALSE,
             sens_ind = TRUE,
             indicator=list(1,2,c(3,4)),
             names_out=c("util","util2","correlated_vector") ,
             indicator_sens_binary = FALSE,
```

```
            sens_iterator = 4,
            distributions = list("rnorm","rnorm","mvrnorm"),
            covariances = list(0.1,0.1,matrix(c(1,0.1,0.1,1),2,2))
)
```

---

qbeta_mse *Draw from a beta distribution based on mean and se (quantile)*

Description

Draw from a beta distribution based on mean and se (quantile)

Usage

```
qbeta_mse(q, mean_v, se)
```

Arguments

q	Quantiles to be used
mean_v	A vector of the mean values
se	A vector of the standard errors of the means

Value

A single estimate from the beta distribution based on given parameters

Examples

```
qbeta_mse(q=0.5,mean_v=0.8,se=0.2)
```

---

qcond_exp *Conditional quantile function for exponential distribution*

Description

Conditional quantile function for exponential distribution

Usage

```
qcond_exp(rnd = 0.5, rate)
```

Arguments

`rnd`	Vector of quantiles
`rate`	The rate parameter Note taht the conditional quantile for an exponential is independent of time due to constant hazard

Value

Estimate(s) from the conditional exponential distribution based on given parameters

Examples

```
qcond_exp(rnd = 0.5,rate = 3)
```

`qcond_gamma` *Conditional quantile function for gamma distribution*

Description

Conditional quantile function for gamma distribution

Usage

```
qcond_gamma(rnd = 0.5, rate, shape, lower_bound = 0, s_obs)
```

Arguments

`rnd`	Vector of quantiles
`rate`	The rate parameter
`shape`	The shape parameter
`lower_bound`	The lower bound to be used (current time)
`s_obs`	is the survival observed up to lower_bound time, normally defined from time 0 as 1 - pgamma(q = lower_bound, rate, shape) but may be different if parametrization has changed previously

Value

Estimate(s) from the conditional gamma distribution based on given parameters

Examples

```
qcond_gamma(rnd = 0.5, rate = 1.06178, shape = 0.01108,lower_bound = 1, s_obs=0.8)
```

`qcond_gompertz` *Quantile function for conditional Gompertz distribution (lower bound only)*

Description

Quantile function for conditional Gompertz distribution (lower bound only)

Usage

```
qcond_gompertz(rnd = 0.5, shape, rate, lower_bound = 0)
```

Arguments

`rnd`	Vector of quantiles
`shape`	The shape parameter of the Gompertz distribution, defined as in the coef() output on a flexsurvreg object
`rate`	The rate parameter of the Gompertz distribution, defined as in the coef() output on a flexsurvreg object
`lower_bound`	The lower bound of the conditional distribution

Value

Estimate(s) from the conditional Gompertz distribution based on given parameters

Examples

```
qcond_gompertz(rnd=0.5,shape=0.05,rate=0.01,lower_bound = 50)
```

`qcond_llogis` *Conditional quantile function for loglogistic distribution*

Description

Conditional quantile function for loglogistic distribution

Usage

```
qcond_llogis(rnd = 0.5, shape, scale, lower_bound = 0)
```

Arguments

`rnd`	Vector of quantiles
`shape`	The shape parameter
`scale`	The scale parameter
`lower_bound`	The lower bound to be used (current time)

Value

Estimate(s) from the conditional loglogistic distribution based on given parameters

Examples

```
qcond_llogis(rnd = 0.5,shape = 1,scale = 1,lower_bound = 1)
```

`qcond_lnorm` *Conditional quantile function for lognormal distribution*

Description

Conditional quantile function for lognormal distribution

Usage

```
qcond_lnorm(rnd = 0.5, meanlog, sdlog, lower_bound = 0, s_obs)
```

Arguments

`rnd`	Vector of quantiles
`meanlog`	The meanlog parameter
`sdlog`	The sdlog parameter
`lower_bound`	The lower bound to be used (current time)
`s_obs`	is the survival observed up to lower_bound time, normally defined from time 0 as 1 - plnorm(q = lower_bound, meanlog, sdlog) but may be different if parametrization has changed previously

Value

Estimate(s) from the conditional lognormal distribution based on given parameters

Examples

```
qcond_lnorm(rnd = 0.5, meanlog = 1,sdlog = 1,lower_bound = 1, s_obs=0.8)
```

`qcond_norm` *Conditional quantile function for normal distribution*

Description

Conditional quantile function for normal distribution

Usage

```
qcond_norm(rnd = 0.5, mean, sd, lower_bound = 0, s_obs)
```

Arguments

`rnd`	Vector of quantiles
`mean`	The mean parameter
`sd`	The sd parameter
`lower_bound`	The lower bound to be used (current time)
`s_obs`	is the survival observed up to lower_bound time, normally defined from time 0 as 1 - pnorm(q = lower_bound, mean, sd) but may be different if parametrization has changed previously

Value

Estimate(s) from the conditional normal distribution based on given parameters

Examples

