

Package ‘WCRBayesDesign’

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Type Package

Title Bayesian Two-Stage Design with Window-Cohort and Controlled Roll-on for Time-to-Event Estimand

Version 1.0.1

Description Calibrates Bayesian two-stage designs for single-arm phase II trials with time-to-event endpoints using a window-cohort with controlled roll-on. Interim monitoring is anchored to a locked interim cohort and a pre-specified follow-up requirement, so analysis timing remains predictable while preserving follow-up maturity. The package searches feasible interim rules, optimizes final sample size and decision thresholds, evaluates operating characteristics by Monte Carlo simulation, and supports exponential, Weibull, log-normal, log-logistic, and user-defined baseline survival models. Related published foundations include Simon (1989) <[doi:10.1016/0197-2456\(89\)90015-9](https://doi.org/10.1016/0197-2456(89)90015-9)> and Cotterill and Whitehead (2015) <[doi:10.1002/sim.6426](https://doi.org/10.1002/sim.6426)>.

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conduct	<i>Bayesian Interim and Final Analysis (Unified Transformed Time Framework)</i>
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Description

Performs Bayesian analysis using the transformed proportional hazards model. By default, observed follow-up times are assumed to be on the original time scale and are transformed internally through the reference survival function S_0 . Transformed times can also be supplied directly.

Usage

```
conduct(
  data,
  current.n,
  nmax,
  tau,
  theta_L,
  a0,
  b0,
  pIA,
  pF,
  S0_dist = c("exp", "weibull", "lognormal", "loglogistic", "custom"),
  S0_par = list(lambda = 0.05),
  S0_fun = NULL,
  time_scale = c("raw", "transformed")
)
```

Arguments

data	A data.frame with columns: <ul style="list-style-type: none"> Time: Observed follow-up time, interpreted according to time_scale. Status: Event indicator (1 = event, 0 = censored).
current.n	Integer. Current number of patients in the analysis.
nmax	Integer. Maximum total sample size.
tau	Numeric. Time horizon used to evaluate survival on the original scale.

theta_L	Numeric. Null-hypothesis survival threshold evaluated at tau.
a0, b0	Numeric. Hyperparameters for the Gamma prior.
pIA, pF	Numeric. Posterior probability thresholds for interim and final analyses.
S0_dist	Character. Baseline survival distribution type.
S0_par	List. Parameters of the baseline survival function.
S0_fun	Function. Baseline survival function (for custom).
time_scale	Character. Time scale supplied in data\$Time: "raw" (default, original follow-up time) or "transformed".

Value

A named list with the following components:

Current.sample.size Integer. The analysis sample size supplied via `current.n`.

Posterior.shape Numeric. Posterior Gamma shape parameter $a_0 + \sum \Delta_i$.

Posterior.rate Numeric. Posterior Gamma rate parameter $b_0 + \sum W_i$, where $W_i = -\log S_0(X_i)$ when `time_scale = "raw"`.

Posterior tail probability (Pr >= threshold) Numeric. Posterior probability $\Pr(\delta \geq \delta_{\text{goal}} \mid \text{data})$ used for the Go/No-Go or efficacy decision.

Posterior mean of survival rate Numeric. Posterior mean of the survival probability at τ , mapped back to the original survival scale via $S_0(\tau)^\delta$.

95% credible interval of survival rate Numeric vector of length 2. Lower and upper bounds of the posterior credible interval for the survival probability at τ .

Decision Character. Interim decision ("Go (Continue)" or "No-Go (Stop for futility)") when `current.n < nmax`, or final decision ("Efficacious" or "Not Efficacious") when `current.n >= nmax`.

Examples

```
dat <- data.frame(Time = c(5, 10, 15, 8, 20), Status = c(1, 0, 1, 1, 0))
conduct(dat, current.n = 5, nmax = 30, tau = 24, theta_L = 0.62,
        a0 = 0.01, b0 = 0.01, pIA = 0.5, pF = 0.05,
        S0_dist = "weibull", S0_par = list(k = 1.2, lambda = 0.08))
```

delta_from_theta_goal *Convert target EFS goal to delta parameter under proportional hazards model*

Description

Converts a target event-free survival (EFS) probability at a given time τ to the corresponding δ_{goal} parameter under the proportional hazards assumption, where $S(t) = S_0(t)^\delta$.

