Package 'NAPrior'

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Title Network Meta-Analytic Predictive Prior for Mid-Trial SoC Changes

Version 0.2.0

Description Implements the Network meta-Analytic Predictive (NAP) prior framework to accommodate changes in the standard of care (SoC) during ongoing randomized controlled trials (RCTs). The method synthesizes pre- and post-change in-trial data by leveraging external evidence, particularly head-to-head trials comparing the original and new standards of care, to bridge the two evidence periods and enable principled borrowing. The package provides utilities to construct NAP-based priors and perform Bayesian inference for time-to-event endpoints using summarized trial evidence.

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NAP_oc *Simulation for operating-characteristics applying NAP-based priors*

Description

Runs Monte Carlo simulations of an E vs C2 trial and performs Bayesian analysis with a NAP-based prior constructed by NAP_prior(). The routine supports both single external study setting and multiple external studies settings as encoded in the provided NAP_prior object, and works with either a fixed mixture weight (mNAP) or an elastic, data-adaptive weight (eNAP).

Usage

```
NAP_oc(
  NAP_prior = NULL,
  theta_EC2 = 0,
  n_EC2 = 200,
  lambda = 2,
  sim_model = c("Exponential", "Weibull"),
  model_param = 0.05,
  iter = 2000,
  chains = 4,
  seed = 123,
  nsim = 100,
  jags_model = NULL
)
```

Arguments

NAP_prior	An object returned by NAP_prior() that contains the prior specification and (for eNAP) any calibrated tuning parameters a, b.
theta_EC2	Numeric scalar. True log-hazard ratio for E vs C2 used to generate the direct trial data.
n_EC2	Integer. Total sample size for the simulated E vs C2 trial.
lambda	Numeric scalar > 0. Randomization ratio E:C2; e.g., lambda = 2 means 2:1 allocation to E:C2.
sim_model	Character string. Event-time model used to simulate individual times; one of "Exponential" or "Weibull".
model_param	Named numeric vector for the baseline hazard of the control arm. For sim_model = "Exponential", use c(rate = ...). For sim_model = "Weibull", use c(shape = ..., rate = ...).
iter	Integer. Total MCMC iterations per chain for JAGS (default 2000).
chains	Integer. Number of MCMC chains (default 4).
seed	Integer. Random seed for the simulation replicates.
nsim	Integer. Number of Monte Carlo replicates (default 100).

jags_model	Either a length-1 character string containing JAGS model code (e.g., a packaged object such as jags_model_RE) or a file path to a .txt JAGS model. If NULL, a default FE/RE model is chosen to match the NAP_prior mode.

Value

A data frame with one row per replicate containing:

- post_mean, post_sd, low95, hi95 — posterior mean, SD, and 95\
- prob_E_better — posterior probability theta_{E,C2} < 0.
- prior_weight, post_weight — prior and updated weights used in the mixture (for eNAP, prior_weight is w(Z)).
- sigma_hat — posterior mean of between-study SD (RE only; NA for FE).

NAP_posterior *Conduct posterior inference with NAP-based priors*

Description

Draw posterior via MCMC (JAGS) with derived NAP priors from NAP_prior function both setting (one external trial/multiple external trials) and NAP method (NAP/mNAP/eNAP) will be determined by the provided NAP_prior object. If using eNAP, make sure the tuning parameter used to derive NAP_prior are calibrated by tune_param_eNAP function.

Usage

```
NAP_posterior(
  NAP_prior = NULL,
  y_EC2,
  s_EC2,
  iter = 2000,
  chains = 4,
  model = NULL
)
```

Arguments

NAP_prior	An object returned by NAP_prior() containing the full the NAP prior (and if eNAP without assumed direct effects, calibrated tuning parameters (a,b))
y_EC2	Numeric scalar. Direct estimate y_{EC2} (e.g., log-HR) for E vs $C2$.
s_EC2	Positive numeric scalar. Sampling variance s^2_{EC2} for y_{EC2}.
iter	Total MCMC iterations per chain (default 2000).
chains	Number of MCMC chains (default 4).
model	Either a length-1 character string containing JAGS model code or a path to a JAGS model file. If NULL, a package default will be used.

