

# Introduction to dtametaTMB

This vignette introduces the main functionality of the `dtametaTMB` package for meta-analysis of diagnostic test accuracy (DTA) studies. We demonstrate how to fit three commonly used models:

- the Reitsma bivariate model
- the Rutter and Gatsonis (HSROC) model
- the Hoyer model for multiple thresholds

using real datasets included in the package.

Subgroup analyses and meta-regression are covered in a separate vignette.

*Note:* Rendering forest plots via `forest` may take longer in an interactive R session due to the underlying grid graphics. Performance is typically faster when knitting the vignette (e.g. via RMarkdown or Quarto).

## How do I load the package?

```
#install.packages("dtametaTMB")  
library(dtametaTMB)
```

## Which model should I use?

- **Reitsma model:** single threshold per study: use when studies apply similar thresholds.
- **Rutter and Gatsonis model:** single threshold per study: use when thresholds vary between studies
- **Hoyer model:** multiple thresholds per study

The Reitsma and Rutter-Gatsonis model classes support parameter constraints for simplified analyses and sparse datasets.

## Validation

The implementations reproduce benchmark results from the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy (including parameter estimates, standard errors, and graphical outputs) for standard datasets such as the Anti-CCP and RF examples.

## How do I use the Reitsma model?

Unlike the `mada` package, `dtametaTMB` uses the binomial likelihood to model the within study distribution as recommended by The Cochrane Handbook.

For sensitivity in study  $i$ , we have the number of diseased individuals testing positive:  $y_{Ai} \sim \mathcal{B}(n_{Ai}, \pi_{Ai})$ .

Similarly for specificity, we have the number of non-diseased individuals testing negative:  $y_{Bi} \sim \mathcal{B}(n_{Bi}, \pi_{Bi})$ .

At the study level, we have

$$\begin{pmatrix} \text{logit}(\pi_{Ai}) \\ \text{logit}(\pi_{Bi}) \end{pmatrix} = \begin{pmatrix} \mu_{Ai} \\ \mu_{Bi} \end{pmatrix} \sim \mathcal{N} \left( \begin{pmatrix} \mu_A \\ \mu_B \end{pmatrix}, \Sigma \right), \quad \text{with} \quad \Sigma = \begin{pmatrix} \sigma_A^2 & \sigma_{AB} \\ \sigma_{AB} & \sigma_B^2 \end{pmatrix}.$$

```
data("anticcp")
reitsma <- fitReitsma(data=anticcp,
                      TP=TP,
                      FP=FP,
                      FN=FN,
                      TN=TN,
                      study=study)

reitsma
#>
#> Reitsma Model
#> -----
#>
#> Number of studies : 37
#> Model fit          : Converged
#> -2 log likelihood : 545.56 ( df = 5 )
#> AIC                : 555.56
#> BIC                : 563.614
#>
#> mu_A (sens)        : 0.653
#> mu_B (spec)        : 3.109
#>
```