Usage

```
delta_from_theta_goal(theta_goal, tau, S0_fun, S0_par = NULL)
```

Arguments

theta_goal	Numeric. Target EFS probability at time τ .
tau	Numeric. Follow-up time at which the EFS probability is defined.
S0_fun	Function. Reference survival function returning values in (0, 1].
S0_par	List. Parameters passed to S0_fun.

Details

This function is used to translate a survival probability goal into the corresponding delta threshold under the transformed model framework.

Value

A numeric value giving the corresponding δ_{goal} .

Examples

```
# Example: Convert an EFS goal of 0.62 at tau = 24
delta_from_theta_goal(
  theta_goal = 0.62,
  tau = 24,
  S0_fun = S0_weibull,
  S0_par = list(k = 1.2, lambda = 0.08)
)
```

find_Nw_pIA

Search for feasible interim analysis thresholds (Unified Framework)

Description

Performs grid search over interim sample sizes (N_w) and time offsets (X), identifying feasible posterior probability thresholds (p_{IA}) for early futility stopping. Uses unified transformed time framework.

Usage

```
find_Nw_pIA(
  tau,
  theta_L,
  theta_alt,
  alpha_target,
  beta_target,
```

```

    rate,
    X_grid,
    num_grid = 20,
    p_H0 = 0.4,
    p_H1 = 0.1,
    nsim = 10000,
    S0_dist = c("exp", "weibull", "lognormal", "loglogistic", "custom"),
    a0 = 0.01,
    b0 = 0.01,
    S0_par = list(lambda = 0.05),
    S0_fun = NULL,
    pIA_grid = seq(0.01, 0.99, by = 0.01),
    seed = 1234,
    method = "landmark",
    drop_na = TRUE
  )

```

Arguments

tau	Numeric. Maximum follow-up time.
theta_L	Numeric. Target EFS probability at tau under H0.
theta_alt	Numeric. EFS probability at tau under H1.
alpha_target, beta_target	Numeric. Target Type I/II error rates.
rate	Numeric. Accrual rate (patients per unit time).
X_grid	Numeric vector. Offset times after enrollment of N_w-th patient.
num_grid	Integer. Number of grid points for N_w search.
p_H0, p_H1	Numeric. Required early stopping probabilities.
nsim	Integer. Number of Monte Carlo simulations per (N_w, X).
S0_dist	Character. Baseline survival distribution type.
a0, b0	Numeric. Hyperparameters for Gamma prior.
S0_par	List. Parameters for S0 distribution.
S0_fun	Function. Custom S0 function (optional).
pIA_grid	Numeric vector. Grid of candidate pIA thresholds.
seed	Integer. Random seed.
method	Character. Analysis method controlling administrative censoring: "hr" (proportional hazards, relaxed follow-up to calendar horizon) or "landmark" (strict landmark censoring, each subject capped at τ). Default is "landmark".
drop_na	Logical. Remove rows with no feasible pIA.

Value

A data frame with one row per candidate (N_w, X) pair and the following columns:

Nw Integer. Interim-stage enrollment target used to trigger the waiting window.

X Numeric. Additional waiting time after enrollment of the N_w -th subject before the interim analysis.

pIA Numeric. Smallest feasible futility threshold identified on pIA_grid for this (N_w, X) combination.

piF_H0 Numeric. Estimated probability under H_0 that the trial stops for futility at interim using the selected pIA.

piF_H1 Numeric. Estimated probability under H_1 that the trial stops for futility at interim using the selected pIA.

Rows with no feasible pIA are removed when drop_na = TRUE.

Examples

```
find_Nw_pIA(
  tau = 24, theta_L = 0.62, theta_alt = 0.80,
  alpha_target = 0.05, beta_target = 0.20,
  rate = 5/12, X_grid = c(1, 2),
  nsim = 500, S0_dist = "exp",
  seed = 123
)
```

oc_two_stage

Evaluate operating characteristics for two-stage adaptive survival designs (Unified Framework)

Description

Simulates operating characteristics (OC) using unified transformed time framework. All internal calculations use transformed times. Output times are reported in original scale.

Time Metrics (all in original time scale):

- E_time_IA_H0/H1: Expected time to interim analysis (unconditional mean, always occurs).
- E_time_FA_H0/H1: Expected time to final analysis **conditional on reaching FA** (i.e., mean over trials that did not stop early at IA).
- E_follow_H0: Expected total follow-up time under H0 (in original time scale).