Value

A list of class "NAP_posterior_result" with elements:

- posterior_sum: data frame with posterior summaries for $\theta_{E,C2}$ (mean, sd, 95\ weights (prior_weight, post_weight).
- enap_prior: For eNAP only: data frame describing the eNAP prior with calculated data-dependent weight: columns for NAP (Informative) and Vague, rows for Mixing Weight, Mean, Variance, and ESS (events) if available.
- jags_fit: the R2jags fit object.

#'

Examples

```
# Create a NAP_prior object
my_naprior <- NAP_prior(
  weight_mtd = "fixed", w = 0.50,       # fixed mixture weight
  y_EC1  = -0.36, s_EC1  = 0.16^2,
  y_C2C1 = -0.30, s_C2C1 = 0.14^2,      # single external trial
  tau0   = 1000
)

# Calculate posterior
out <- NAP_posterior(
  NAP_prior = my_naprior,
  y_EC2 = -0.20, s_EC2 = 0.18^2,
  iter = 1000, chains = 2
)
out$posterior_sum
out$enap_prior
```

NAP_prior *NAP_prior: Derive NAP/mNAP/eNAP priors*

Description

Builds the informative NAP component (mean/variance from the indirect path) and the vague component, and reports the mixing weight depending on the mode:

- weight_mtd = "fixed": use the supplied fixed weight w in [0,1].
- weight_mtd = "adaptive" (eNAP): if y_EC2 is provided, compute the data-dependent weight via the elastic link; otherwise, print a formula note.

Derive NAP-based prior (s) based on indirect evidence

Derive the NAP-based posteriors with provided summary statistics on indirect evidence edges By default, the function assumes a vague component is desired, as a result, to obtain NAP/mNAP/eNAP:

- *NAP* Set `weight_mtd="fixed"` and `w=1`, use the NAP (informative component) column results
- *mNAP* Set `weight_mtd="fixed"` and `w` as pre-specified fixed weight. The resulting mNAP is $w\pi_{NAP} + (1-w)\pi_0$
- *eNAP* Set `weight_mtd="adaptive"` and provide calibrated `a` and `b` as from tune_param_eNAP function, then either: 1). Provide assumed value for `y_EC2` and `s_EC2` (i.e., as for sample size calculation): return a calculated dynamic weight $w(Z)$, the resulting eNAP is then $w(Z)\pi_{NAP} + (1-w(Z))\pi_0$; OR 2). Leave `y_EC2` and `s_EC2` as NULL, return the NAP (informative component) and Vague component, with description for protocol reference

Usage

```
NAP_prior(
  weight_mtd = c("adaptive", "fixed"),
  w = NULL,
  a = NULL,
  b = NULL,
  y_EC2 = NULL,
  s_EC2 = NULL,
  y_EC1,
  s_EC1,
  y_C2C1,
  s_C2C1,
  mu0 = 0,
  tau0 = 1000,
  lambda = 1,
  sigma2_hat = NULL
)
```

Arguments

`weight_mtd`	Either `"adaptive"` (eNAP) or `"fixed"` (NP/NAP/mNAP).
`w`	Fixed prior weight in [0,1]; **required only** if `weight_mtd="fixed"`. Ignored otherwise. `0<w<1` infers mixture NAP; `w=0` infers NP; `w=1` infers NAP.
`a, b`	eNAP tuning parameters; **required only** if `weight_mtd="adaptive"` (`a<0` and `b>0`). Ignored in fixed mode.
`y_EC2, s_EC2`	Log-HR and SE for $E:C2$ (Current trial post-SoC change).
`y_EC1, s_EC1`	Log-HR and SE for $E:C1$ (Current trial pre-SoC change).
`y_C2C1, s_C2C1`	Historical C2 vs. C1 trial Log-HRs and SEs.
`mu0, tau0`	mean and variance of the vague component (default sqrt(1000)).
`lambda`	Randomization ratio (default 1).
`sigma2_hat`	Positive scalar, required only for multiple external trials setting, leave blank if use default REML estimate, otherwise provide user-specified value

Details

This function automatically selects one external trial vs multiple external trials setting:

- One external trial if `length(y_C2C1) == 1 & length(s_C2C1)==1` (one external trial).
- Multiple external trials if `length(y_C2C1) > 1 & length(s_C2C1)==length(y_C2C1)`. By default uses `metafor::rma.uni(..., method="REML")` to obtain REML estimate; Otherwise please provide `sigma2_hat`

Value

Displays the NAP prior as a mixture of an informative prior (constructed based on the indirect evidence path) and a vague prior.