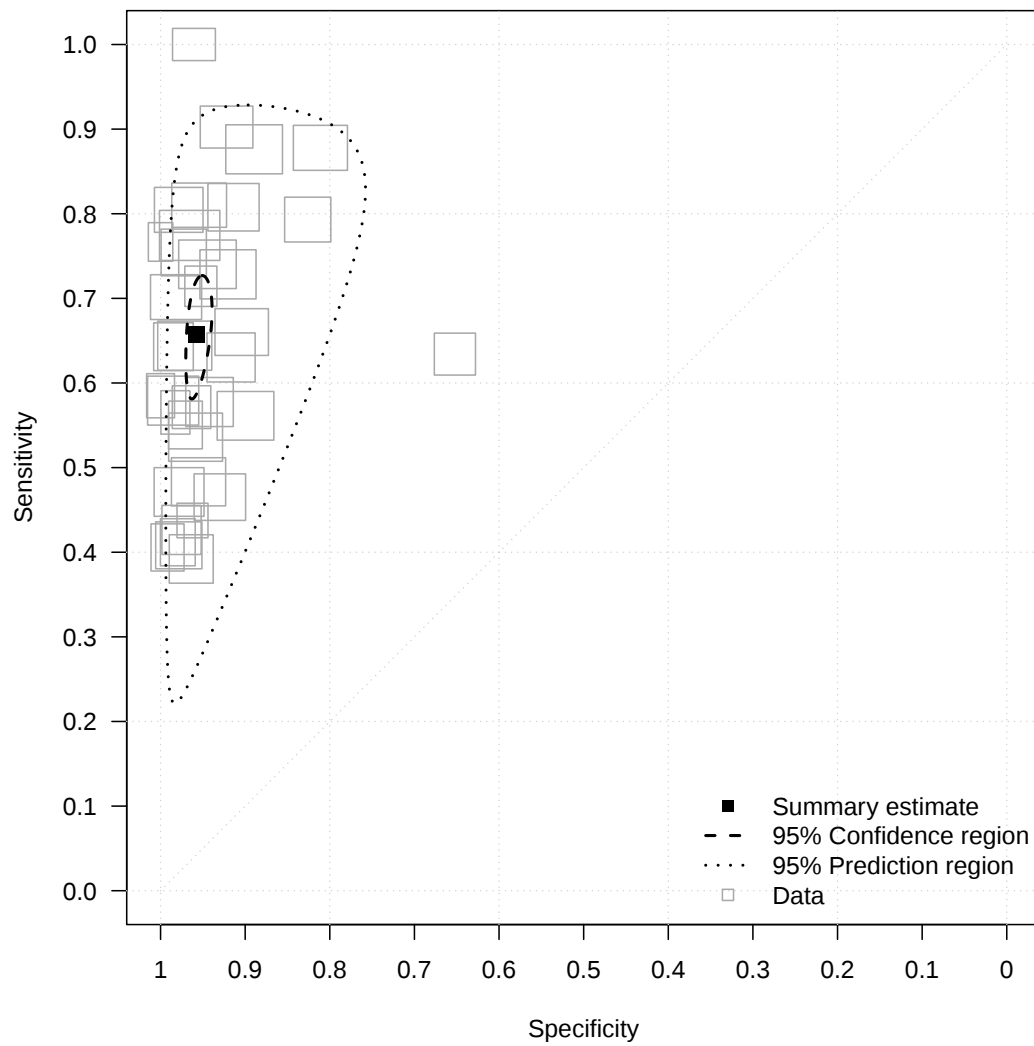
```
#> Use summary() for parameter estimates.
summary(reitsma)
#> $estimates
#>
#>      Estimate Std_Error
#> mu_A.sens    0.6534029 0.1274866
#> mu_B.spec    3.1089906 0.1458847
#> sigma2_A.sens 0.5426397 0.1463478
#> sigma2_B.spec 0.5717019 0.1873211
#> sigma_AB     -0.2704148 0.1198520
#>
#> $sensspec
#>      Estimate conflevel CI_Lower CI_Upper
#> sens 0.6577769      0.95 0.5995364 0.7116214
#> spec 0.9572621      0.95 0.9439094 0.9675454
#>
#> $RutterGatsonis_recovered
#>
#>      Lambda      Theta      beta sigma2_alpha sigma2_theta
#> Estimate (recovered) 3.730684 -1.203361 0.02608605      0.573133      0.4136981
```

## How do I get a summary plot of the Reitsma model?

The confidence region reflects uncertainty in the estimated summary point, whereas the prediction region reflects the likely location of a future study.