```
qcond_norm(rnd = 0.5, mean = 1,sd = 1,lower_bound = 1, s_obs=0.8)
```

`qcond_weibull` *Conditional quantile function for weibull distribution*

Description

Conditional quantile function for weibull distribution

Usage

```
qcond_weibull(rnd = 0.5, shape, scale, lower_bound = 0)
```

Arguments

`rnd`	Vector of quantiles
`shape`	The shape parameter as in R stats package weibull
`scale`	The scale parameter as in R stats package weibull
`lower_bound`	The lower bound to be used (current time)

Value

Estimate(s) from the conditional weibull distribution based on given parameters

Examples

```
qcond_weibull(rnd = 0.5,shape = 3,scale = 66.66,lower_bound = 50)
```

`qgamma_mse` *Use quantiles from a gamma distribution based on mean and se*

Description

Use quantiles from a gamma distribution based on mean and se

Usage

```
qgamma_mse(q = 1, mean_v, se, seed = NULL)
```

Arguments

`q`	Quantile to draw
`mean_v`	A vector of the mean values
`se`	A vector of the standard errors of the means
`seed`	An integer which will be used to set the seed for this draw.

Value

A single estimate from the gamma distribution based on given parameters

Examples

```
qgamma_mse(q=0.5,mean_v=0.8,se=0.2)
```

`random_stream` *Creates an environment (similar to R6 class) of random uniform numbers to be drawn from*

Description

Creates an environment (similar to R6 class) of random uniform numbers to be drawn from

Usage

```
random_stream(stream_size = 100)
```

Arguments

`stream_size`	Length of the vector of random uniform values to initialize

Details

This function creates an environment object that behaves similar to an R6 class but offers more speed vs. an R6 class.

The object is always initialized (see example below) to a specific vector of random uniform values. The user can then call the object with `obj$draw_number(n)`, where n is an integer, and will return the first n elements of the created vector of uniform values. It will automatically remove those indexes from the vector, so the next time the user calls `obj$draw_n()` it will already consider the next index.

The user can also access the latest elements drawn by accessing `obj$random_n` (useful for when performing a luck adjustment), the current stream still to be drawn using `obj$stream` and the original size (when created) using `obj$stream_size`.

If performing luck adjustment, the user can always modify the random value by using `obj$random_n <- luck_adj(...)` (only valid if used with the expression approach, not with `modify_item`)

Value

Self (environment) behaving similar to R6 class

Examples

```
stream_1 <- random_stream(1000)
number_1 <- stream_1$draw_n() #extract 1st index from the vector created
identical(number_1,stream_1$random_n) #same value
number_2 <- stream_1$draw_n() #gets 1st index (considers previous)
identical(number_2,stream_1$random_n) #same value
```

`rbeta_mse` *Draw from a beta distribution based on mean and se*

Description

Draw from a beta distribution based on mean and se

Usage

```
rbeta_mse(n = 1, mean_v, se, seed = NULL)
```

Arguments

`n`	Number of draws (must be >= 1)
`mean_v`	A vector of the mean values
`se`	A vector of the standard errors of the means
`seed`	An integer which will be used to set the seed for this draw.

Value

A single estimate from the beta distribution based on given parameters

Examples

```
rbeta_mse(n=1,mean_v=0.8,se=0.2)
```

`rcond_gompertz` *Draw from a conditional Gompertz distribution (lower bound only)*

Description

Draw from a conditional Gompertz distribution (lower bound only)

Usage

```
rcond_gompertz(n = 1, shape, rate, lower_bound = 0, seed = NULL)
```

Arguments

`n`	The number of observations to be drawn
`shape`	The shape parameter of the Gompertz distribution, defined as in the coef() output on a flexsurvreg object
`rate`	The rate parameter of the Gompertz distribution, defined as in the coef() output on a flexsurvreg object
`lower_bound`	The lower bound of the conditional distribution
`seed`	An integer which will be used to set the seed for this draw.

Value

Estimate(s) from the conditional Gompertz distribution based on given parameters

Examples

```
rcond_gompertz(1,shape=0.05,rate=0.01,lower_bound = 50)
```

`rcond_gompertz_lu` *Draw from a Conditional Gompertz distribution (lower and upper bound)*

Description

Draw from a Conditional Gompertz distribution (lower and upper bound)

Usage

```
rcond_gompertz_lu(
  n,
  shape,
  rate,
  lower_bound = 0,
  upper_bound = Inf,
  seed = NULL
)
```

Arguments

`n`	The number of observations to be drawn
`shape`	The shape parameter of the Gompertz distribution, defined as in the coef() output on a flexsurvreg object
`rate`	The rate parameter of the Gompertz distribution, defined as in the coef() output on a flexsurvreg object
`lower_bound`	The lower bound of the conditional distribution
`upper_bound`	The upper bound of the conditional distribution
`seed`	An integer which will be used to set the seed for this draw.

Value

Estimate(s) from the Conditional Gompertz distribution based on given parameters

Examples