Usage

```
oc_two_stage(
  N,
  Nw,
  X,
  pIA,
  pF,
  rate,
```

```

    tau,
    theta_L,
    theta_alt,
    a0,
    b0,
    nsim = 2000,
    S0_dist = c("exp", "weibull", "lognormal", "loglogistic", "custom"),
    S0_par = list(lambda = 0.05),
    S0_fun = NULL,
    S0_inv_fun = NULL,
    seed = NULL,
    method = "landmark"
)

```

Arguments

N	Integer. Total sample size.
Nw	Integer. Number of patients enrolled before interim analysis.
X	Numeric. Additional time after enrollment of N_w-th subject before IA.
pIA	Numeric. Posterior probability threshold for futility at IA.
pF	Numeric. Posterior probability threshold for efficacy at FA.
rate	Numeric. Accrual rate (patients per unit time).
tau	Numeric. Maximum follow-up duration per subject.
theta_L	Numeric. Event-free survival probability at tau under H0.
theta_alt	Numeric. Event-free survival probability at tau under H1.
a0, b0	Numeric. Prior hyperparameters for Gamma posterior.
nsim	Integer. Number of Monte Carlo simulation replicates.
S0_dist	Character. Baseline survival distribution type.
S0_par	List. Parameters for S0 distribution.
S0_fun	Function. Custom S0 function (optional).
S0_inv_fun	Function. Inverse baseline survival function for S0_dist = "custom". If omitted, S0_par\$inv_fun is used.
seed	Integer or NULL. Random seed for reproducibility.
method	Character. Analysis method controlling administrative censoring: "hr" (proportional hazards, relaxed follow-up to calendar horizon) or "landmark" (strict landmark censoring, each subject capped at τ). Default is "landmark".

Value

A named list with estimated operating characteristics:

alpha Numeric. Estimated Type I error under H_0 .

power Numeric. Estimated power under H_1 .

ESP_H0 Numeric. Early stopping probability at interim under H_0 .

- ESP_H1** Numeric. Early stopping probability at interim under H_1 .
- ESS_H0** Numeric. Expected total number of enrolled subjects under H_0 , accounting for interim stopping.
- E_event_H0** Numeric. Expected number of observed events under H_0 .
- E_event_H1** Numeric. Expected number of observed events under H_1 .
- E_follow_H0** Numeric. Expected total observed follow-up under H_0 , on the original time scale.
- max_n_total_H0** Numeric. Maximum realized sample size under H_0 .
- mean_n_between** Numeric. Mean number of subjects enrolled between the N_w -th enrollment and the interim analysis under H_0 .
- median_n_between** Numeric. Median number of subjects enrolled between the N_w -th enrollment and the interim analysis under H_0 .
- mean_fu_between** Numeric. Mean observed follow-up, on the original time scale, among subjects enrolled between the N_w -th enrollment and the interim analysis under H_0 .
- median_fu_between** Numeric. Median observed follow-up, on the original time scale, among subjects enrolled between the N_w -th enrollment and the interim analysis under H_0 .
- E_time_IA_H0** Numeric. Expected calendar time to the interim analysis under H_0 .
- E_time_FA_H0** Numeric or NA. Expected calendar time to the final analysis under H_0 , conditional on reaching final analysis.
- E_time_IA_H1** Numeric. Expected calendar time to the interim analysis under H_1 .
- E_time_FA_H1** Numeric or NA. Expected calendar time to the final analysis under H_1 , conditional on reaching final analysis.

Examples

```
oc_two_stage(
  N = 40, Nw = 20, X = 2, pIA = 0.5, pF = 0.05,
  rate = 5/12, tau = 24, theta_L = 0.62, theta_alt = 0.80,
  a0 = 0.01, b0 = 0.01, nsim = 500,
  S0_dist = "exp", seed = 123
)
```

run_two_stage_trial *Run Two-Stage Bayesian Single-Arm Survival Trial Simulation*

Description

Simulates a two-stage Bayesian adaptive single-arm survival trial. Performs an interim analysis after the first-stage sample (N_w) and decides whether to continue to the final analysis (N_{max}) based on a Bayesian posterior decision rule.