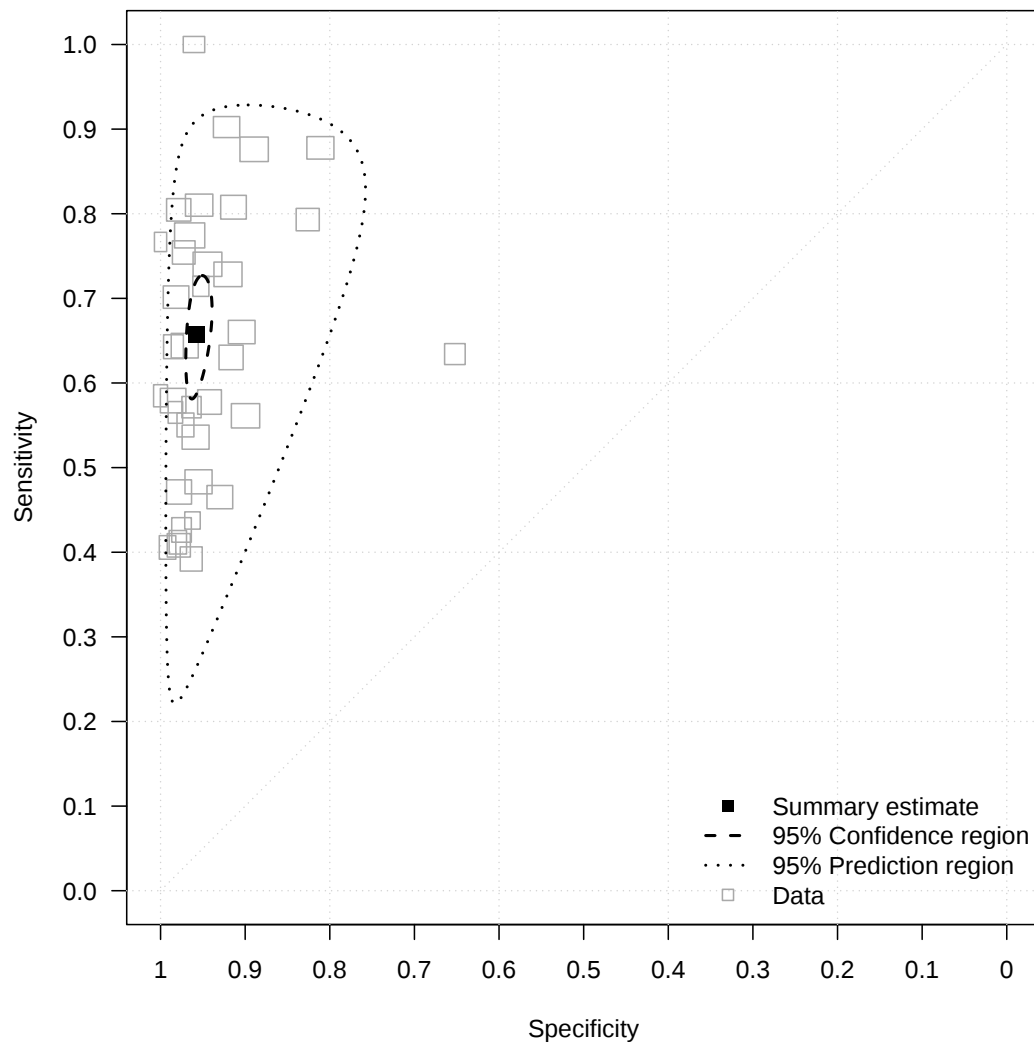
```
plot(reitsma)
```

## Diagnostic Test Accuracy Meta-Analysis



```
plot(reitsma,scale=0.01)
```

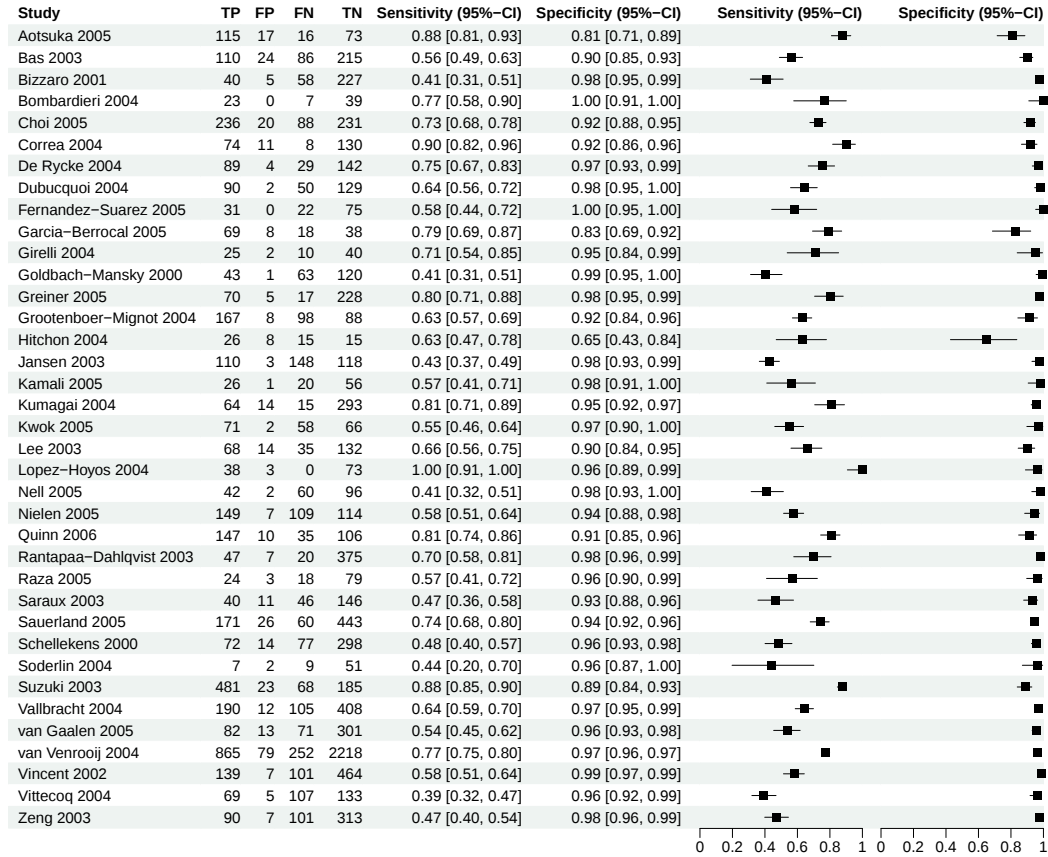
## Diagnostic Test Accuracy Meta-Analysis