```
rcond_gompertz_lu(1,shape=0.05,rate=0.01,lower_bound = 50)
```

`rdirichlet` *Draw from a dirichlet distribution based on number of counts in transition. Adapted from brms::rdirichlet*

Description

Draw from a dirichlet distribution based on number of counts in transition. Adapted from brms::rdirichlet

Usage

```
rdirichlet(n = 1, alpha, seed = NULL)
```

Arguments

`n`	Number of draws (must be >= 1). If n>1, it will return a list of matrices.
`alpha`	A matrix of alphas (transition counts)
`seed`	An integer which will be used to set the seed for this draw.

Value

A transition matrix. If n>1, it will return a list of matrices.

Examples

```
rdirichlet(n=1,alpha= matrix(c(1251, 0, 350, 731),2,2))
rdirichlet(n=2,alpha= matrix(c(1251, 0, 350, 731),2,2))
```

`rdirichlet_prob` *Draw from a dirichlet distribution based on mean transition probabilities and standard errors*

Description

Draw from a dirichlet distribution based on mean transition probabilities and standard errors

Usage

```
rdirichlet_prob(n = 1, alpha, se, seed = NULL)
```

Arguments

`n`	Number of draws (must be >= 1). If n>1, it will return a list of matrices.
`alpha`	A matrix of transition probabilities
`se`	A matrix of standard errors
`seed`	An integer which will be used to set the seed for this draw.

Value

A transition matrix. If n>1, it will return a list of matrices.

Examples

```
rdirichlet_prob(n=1,alpha= matrix(c(0.7,0.3,0,0.1,0.7,0.2,0.1,0.2,0.7),3,3),
se=matrix(c(0.7,0.3,0,0.1,0.7,0.2,0.1,0.2,0.7)/10,3,3))

rdirichlet_prob(n=2,alpha= matrix(c(0.7,0.3,0,0.1,0.7,0.2,0.1,0.2,0.7),3,3),
se=matrix(c(0.7,0.3,0,0.1,0.7,0.2,0.1,0.2,0.7)/10,3,3))
```

`replicate_profiles` *Replicate profiles data.frame*

Description

Replicate profiles data.frame

Usage

```
replicate_profiles(
  profiles,
  replications,
  probabilities = NULL,
  replacement = TRUE,
  seed_used = NULL
)
```

Arguments

`profiles`	data.frame of profiles
`replications`	integer, final number of observations
`probabilities`	vector of probabilities with the same length as the number of rows of profiles. Does not need to add up to 1 (are reweighted)
`replacement`	Boolean whether replacement is used
`seed_used`	Integer with the seed to be used for consistent results

Value

Resampled data.frame of profiles

Examples

```
replicate_profiles(profiles=data.frame(id=1:100,age=rnorm(100,60,5)),
replications=200,probabilities=rep(1,100))
```

`rgamma_mse` *Draw from a gamma distribution based on mean and se*

Description

Draw from a gamma distribution based on mean and se

Usage

```
rgamma_mse(n = 1, mean_v, se, seed = NULL)
```

Arguments

`n`	Number of draws (must be >= 1)
`mean_v`	A vector of the mean values
`se`	A vector of the standard errors of the means
`seed`	An integer which will be used to set the seed for this draw.

Value

A single estimate from the gamma distribution based on given parameters

Examples

```
rgamma_mse(n=1,mean_v=0.8,se=0.2)
```

`rpoisgamma` *Draw time to event (tte) from a Poisson or Poisson-Gamma (PG) Mixture/Negative Binomial (NB) Process*

Description

Draw time to event (tte) from a Poisson or Poisson-Gamma (PG) Mixture/Negative Binomial (NB) Process

Usage

```
rpoisgamma(
  n,
  rate,
  theta = NULL,
  obs_time = 1,
  t_reps,
  seed = NULL,
  return_ind_rate = FALSE,
  return_df = FALSE
)
```

Arguments

`n`	The number of observations to be drawn
`rate`	rate of the event (in terms of events per observation-time)
`theta`	Optional. When omitted, the function simulates times for a Poisson process. Represents the shape of the gamma mixture distribution. Estimated and reported as theta in negative binomial regression analyses in r.
`obs_time`	period over which events are observable
`t_reps`	Optional. Number of TBEs to be generated to capture events within the observation window. When omitted, the function sets t_reps to the 99.99th quantile of the Poisson (if no theta is provided) or negative binomial (if theta is provided). Thus, the risk of missing possible events in the observation window is 0.01%.
`seed`	An integer which will be used to set the seed for this draw.
`return_ind_rate`	A boolean that indicates whether an additional vector with the rate parameters used per observation is used. It will alter the structure of the results to two lists, one storing tte with name tte, and the other with name ind_rate
`return_df`	A boolean that indicates whether a data.table object should be returned

Details

Function to simulate event times from a Poisson or Poisson-Gamma (PG) Mixture/Negative Binomial (NB) Process Event times are determined by sampling times between events (TBEs) from an exponential distribution, and cumulating these to derive the event times. Events occurring within the set observation time window are retained and returned. For times for a Poisson process, the provided rate is assumed constant. For a PG or NB, the individual rates are sampled from a Gamma distribution with shape = theta and scale = rate/theta.

Value

Estimate(s) from the time to event based on poisson/Poisson-Gamma (PG) Mixture/Negative Binomial (NB) distribution based on given parameters

Examples