Usage

```
run_two_stage_trial(
  seed = NULL,
  tau,
  theta_L,
  theta_true,
  a0 = 0.01,
  b0 = 0.01,
  rate,
  Nw,
  Nmax,
  X,
  pIA,
  pF,
  dist = c("exp", "weibull", "lognormal", "loglogistic"),
  dist_par = list(lambda = 0.05, k = 1.2),
  model = "exp",
  method = "landmark",
  verbose = TRUE
)
```

Arguments

seed	Integer. Random seed for reproducibility.
tau	Numeric. Time horizon (τ) for evaluating survival.
theta_L	Numeric. Null-hypothesis survival threshold at τ .
theta_true	Numeric. True underlying survival probability at τ .
a0, b0	Numeric. Hyperparameters for Gamma(a_0 , b_0) prior.
rate	Numeric. Accrual rate parameter (exponential inter-arrival times).
Nw	Integer. Interim-stage sample size.
Nmax	Integer. Maximum (final) sample size.
X	Numeric. Additional follow-up time window for interim analysis.
pIA, pF	Numeric. Posterior probability thresholds for interim and final decisions.
dist	Character. Distribution for generating event times. One of: <ul style="list-style-type: none"> "exp": Exponential with rate λ. "weibull": Weibull with shape k and rate λ. "lognormal": Log-normal with meanlog μ, sdlog σ. "loglogistic": Log-logistic with shape k, rate λ.
dist_par	List. Parameters for the chosen event-time distribution.
model	Deprecated. Retained for backward compatibility and ignored. Analysis always uses the unified transformed-time framework.
method	Character. Analysis method controlling administrative censoring: "hr" (proportional hazards, relaxed follow-up) or "landmark" (strict landmark censoring, each subject capped at τ). Default is "landmark".

- method = "landmark": strict censoring.
 - Interim analysis: follow-up cannot exceed the design horizon τ .
 - Final analysis: each subject is administratively censored at τ from randomization (patient-level horizon).
 - method = "hr": relaxed censoring.
 - Interim analysis: the maximum follow-up available by the interim calendar time, without truncation at τ .
 - Final analysis: the trial ends at $t_{final} = a_{(N)} + \tau$, where $a_{(N)}$ is the accrual time of the last enrolled subject; each subject is then censored at $f_i = t_{final} - a_i$.
- verbose Logical. If TRUE, emit progress messages during simulation. Set to FALSE to suppress console output.

Details

The function simulates accrual and event times for all N_{max} patients, performs an interim analysis using the first N_w patients, and, if the posterior probability is below p_{IA} , continues to final analysis. At the final stage, all patients (including interim ones) are followed up to τ and analyzed again using the same Bayesian decision rule.

The internal analysis relies on the `conduct()` function for posterior inference.

Value

A named list describing one simulated trial trajectory:

data_interim Data frame for the interim analysis cohort. Columns are Time (observed raw follow-up), Status (event indicator), and Time_transformed (reference transformed time for the same records).

data_final Data frame for the final analysis cohort, with the same columns as `data_interim`, or NULL if the trial stopped at interim.

result_interim Named list returned by `conduct()` for the interim analysis.

result_final Named list returned by `conduct()` for the final analysis, or NULL if the trial stopped at interim.

accrual_times Numeric vector of calendar enrollment times for all simulated subjects.

event_times Numeric vector of true event times generated under the chosen data-generating distribution.

method Character. Administrative censoring method actually used in the simulation ("landmark" or "hr").

Examples

```
run_two_stage_trial(
  seed = 123,
  tau = 12,
  theta_L = 0.4,
  theta_true = 0.6,
  a0 = 0.01, b0 = 0.01,
```

```

rate = 0.5,
Nw = 20, Nmax = 40,
X = 3,
pIA = 0.2, pF = 0.05,
dist = "weibull",
dist_par = list(k = 1.2, lambda = 0.08),
method = "landmark",
verbose = FALSE
)

```

S0_inverse

Inverse of baseline survival function S_0

Description

Computes the inverse of the baseline survival function S_0 . Given a survival probability S , returns the time t such that $S_0(t) = S$.

Usage

```

S0_inverse(
  surv_prob,
  dist = c("exp", "weibull", "lognormal", "loglogistic", "custom"),
  par
)

```

Arguments

surv_prob	Numeric vector. Survival probability values (between 0 and 1).
dist	Character. Distribution type: "exp", "weibull", "lognormal", "loglogistic", or "custom".
par	List. Parameters for the distribution: <ul style="list-style-type: none"> • For "exp": list(lambda) • For "weibull": list(k, lambda) (shape and rate; $S_0(t) = \exp\{-(\lambda t)^k\}$) • For "lognormal": list(meanlog, sdlog) • For "loglogistic": list(k, lambda) (shape and rate) • For "custom": list(inv_fun) where inv_fun is a function(S) returning t

Value

Numeric vector of times corresponding to the survival probabilities.