### How do I get a coupled forest plot?

*Note:* Rendering forest plots may take longer in an interactive R session due to the underlying grid graphics. Performance is typically faster when knitting the vignette (e.g. via RMarkdown or Quarto).

```
forest(reitsma)
```



## How do I export results to RevMan?

```
as_revman(reitsma)
#>      Externally_Calculated_Parameters      Parameter      Estimate
#> 1      HSROC model parameters      Lambda 3.730684359
#> 2      HSROC model parameters      Theta -1.203361126
#> 3      HSROC model parameters      beta 0.026086047
#> 4      HSROC model parameters Var(accuracy) 0.573132997
#> 5      HSROC model parameters Var(threshold) 0.413698070
#> 6      Bivariate model parameters      E(logitSe) 0.653402883
#> 7      Bivariate model parameters      E(logitSp) 3.108990638
#> 8      Bivariate model parameters      Var(logitSe) 0.542639749
```

```
#> 9      Bivariate model parameters  Var(logitSp)  0.571701927
#> 10     Bivariate model parameters   Cov(logits) -0.270414821
#> 11     Bivariate model parameters   Corr(logits) -0.485500701
#> 12 Confidence and prediction regions SE(E(logitSe))  0.127486590
#> 13 Confidence and prediction regions SE(E(logitSp))  0.145884662
#> 14 Confidence and prediction regions   Cov(Es) -0.007412423
#> 15 Confidence and prediction regions   Studies 37.000000000
```

## How do I use the Rutter and Gatsonis model?

The number of diseased individuals from study  $i$  who test positive is denoted by  $y_{i1} \sim \mathcal{B}(n_{i1}, \pi_{i1})$ .

Similarly, the number of non-diseased individuals who test positive is  $y_{i2} \sim \mathcal{B}(n_{i2}, \pi_{i2})$ .

At the study level, we have

$$\text{logit}(\pi_{ij}) = (\theta_i + \alpha_i x_{ij}) \exp(-\beta x_{ij}), \quad \alpha_i \sim \mathcal{N}(\Lambda, \sigma_\alpha^2), \quad \theta_i \sim \mathcal{N}(\Theta, \sigma_\theta^2),$$

where

$$x_{ij} = \begin{cases} -0.5 & \text{for non-diseased individuals,} \\ 0.5 & \text{for diseased individuals.} \end{cases}$$