```
rpoisgamma(1,rate=1,obs_time=1,theta=1)
```

`run_sim` *Run the simulation*

Description

Run the simulation

Usage

```
run_sim(
  arm_list = c("int", "noint"),
  sensitivity_inputs = NULL,
  common_all_inputs = NULL,
  common_pt_inputs = NULL,
  unique_pt_inputs = NULL,
  init_event_list = NULL,
  evt_react_list = evt_react_list,
  util_ongoing_list = NULL,
  util_instant_list = NULL,
  util_cycle_list = NULL,
  cost_ongoing_list = NULL,
  cost_instant_list = NULL,
  cost_cycle_list = NULL,
  other_ongoing_list = NULL,
  other_instant_list = NULL,
  npats = 500,
  n_sim = 1,
  psa_bool = NULL,
  sensitivity_bool = FALSE,
  sensitivity_names = NULL,
  n_sensitivity = 1,
  input_out = NULL,
  ipd = 1,
  timed_freq = NULL,
  debug = FALSE,
  accum_backwards = FALSE,
  continue_on_error = FALSE,
  seed = NULL
)
```

Arguments

`arm_list`	A vector of the names of the interventions evaluated in the simulation
`sensitivity_inputs`	A list of sensitivity inputs that do not change within a sensitivity in a similar fashion to common_all_inputs, etc
`common_all_inputs`	A list of inputs common across patients that do not change within a simulation
`common_pt_inputs`	A list of inputs that change across patients but are not affected by the intervention
`unique_pt_inputs`	A list of inputs that change across each intervention
`init_event_list`	A list of initial events and event times. If no initial events are given, a "Start" event at time 0 is created automatically

`evt_react_list`	A list of event reactions
`util_ongoing_list`	Vector of QALY named variables that are accrued at an ongoing basis (discounted using drq)
`util_instant_list`	Vector of QALY named variables that are accrued instantaneously at an event (discounted using drq)
`util_cycle_list`	Vector of QALY named variables that are accrued in cycles (discounted using drq)
`cost_ongoing_list`	Vector of cost named variables that are accrued at an ongoing basis (discounted using drc)
`cost_instant_list`	Vector of cost named variables that are accrued instantaneously at an event (discounted using drc)
`cost_cycle_list`	Vector of cost named variables that are accrued in cycles (discounted using drc)
`other_ongoing_list`	Vector of other named variables that are accrued at an ongoing basis (discounted using drq)
`other_instant_list`	Vector of other named variables that are accrued instantaneously at an event (discounted using drq)
`npats`	The number of patients to be simulated (it will simulate npats * length(arm_list))
`n_sim`	The number of simulations to run per sensitivity
`psa_bool`	A boolean to determine if PSA should be conducted. If n_sim > 1 and psa_bool = FALSE, the differences between simulations will be due to sampling
`sensitivity_bool`	A boolean to determine if Scenarios/DSA should be conducted.
`sensitivity_names`	A vector of scenario/DSA names that can be used to select the right sensitivity (e.g., c("Scenario_1", "Scenario_2")). The parameter "sens_name_used" is created from it which corresponds to the one being used for each iteration.
`n_sensitivity`	Number of sensitivity analysis (DSA or Scenarios) to run. It will be interacted with sensitivity_names argument if not null (n_sensitivityitivity = n_sensitivity * length(sensitivity_names)). For DSA, it should be as many parameters as there are. For scenario, it should be 1.
`input_out`	A vector of variables to be returned in the output data frame
`ipd`	Integer taking value 1 for full IPD data returned, and 2 IPD data but aggregating events (returning last value for numeric/character/factor variables. For other objects (e.g., matrices), the IPD will still be returned as the aggregation rule is not clear). Other values mean no IPD data returned (removes non-numerical or length>1 items)

`timed_freq`	If NULL, it does not produce any timed outputs. Otherwise should be a number (e.g., every 1 year)
`debug`	If TRUE, will generate a log file
`accum_backwards`	If TRUE, the ongoing accumulators will count backwards (i.e., the current value is applied until the previous update). If FALSE, the current value is applied between the current event and the next time it is updated. If TRUE, user must use `modify_item` and `modify_item_seq` or results will be incorrect.
`continue_on_error`	If TRUE, on error it will attempt to continue by skipping the current simulation
`seed`	Starting seed to be used for the whole analysis. If null, it's set to 1 by default.

Details

This function is slightly different from `run_sim_parallel`. `run_sim_parallel` only runs multiple-core at the simulation level. `run_sim` uses only-single core. `run_sim` can be more efficient if using only one simulation (e.g., deterministic), while `run_sim_parallel` will be more efficient if the number of simulations is >1 (e.g., PSA).

Event ties are processed in the order declared within the `init_event_list` argument (`evts` argument within the first sublist of that object). To do so, the program automatically adds a sequence from to 0 to the (number of events - 1) times 1e-10 to add to the event times when selecting the event with minimum time. This time has been selected as it's relatively small yet not so small as to be ignored by which.min (see .Machine for more details)

A list of protected objects that should not be used by the user as input names or in the global environment to avoid the risk of overwriting them is as follows: c("arm", "arm_list", "categories_for_export", "cur_evtlist", "curtime", "evt", "i", "prevtime", "sens", "simulation", "sens_name_used","list_env","uc_lists","npats","ipd").

The engine uses the L'Ecuyer-CMRG for the random number generator. Note that the random seeds are set to be unique in their category (i.e., at patient level, patient-arm level, etc.)

If no `drc` or `drq` parameters are passed within `sensitivity` or `common_all` input lists, these are assigned a default value 0.03 for discounting costs, QALYs and others.

Ongoing items will look backward to the last time updated when performing the discounting and accumulation. This means that the user does not necessarily need to keep updating the value, but only add it when the value changes looking forward (e.g., o_q = utility at event 1, at event 2 utility does not change, but at event 3 it does, so we want to make sure to add o_q = utility at event 3 before updating utility. The program will automatically look back until event 1). Note that in previous versions of the package backward was the default, and now this has switched to forward.

If using `accum_backwards = TRUE`, then it is mandatory for the user to use `modify_item` and `modify_item_seq` in event reactions, as the standard assignment approach (e.g., `a <- 5`) will not calculate the right results, particularly in the presence of conditional statements.

It is important to note that the QALYs and Costs (ongoing or instant or per cycle) used should be of length 1. If they were of length > 1, the model would expand the data, so instead of having each event as a row, the event would have N rows (equal to the length of the costs/qalys to discount passed). This means more processing of the results data would be needed in order for it to provide the correct results.

If the `cycle` lists are used, then it is expected the user will declare as well the name of the variable pasted with `cycle_l` and `cycle_starttime` (e.g., c_default_cycle_l and c_default_cycle_starttime) to ensure the discounting can be computed using cycles, with cycle_l being the cycle length, and cycle_starttime being the starting time in which the variable started counting.

`debug = TRUE` will export a log file with the timestamp up the error in the main working directory. Note that using this mode without modify_item or modify_item_seq may lead to inaccuracies if assignments are done in non-standard ways, as the AST may not catch all the relevant assignments (e.g., an assigment like assign(paste("x_",i),5) in a loop will not be identified, unless using modify_item(_seq)).

`continue_on_error` will skip the current simulation (so it won't continue for the rest of patient-arms) if TRUE. Note that this will make the progress bar not correct, as a set of patients that were expected to be run is not.

Value

A list of data frames with the simulation results

Examples