An object of class "NAPrior" (data.frame + attributes).

Examples

```
## ------------------------------------------------------------
## Example 1: One external trial setting with fixed mixing weight of 0.5 (mNAP)
## ------------------------------------------------------------
mNAP_test1 <- NAP_prior(
  weight_mtd = "fixed", w = 0.50,                  # fixed mixture weight
  y_EC1  = -0.36, s_EC1  = 0.16^2,
  y_C2C1 = -0.30, s_C2C1 = 0.14^2,                  # single external trial
  tau0   = 1000
)
print(mNAP_test1)
plot(mNAP_test1)

## ------------------------------------------------------------
## Example 2: RE case (multiple historical), ADAPTIVE weight
## ------------------------------------------------------------
eNAP_test1 <- NAP_prior(
  weight_mtd = "adaptive",
  a = -2, b = 10,            # from calibration
  y_EC1  = -0.36, s_EC1  = 0.16^2,                 # E:C1 (current, pre-change)
  y_C2C1 = c(-0.28, -0.35, -0.31),                 # C2:C1 (external trials)
  s_C2C1 = c(0.12^2, 0.11^2, 0.15^2),
  tau0   = 1000                                     # vague variance
)
print(eNAP_test1)
```

`post_w` *Posterior mixture weight calculation*

Description

Computes posterior updated mixture weights for a two-component normal–normal model using the standard logit-additive update. The *prior* mixing weight is either a fixed weight $w \in (0, 1)$ or a dynamic mixing weight as for eNAP prior: $Z = n_{eff}^{-1/4}|y_{\text{dir}} - y_{\text{ind}}|/s_{\text{link}}$: where, $n_{eff} = s_{\text{link}}^{-1}$ $w_(Z) = 1/exp(a + b\log(Z + 1)), \quad a < 0,\ b > 0.$

Usage

```
post_w(
  w,
  a,
  b,
  s_EC2,
  s_EC1,
  s_C2C1,
  y_EC2,
  y_EC1 = -0.5,
  y_C2C1 = -0.5,
  tau0 = 1000,
  mu0 = 0,
  eps = 1e-12
)
```

Arguments

w	Scalar. If w > 1, use the ADAPTIVE branch (logistic prior on log-Z). If 0 < w < 1, use a fixed prior weight equal to w.
a, b	Parameters used in the elastic function for dynamic mixing weight. Must satisfy a < 0 and b > 0.
s_EC2, s_EC1, s_C2C1	Sampling variances for direct evidence (E vs. C2 trial), and edges of indirect evidence (E vs. C1 trial and C2 vs. C1 trial).
y_EC2, y_EC1, y_C2C1	Estimated log-HR for E vs. C2 tria, E vs. C1 trial, C2 vs. C1 trial, respectively
mu0, tau0	Mean and variance for the vague component.
eps	Numeric scalar used for small-value clipping (default 1e-12).

Details

- **Fixed prior mixing weight (Robust NMAP Prior):** requires 0 < w < 1.
- **Adaptive branch (Adaptive NMAP Prior):** triggered by w > 1, requires a<0 and b > 0. This corresponds to a decreasing prior weight as the inconsistency grows.
- All variance/SD arguments may be given as scalars or vectors; scalars are recycled.

Value

A numeric vector of posterior weights in (0,1) reflecting realized borrowing fraction of the informative component.