In this parameterization  $\Lambda$  corresponds to accuracy,  $\Theta$  to threshold, and  $\beta$  controls the shape of the HSROC curve.

```
data("RF")
ruttergatsonis <- fitRutterGatsonis(data=RF,
                                   TP=TP,
                                   FP=FP,
                                   FN=FN,
                                   TN=TN,
                                   study=study)
```

```
ruttergatsonis
#>
#> Rutter & Gatsonis Model
#> -----
#>
#> Number of studies : 50
#> Model fit         : Converged
```

```

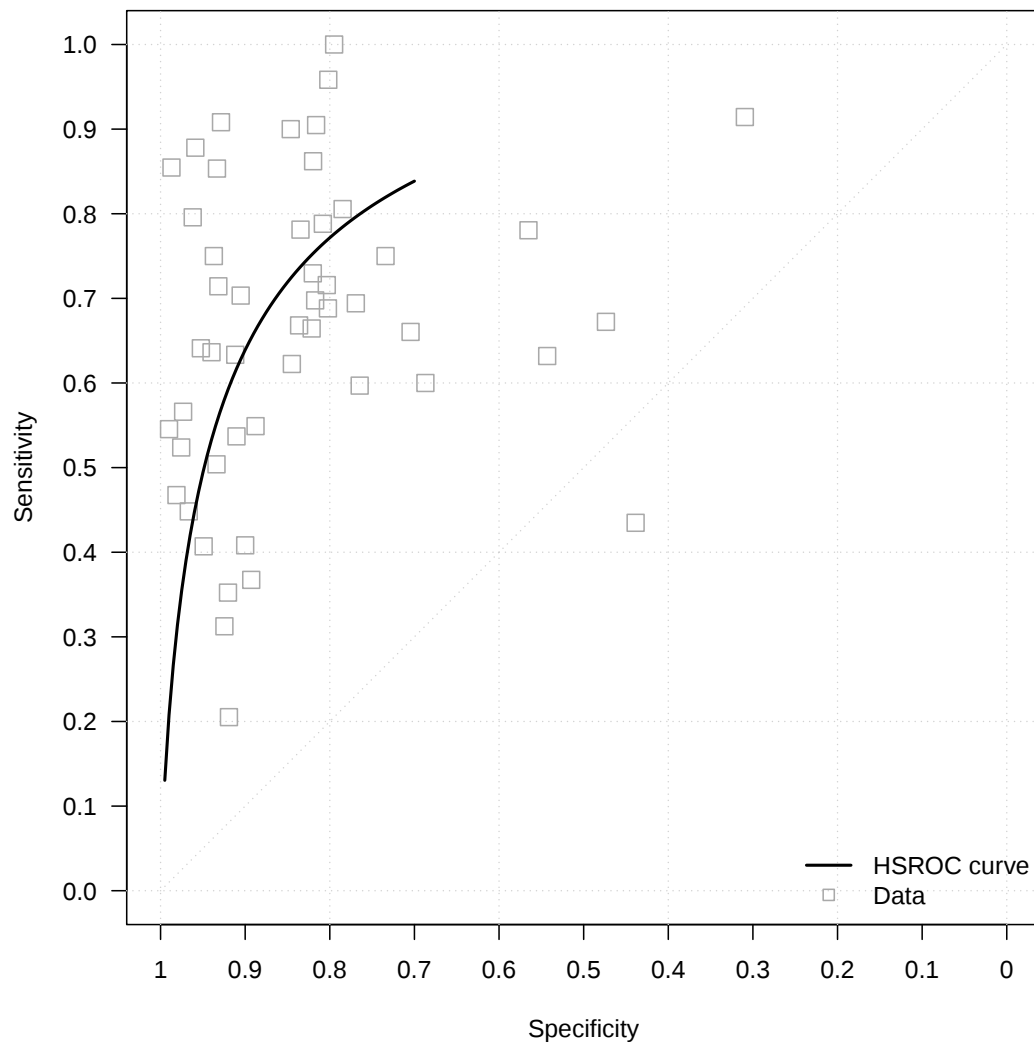
#> -2 log likelihood : 806.934 ( df = 5 )
#> AIC : 816.934
#> BIC : 826.494
#>
#> Lambda : 2.602
#> Theta : -0.437
#> Beta : 0.227
#>
#> Use summary() for parameter estimates.
summary(ruttergatsonis)
#> $estimates
#> Estimate Std. Error
#> Lambda 2.6015985 0.18616691
#> Theta -0.4370167 0.14685177
#> beta 0.2266849 0.16236992
#> sigma2_alpha 1.3014057 0.30455918
#> sigma2_theta 0.5422965 0.12366256
#> logitsens 0.8286883 0.15539440
#> sens 0.6960775 0.03287424
#>
#> $sensspec
#> spec conflevel logitsens Std_Error CI_Lower CI_Upper Sens
#> 1 0.8669545 0.95 0.8286883 0.1553944 0.5241209 1.133256 0.6960775
#> SensCI_Lower SensCI_Upper
#> 1 0.6281109 0.7564392
#>
#> $Reitsma_recovered
#> mu_A.sens mu_B.spec sigma2_A.sens sigma2_B.spec sigma_AB
#> Estimate (recovered) 0.7712238 1.946381 0.6916646 1.088408 -0.2169451