Examples

```
# Exponential
S0_inverse(0.5, "exp", list(lambda = 0.1))

# Weibull
S0_inverse(c(0.8, 0.5), "weibull", list(k = 1.2, lambda = 0.08))
```

S0_weibull	<i>Weibull reference survival function</i>
------------	--

Description

Computes the Weibull reference survival function $S_0(t) = \exp\{-(\lambda t)^k\}$ for given shape and rate parameters.

Usage

```
S0_weibull(t, k, lambda)
```

Arguments

t	Numeric vector of time points.
k	Numeric. Shape parameter of the Weibull distribution.
lambda	Numeric. Rate parameter of the Weibull distribution (reciprocal of the conventional scale; larger values imply shorter survival).

Details

This function can be used as a baseline survival model within the transformed analysis framework. It is also directly accessible to users for defining custom reference survival functions.

Value

A numeric vector of survival probabilities $S_0(t)$.

Examples

```
S0_weibull(c(0, 5, 10), k = 1.2, lambda = 0.08)
```

stats_transformed *Compute transformed statistics for survival data*

Description

Computes the sufficient statistics (d, U) used in the transformed survival model framework, where:

- $d = \sum \Delta_i$ is the total number of observed events, and
- $U = \sum -\log(S_0(X_i))$ is the cumulative transformed time using the reference survival function $S_0(t)$.

Usage

```
stats_transformed(X, Delta, S0_fun, S0_par)
```

Arguments

X	Numeric vector. Observed follow-up times from enrollment.
Delta	Integer or logical vector. Event indicator (1 = event, 0 = censored).
S0_fun	Function. Baseline survival function that returns values in (0, 1].
S0_par	List. Parameters passed to S0_fun.

Details

This function allows users to derive model-specific posterior parameters for transformed analyses, given observed follow-up times and event indicators.

Value

A named list with components:

- d** Integer. Total number of observed events $d = \sum \Delta_i$.
- U** Numeric. Total transformed follow-up $U = \sum -\log\{S_0(X_i)\}$. This is the exposure term that enters the Gamma posterior update for δ .

Examples

```
# Example with Weibull baseline
times <- c(5, 8, 12)
events <- c(1, 0, 1)
stats_transformed(times, events, S0_fun = S0_weibull, S0_par = list(k = 1.2, lambda = 0.08))
```

```
two_stage_optimize_design
```

Optimize two-stage adaptive survival design

Description

Searches for optimal two-stage adaptive survival designs based on simulated operating characteristics and user-defined optimality criteria.

Usage

```
two_stage_optimize_design(
  NwX_pIA_results,
  rate,
  tau,
  theta_L,
  theta_alt,
  a0,
  b0,
  alpha_target,
  beta_target,
  nsim = 2000,
  S0_dist = c("exp", "weibull", "lognormal", "loglogistic", "custom"),
  S0_par = list(lambda = 0.05),
  S0_fun = NULL,
  S0_inv_fun = NULL,
  tol = 0.01,
  max_iter = 25,
  pF_lo = 0.01,
  pF_hi = 0.99,
  ncores = max(1, parallel::detectCores() - 1),
  seed = 1234,
  optimize = c("followup", "ESS", "minimax"),
  method = "landmark",
  verbose = TRUE
)
```

Arguments

<code>NwX_pIA_results</code>	Data frame. Output from <code>find_Nw_pIA()</code> , containing columns <code>Nw</code> , <code>X</code> , and <code>pIA</code> .
<code>rate</code>	Numeric. Accrual rate (patients per unit time).
<code>tau</code>	Numeric. Maximum follow-up duration per subject.
<code>theta_L</code>	Numeric. Event-free survival probability at τ under H_0 .
<code>theta_alt</code>	Numeric. Event-free survival probability at τ under H_1 .
<code>a0, b0</code>	Numeric. Prior hyperparameters for the Gamma posterior.