```
library(magrittr)
common_all_inputs <-add_item(
util.sick = 0.8,
util.sicker = 0.5,
cost.sick = 3000,
cost.sicker = 7000,
cost.int = 1000,
coef_noint = log(0.2),
HR_int = 0.8,
drc = 0.035, #different values than what's assumed by default
drq = 0.035,
random_seed_sicker_i = sample.int(100000,5,replace = FALSE)
)

common_pt_inputs <- add_item(death= max(0.0000001,rnorm(n=1, mean=12, sd=3)))

unique_pt_inputs <- add_item(fl.sick = 1,
                             q_default = util.sick,
                             c_default = cost.sick + if(arm=="int"){cost.int}else{0})

init_event_list <-
add_tte(arm=c("noint","int"), evts = c("sick","sicker","death") ,input={
  sick <- 0
  sicker <- draw_tte(1,dist="exp",
   coef1=coef_noint, beta_tx = ifelse(arm=="int",HR_int,1),
    seed = random_seed_sicker_i[i])

})

evt_react_list <-
add_reactevt(name_evt = "sick",
             input = {}) %>%
  add_reactevt(name_evt = "sicker",
               input = {
```

```
                modify_item(list(q_default = util.sicker,
                              c_default = cost.sicker + if(arm=="int"){cost.int}else{0},
                                 fl.sick = 0))
              }) %>%
  add_reactevt(name_evt = "death",
              input = {
                modify_item(list(q_default = 0,
                                 c_default = 0,
                                 curtime = Inf))
              })

util_ongoing <- "q_default"
cost_ongoing <- "c_default"


run_sim(arm_list=c("int","noint"),
common_all_inputs = common_all_inputs,
common_pt_inputs = common_pt_inputs,
unique_pt_inputs = unique_pt_inputs,
init_event_list = init_event_list,
evt_react_list = evt_react_list,
util_ongoing_list = util_ongoing,
cost_ongoing_list = cost_ongoing,
npats = 2,
n_sim = 1,
psa_bool = FALSE,
ipd = 1)
```

`run_sim_parallel` *Run simulations in parallel mode (at the simulation level)*

Description

Run simulations in parallel mode (at the simulation level)

Usage