```

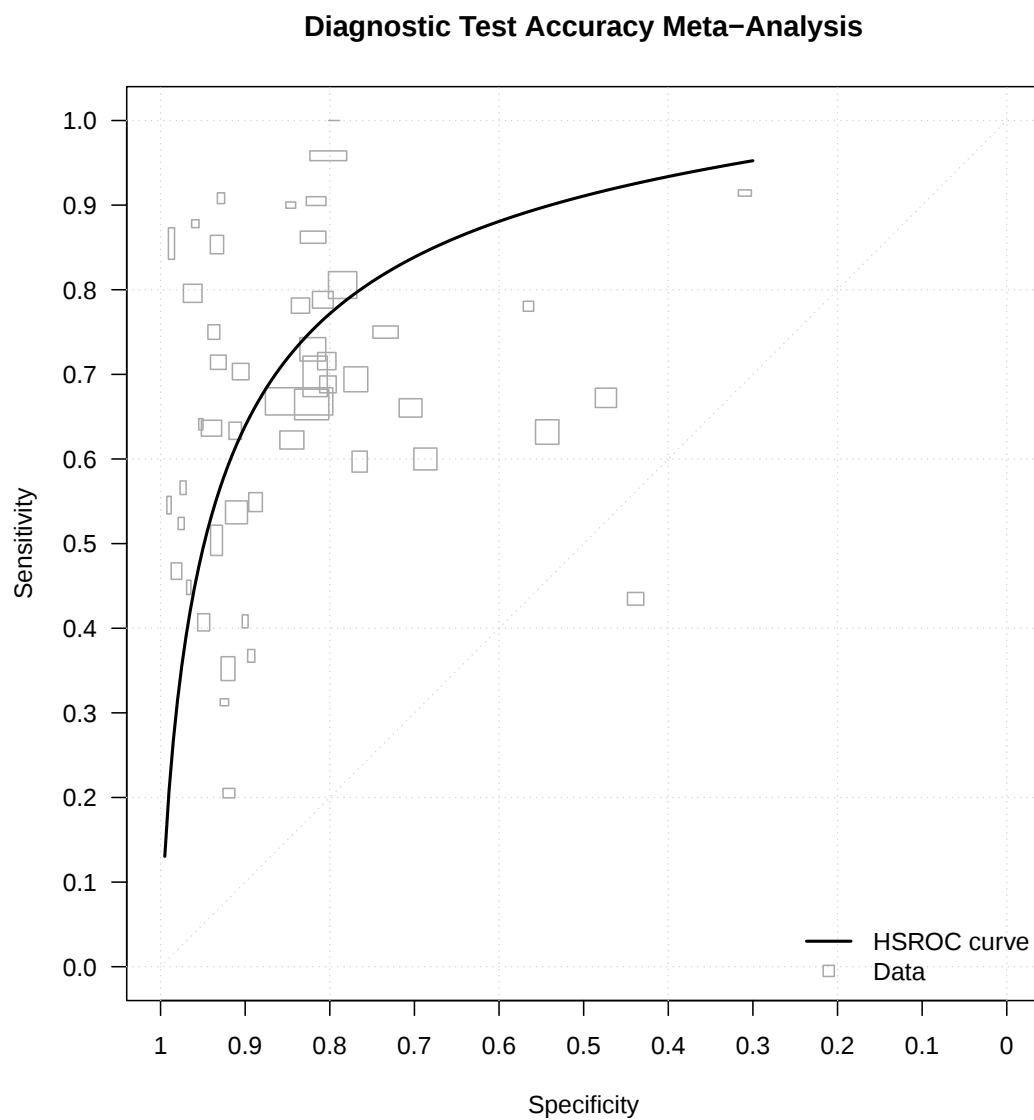
**How do I get a summary plot of the Rutter and Gatsonis model?**

```
plot(ruttergatsonis)
```