Examples

```
y_EC2  <- -0.5; y_EC1  <- -0.8; y_C2C1 <- -0.3
s_EC2 <- 0.2; s_EC1 <- 0.18; s_C2C1 <- 0.18
```

```
# Fixed mixing weight 0.5
post_w(w = 0.5, a = NA, b = NA,s_EC2,s_EC1,s_C2C1,
       y_EC2,y_EC1,y_C2C1)

# Dynamic weight with elastic function of (a=-4.6, b=3):
post_w(w = 2, a = -2.5, b = 10,s_EC2,s_EC1,s_C2C1,
       y_EC2,y_EC1,y_C2C1)
```

`tune_param_eNAP` *Calibrate (a, b) for eNAP prior*

Description

Calibrates the tuning parameters (a, b) of the elastic NAP prior. This function supports both the one external trial setting and multiple external trials setting:

- *Single external trial* provide y_C2C1 and s_C2C1 as scalars.
- *Multiple external trials* provide y_C2C1 and s_C2C1 as vectors of same lengths. by default the cross-trial variance will be automatically calculated by REML, otherwise please provide the cross-trial variance as input parameter: sigma2_hat

Usage

```
tune_param_eNAP(
  s_EC2,
  s_EC1,
  s_C2C1,
  tau0 = 1000,
  delta = 0.5,
  t1 = 0.999,
  t0 = 0.05,
  clip_a = c(-5, -0.5),
  clip_b = c(1e-05, 50),
  exact = FALSE,
  y_EC1 = -0.5,
  y_C2C1 = -0.5,
  mu0 = 0,
  sigma2_hat = NULL,
  verbose = FALSE
)
```

Arguments

`s_EC2, s_EC1, s_C2C1`
: Sampling variances for post-SoC change period (E vs. C2), pre-SoC change period of current trial (E vs. C1 trial) and external trial (C2 vs. C1 trial)

delta	Positive scalar; Clinically significant difference on the log-HR scale such that direct and indirect evidence should be considered as strongly inconsistent.
t1, t0	Positive scalar; Calibration targets at consisntency and strongly inconsistency: $w'(0) = t1$ (near 1; default 0.99), $w'(\delta) = t0$ (near 0; default 0.05).
clip_a, clip_b	Numeric Vector of Legnth 2: Minimum and maximum caps for tuning parameters (a,b), by default clip_a=(-5,0.5) and clip_b=(0,50)
exact	Logical (TRUE/FALSE); If TRUE, require the exact solution for parameter (a,b), which further requires more parameters input
y_EC1, y_C2C1	Log-HR for pre-SoC change period and external trial, required only if exact=TRUE
mu0, tau0	Mean and variance for the vague component, by default mu0=0 and tau0=1000.
sigma2_hat	Positive scalar, required only for multiple external trials setting, leave blank if use default REML estimate, otherwise provide user-specified value
verbose	Logical; print diagnostics.

Details

Calibration procedure:

- *Consistency case ($Z = 0$).* Enforce near-full borrowing at exact consistency by solving $w'(Z = 0) = t_1$ for a.
- *Strong inconsistency case ($Z(\delta) = \frac{|\delta|}{\sqrt{s_{E,C_2}+s_{E,C_1}+s_{C_2,C_1}}}$).* Enforce minimal borrowing at a clinically significant difference by targeting the *updated* weight $w'(Z(\delta)) = t_0$, with calibrated a from step 1, solve for b.

For further details, see the original NAP paper by Zhang and et al. (manuscript).

Value

list with a, b, mode ("FE" or "RE"), and simple check summary.

Examples

```
s_EC2 <- 0.2^2; s_EC1 <- 0.18^2; s_C2C1 <- 0.18^2
tau0 <- 1000

# One external trial setting
tune_param_eNAP(
  s_EC2,s_EC1,s_C2C1, tau0=1000,
  delta=0.5, t1 = 0.999, t0 = 0.05)

# Multiple external trials setting
s_C2C1=c(0.19^2,0.18^2,0.20^2)
y_C2C1=c(-0.5,-0.45,-0.6)
tune_param_eNAP(
  s_EC2,s_EC1,s_C2C1, tau0=10,
  delta=0.5, t1 = 0.999, t0 = 0.05,
  exact=TRUE,y_EC1=-0.8,y_C2C1=y_C2C1)
```

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