```
run_sim_parallel(
  arm_list = c("int", "noint"),
  sensitivity_inputs = NULL,
  common_all_inputs = NULL,
  common_pt_inputs = NULL,
  unique_pt_inputs = NULL,
  init_event_list = NULL,
  evt_react_list = evt_react_list,
  util_ongoing_list = NULL,
  util_instant_list = NULL,
  util_cycle_list = NULL,
```

```
  cost_ongoing_list = NULL,
  cost_instant_list = NULL,
  cost_cycle_list = NULL,
  other_ongoing_list = NULL,
  other_instant_list = NULL,
  npats = 500,
  n_sim = 1,
  psa_bool = NULL,
  sensitivity_bool = FALSE,
  sensitivity_names = NULL,
  n_sensitivity = 1,
  ncores = 1,
  input_out = NULL,
  ipd = 1,
  timed_freq = NULL,
  debug = FALSE,
  accum_backwards = FALSE,
  continue_on_error = FALSE,
  seed = NULL
)
```

Arguments

`arm_list`	A vector of the names of the interventions evaluated in the simulation
`sensitivity_inputs`	A list of sensitivity inputs that do not change within a sensitivity in a similar fashion to common_all_inputs, etc
`common_all_inputs`	A list of inputs common across patients that do not change within a simulation
`common_pt_inputs`	A list of inputs that change across patients but are not affected by the intervention
`unique_pt_inputs`	A list of inputs that change across each intervention
`init_event_list`	A list of initial events and event times. If no initial events are given, a "Start" event at time 0 is created automatically
`evt_react_list`	A list of event reactions
`util_ongoing_list`	Vector of QALY named variables that are accrued at an ongoing basis (discounted using drq)
`util_instant_list`	Vector of QALY named variables that are accrued instantaneously at an event (discounted using drq)
`util_cycle_list`	Vector of QALY named variables that are accrued in cycles (discounted using drq)

`cost_ongoing_list`	Vector of cost named variables that are accrued at an ongoing basis (discounted using drc)
`cost_instant_list`	Vector of cost named variables that are accrued instantaneously at an event (discounted using drc)
`cost_cycle_list`	Vector of cost named variables that are accrued in cycles (discounted using drc)
`other_ongoing_list`	Vector of other named variables that are accrued at an ongoing basis (discounted using drq)
`other_instant_list`	Vector of other named variables that are accrued instantaneously at an event (discounted using drq)
`npats`	The number of patients to be simulated (it will simulate npats * length(arm_list))
`n_sim`	The number of simulations to run per sensitivity
`psa_bool`	A boolean to determine if PSA should be conducted. If n_sim > 1 and psa_bool = FALSE, the differences between simulations will be due to sampling
`sensitivity_bool`	A boolean to determine if Scenarios/DSA should be conducted.
`sensitivity_names`	A vector of scenario/DSA names that can be used to select the right sensitivity (e.g., c("Scenario_1", "Scenario_2")). The parameter "sens_name_used" is created from it which corresponds to the one being used for each iteration.
`n_sensitivity`	Number of sensitivity analysis (DSA or Scenarios) to run. It will be interacted with sensitivity_names argument if not null (n_sensitivityitivity = n_sensitivity * length(sensitivity_names)). For DSA, it should be as many parameters as there are. For scenario, it should be 1.
`ncores`	The number of cores to use for parallel computing
`input_out`	A vector of variables to be returned in the output data frame
`ipd`	Integer taking value 0 if no IPD data returned, 1 for full IPD data returned, and 2 IPD data but aggregating events
`timed_freq`	If NULL, it does not produce any timed outputs. Otherwise should be a number (e.g., every 1 year)
`debug`	If TRUE, will generate a log file
`accum_backwards`	If TRUE, the ongoing accumulators will count backwards (i.e., the current value is applied until the previous update). If FALSE, the current value is applied between the current event and the next time it is updated. If TRUE, user must use `modify_item` and `modify_item_seq` or results will be incorrect.
`continue_on_error`	If TRUE, on error at patient stage will attempt to continue to the next simulation (only works if n_sim and/or n_sensitivity are > 1, not at the patient level)
`seed`	Starting seed to be used for the whole analysis. If null, it's set to 1 by default.

Details

This function is slightly different from `run_sim`. `run_sim` allows to run single-core. `run_sim_parallel` allows to use multiple-core at the simulation level, making it more efficient for a large number of simulations relative to `run_sim` (e.g., for PSA).

Event ties are processed in the order declared within the `init_event_list` argument (`evts` argument within the first sublist of that object). To do so, the program automatically adds a sequence from to 0 to the (number of events - 1) times 1e-10 to add to the event times when selecting the event with minimum time. This time has been selected as it's relatively small yet not so small as to be ignored by which.min (see .Machine for more details)

A list of protected objects that should not be used by the user as input names or in the global environment to avoid the risk of overwriting them is as follows: c("arm", "arm_list", "categories_for_export", "cur_evtlist", "curtime", "evt", "i", "prevtime", "sens", "simulation", "sens_name_used","list_env","uc_lists","npats","ipd").

The engine uses the L'Ecuyer-CMRG for the random number generator. Note that if ncores > 1, then results per simulation will only be exactly replicable if using run_sim_parallel (as seeds are automatically transformed to be seven integer seeds -i.e, L'Ecuyer-CMRG seeds-) Note that the random seeds are set to be unique in their category (i.e., at patient level, patient-arm level, etc.)

If no `drc` or `drq` parameters are passed within `sensitivity` or `common_all` input lists, these are assigned a default value 0.03 for discounting costs, QALYs and others.

Ongoing items will look backward to the last time updated when performing the discounting and accumulation. This means that the user does not necessarily need to keep updating the value, but only add it when the value changes looking forward (e.g., o_q = utility at event 1, at event 2 utility does not change, but at event 3 it does, so we want to make sure to add o_q = utility at event 3 before updating utility. The program will automatically look back until event 1). Note that in previous versions of the package backward was the default, and now this has switched to forward.

If using `accum_backwards = TRUE`, then it is mandatory for the user to use `modify_item` and `modify_item_seq` in event reactions, as the standard assignment approach (e.g., `a <- 5`) will not calculate the right results, particularly in the presence of conditional statements.

If the `cycle` lists are used, then it is expected the user will declare as well the name of the variable pasted with `cycle_l` and `cycle_starttime` (e.g., c_default_cycle_l and c_default_cycle_starttime) to ensure the discounting can be computed using cycles, with cycle_l being the cycle length, and cycle_starttime being the starting time in which the variable started counting.

`debug = TRUE` will export a log file with the timestamp up the error in the main working directory. Note that using this mode without modify_item or modify_item_seq may lead to inaccuracies if assignments are done in non-standard ways, as the AST may not catch all the relevant assignments (e.g., an assigment like assign(paste("x_",i),5) in a loop will not be identified, unless using modify_item()).

If `continue_on_error` is set to FALSE, it will only export analysis level inputs due to the parallel engine (use single-engine for those inputs) `continue_on_error` will skip the current simulation (so it won't continue for the rest of patient-arms) if TRUE. Note that this will make the progress bar not correct, as a set of patients that were expected to be run is not.

Value

A list of lists with the analysis results

Examples