alpha_target	Numeric. Target Type I error rate.
beta_target	Numeric. Target Type II error rate.
nsim	Integer. Number of Monte Carlo simulations per candidate design.
S0_dist	Character. Baseline survival distribution type.
S0_par	List. Parameters passed to S0_fun.
S0_fun	Function. Reference survival function (used when method = "trans").
S0_inv_fun	Function. Inverse baseline survival function for S0_dist = "custom". If omitted, S0_par\$inv_fun is used.
tol	Numeric. Tolerance for the binary search over final posterior thresholds.
max_iter	Integer. Maximum number of iterations during binary search.
pF_lo, pF_hi	Numeric. Lower and upper bounds for searching final posterior threshold.
ncores	Integer. Number of CPU cores for parallel computation.
seed	Integer. Random seed for reproducibility.
optimize	Character. Criterion used to select the optimal design: "followup" Minimize expected total follow-up time under H0 (default). "ESS" Minimize expected sample size under H0. "minimax" Minimize maximum realized sample size under H0.
method	Character. Analysis method controlling administrative censoring: "hr" (proportional hazards, relaxed follow-up to calendar horizon) or "landmark" (strict landmark censoring, each subject capped at τ). Default is "landmark". <ul style="list-style-type: none"> • method = "landmark": strict censoring. <ul style="list-style-type: none"> – Interim analysis: follow-up cannot exceed the design horizon τ. – Final analysis: each subject is administratively censored at τ from randomization (patient-level horizon). • method = "hr": relaxed censoring. <ul style="list-style-type: none"> – Interim analysis: the maximum follow-up available by the interim calendar time, without truncation at τ. – Final analysis: the trial ends at $t_{final} = a_{(N)} + \tau$, where $a_{(N)}$ is the accrual time of the last enrolled subject; each subject is then censored at $f_i = t_{final} - a_i$.
verbose	Logical. Whether to print progress messages.

Details

The function evaluates candidate combinations of interim sample size (N_w), offset time (X), and total sample size (N) using Monte Carlo simulation, and identifies the design that satisfies Type I / II error constraints while minimizing a specified optimization criterion.

Each candidate design is simulated using `oc_two_stage()`. For each combination of N_w , X , and N , the function performs a binary search over the final posterior threshold pF to satisfy:

$$\text{power} \geq 1 - \beta_{\text{target}}, \quad \alpha \leq \alpha_{\text{target}}.$$

The design with the smallest selected optimization metric under H0 is reported as optimal.

Seed consistency with `find_Nw_pIA()`: For each (N_w, X) combination, the seed passed to `oc_two_stage()` is derived as `seed + Nw * 997L + round(X * 1000) * 13L`, matching the sub-seed formula used in `find_Nw_pIA()`. This ensures that the early stopping probability (`ESP_H0`) reported here is comparable to the `piF_H0` from `find_Nw_pIA()` when the same seed is used. To reproduce the OC of the best design independently, call `oc_two_stage(..., seed = best$seed_used)`.

Value

A list with two components:

- all** Data frame of all evaluated candidate designs. Each row corresponds to one feasible combination of (N_w, X, p_{IA}, N, p_F) together with its simulated operating characteristics. Columns include design parameters (`Nw`, `X`, `pIA`, `N`, `pF`), reproducibility metadata (`seed_used`), error-rate summaries (`alpha`, `power`, `ESP_H0`, `ESP_H1`), resource summaries (`ESS_H0`, `E_event_H0`, `E_event_H1`, `E_follow_H0`, `max_n_total_H0`), interim-gap summaries (`mean_n_between`, `median_n_between`, `mean_fu_between`, `median_fu_between`), calendar-time summaries (`E_time_IA_H0`, `E_time_FA_H0`, `E_time_IA_H1`, `E_time_FA_H1`), and a logical feasibility flag `feasible`.
- best** One-row data frame giving the optimal feasible design under the requested optimize criterion. This row has the same columns as `all`. Pass `best$seed_used` back to `oc_two_stage()` to reproduce the reported operating characteristics exactly. Returns `NULL` if no feasible design is found.

Examples

```
res_pIA <- find_Nw_pIA(
  tau = 24, theta_L = 0.62, theta_alt = 0.80,
  alpha_target = 0.05, beta_target = 0.20,
  rate = 5/12, X_grid = 1,
  num_grid = 3, nsim = 100,
  pIA_grid = seq(0.1, 0.9, by = 0.2),
  S0_dist = "exp", seed = 123
)

opt <- two_stage_optimize_design(
  NwX_pIA_results = res_pIA,
  rate = 5/12, tau = 24,
  theta_L = 0.62, theta_alt = 0.80,
  a0 = 0.01, b0 = 0.01,
  alpha_target = 0.05, beta_target = 0.20,
  nsim = 100, S0_dist = "exp",
  optimize = "ESS",
  ncores = 1, seed = 123, verbose = FALSE
)
opt$best
```

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