```
library(magrittr)
common_all_inputs <-add_item(
util.sick = 0.8,
util.sicker = 0.5,
cost.sick = 3000,
cost.sicker = 7000,
cost.int = 1000,
coef_noint = log(0.2),
HR_int = 0.8,
drc = 0.035, #different values than what's assumed by default
drq = 0.035,
random_seed_sicker_i = sample.int(100000,5,replace = FALSE)
)

common_pt_inputs <- add_item(death= max(0.0000001,rnorm(n=1, mean=12, sd=3)))

unique_pt_inputs <- add_item(fl.sick = 1,
                             q_default = util.sick,
                             c_default = cost.sick + if(arm=="int"){cost.int}else{0})

init_event_list <-
add_tte(arm=c("noint","int"), evts = c("sick","sicker","death") ,input={
  sick <- 0
  sicker <- draw_tte(1,dist="exp",
   coef1=coef_noint, beta_tx = ifelse(arm=="int",HR_int,1),
   seed = random_seed_sicker_i[i])

})

evt_react_list <-
add_reactevt(name_evt = "sick",
             input = {}) %>%
  add_reactevt(name_evt = "sicker",
               input = {
                 modify_item(list(q_default = util.sicker,
                              c_default = cost.sicker + if(arm=="int"){cost.int}else{0},
                                  fl.sick = 0))
               }) %>%
  add_reactevt(name_evt = "death",
               input = {
                 modify_item(list(q_default = 0,
                                  c_default = 0,
                                  curtime = Inf))
               })

util_ongoing <- "q_default"
cost_ongoing <- "c_default"


run_sim_parallel(arm_list=c("int","noint"),
common_all_inputs = common_all_inputs,
```

```
common_pt_inputs = common_pt_inputs,
unique_pt_inputs = unique_pt_inputs,
init_event_list = init_event_list,
evt_react_list = evt_react_list,
util_ongoing_list = util_ongoing,
cost_ongoing_list = cost_ongoing,
npats = 2,
n_sim = 1,
psa_bool = FALSE,
ipd = 1,
ncores = 1)
```

`sens_iterator` *Create an iterator based on sens of the current iteration within a scenario (DSA)*

Description

Create an iterator based on sens of the current iteration within a scenario (DSA)

Usage

```
sens_iterator(sens, n_sensitivity)
```

Arguments

`sens`	current analysis iterator
`n_sensitivity`	total number of analyses to be run

Details

In a situation like a DSA, where two (low and high) scenarios are run, sens will go from 1 to n_sensitivity*2. However, this is not ideal as the parameter selector may depend on knowing the parameter order (i.e., 1, 2, 3...), which means resetting the counter back to 1 once sens reaches n_sensitivity (or any multiple of n_sensitivity) is needed.

Value

Integer iterator based on the number of sensitivity analyses being run and the total iterator

Examples

```
sens_iterator(5,20)
sens_iterator(25,20)
```

`summary_results_det` *Deterministic results for a specific treatment*

Description

Deterministic results for a specific treatment

Usage

```
summary_results_det(out = results[[1]][[1]], arm = NULL, wtp = 50000)
```

Arguments

`out`	The final_output data frame from the list object returned by `run_sim()`
`arm`	The reference treatment for calculation of incremental outcomes
`wtp`	Willingness to pay to have INMB

Value

A dataframe with absolute costs, LYs, QALYs, and ICER and ICUR for each intervention

Examples

```
res <- list(list(list(sensitivity_name = "", arm_list = c("int", "noint"
), total_lys = c(int = 9.04687362556945, noint = 9.04687362556945
), total_qalys = c(int = 6.20743830697466, noint = 6.18115138126336
), total_costs = c(int = 49921.6357486899, noint = 41225.2544659378
), total_lys_undisc = c(int = 10.8986618377039, noint = 10.8986618377039
), total_qalys_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), total_costs_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), c_default = c(int = 49921.6357486899, noint = 41225.2544659378
), c_default_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), q_default = c(int = 6.20743830697466, noint = 6.18115138126336
), q_default_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), merged_df = list(simulation = 1L, sensitivity = 1L))))


summary_results_det(res[[1]][[1]],arm="int")
```

`summary_results_sens` *Summary of sensitivity outputs for a treatment*

Description

Summary of sensitivity outputs for a treatment

Usage

```
summary_results_sens(out = results, arm = NULL, wtp = 50000)
```

Arguments

`out`	The list object returned by `run_sim()`
`arm`	The reference treatment for calculation of incremental outcomes
`wtp`	Willingness to pay to have INMB

Value

A data frame with each sensitivity output per arm

Examples

```
res <- list(list(list(sensitivity_name = "", arm_list = c("int", "noint"
), total_lys = c(int = 9.04687362556945, noint = 9.04687362556945
), total_qalys = c(int = 6.20743830697466, noint = 6.18115138126336
), total_costs = c(int = 49921.6357486899, noint = 41225.2544659378
), total_lys_undisc = c(int = 10.8986618377039, noint = 10.8986618377039
), total_qalys_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), total_costs_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), c_default = c(int = 49921.6357486899, noint = 41225.2544659378
), c_default_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), q_default = c(int = 6.20743830697466, noint = 6.18115138126336
), q_default_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), merged_df = list(simulation = 1L, sensitivity = 1L))))


summary_results_sens(res,arm="int")
```

`summary_results_sim` *Summary of PSA outputs for a treatment*

Description

Summary of PSA outputs for a treatment

Usage

```
summary_results_sim(out = results[[1]], arm = NULL, wtp = 50000)
```

Arguments

`out`	The output_sim data frame from the list object returned by `run_sim()`
`arm`	The reference treatment for calculation of incremental outcomes
`wtp`	Willingness to pay to have INMB

Value

A data frame with mean and 95% CI of absolute costs, LYs, QALYs, ICER and ICUR for each intervention from the PSA samples

Examples

```
res <- list(list(list(sensitivity_name = "", arm_list = c("int", "noint"
), total_lys = c(int = 9.04687362556945, noint = 9.04687362556945
), total_qalys = c(int = 6.20743830697466, noint = 6.18115138126336
), total_costs = c(int = 49921.6357486899, noint = 41225.2544659378
), total_lys_undisc = c(int = 10.8986618377039, noint = 10.8986618377039
), total_qalys_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), total_costs_undisc = c(int = 59831.3573929783, noint = 49293.1025437205
), c_default = c(int = 49921.6357486899, noint = 41225.2544659378
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), q_default = c(int = 6.20743830697466, noint = 6.18115138126336
), q_default_undisc = c(int = 7.50117621700097, noint = 7.47414569286751
), merged_df = list(simulation = 1L, sensitivity = 1L))))


summary_results_sim(res[[1]],arm="int")
```

`tte.df` *Example TTE IPD data*

Description

An example of TTE IPD data for the example_ipd file

Usage

```
tte.df
```

Format

`tte.df`**:**

A data frame with 1000 rows and 8 columns:

USUBJID Patient ID

ARMCD, ARM Arm code and variables

PARAMCD, PARAM Parameter

AVAL, AVALCD Values of interest

CNSR Censored observation?

Source

Simulated through FlexsurvPlus package using sim_adtte(seed = 821, rho = 0, beta_1a = log(0.6), beta_1b = log(0.6), beta_pd = log(0.2))

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