### Diagnostic Test Accuracy Meta-Analysis



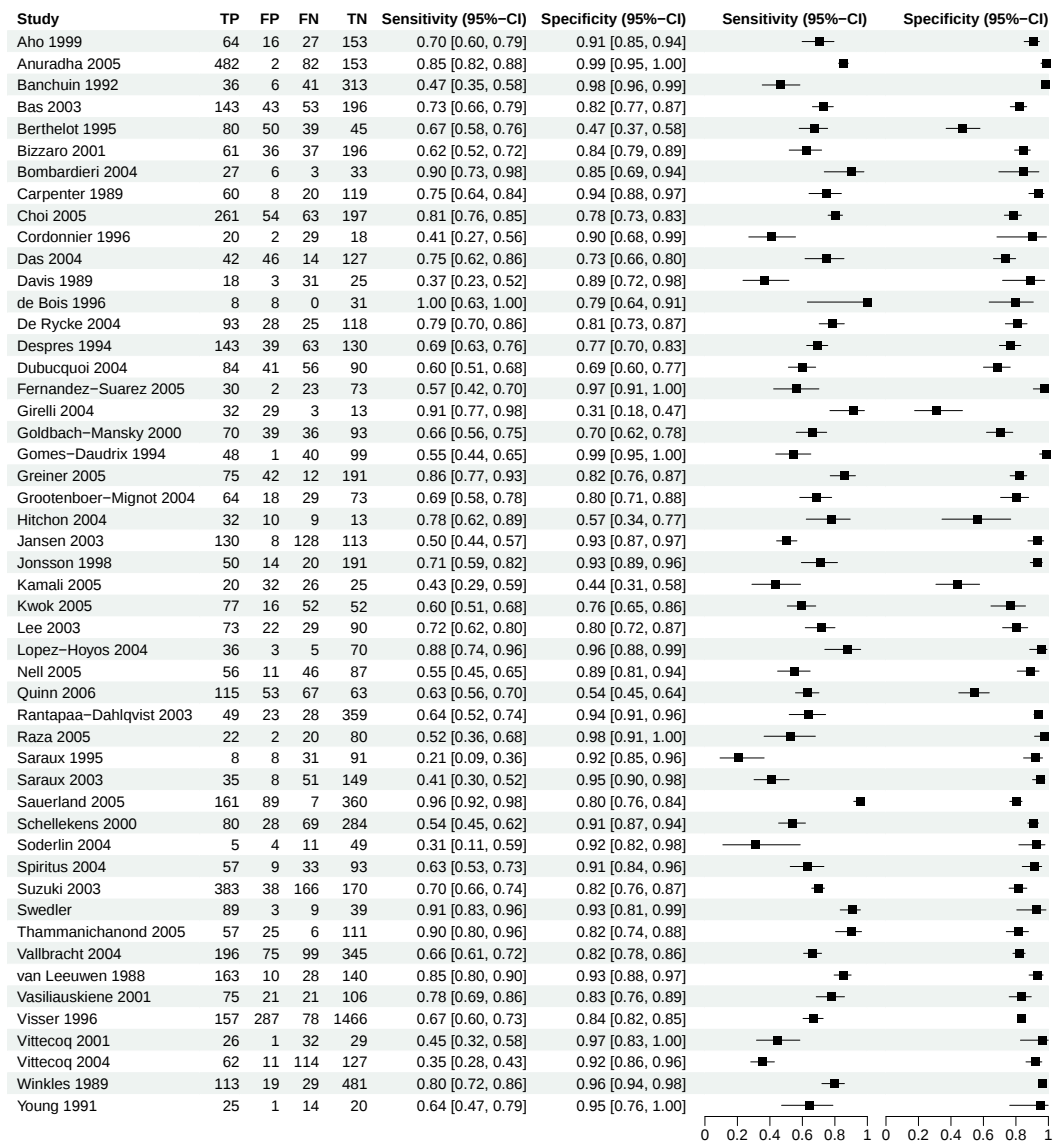
```
plot(ruttergatsonis,size="se",specrange=c(0.3,0.995),scale=0.01)
```



### How do I get a coupled forest plot?

*Note:* Rendering forest plots may take longer in an interactive R session due to the underlying grid graphics. Performance is typically faster when knitting the vignette (e.g. via RMarkdown or Quarto).

```
forest(ruttergatsonis)
```



## How do I simplify the models via parameter constraints?

The package allows model parameters to be constrained to zero during estimation. This can be useful in meta-analysis of sparse data, when convergence is difficult, or when fitting simplified models as described in the Cochrane Handbook. For example,

```

reitsmacons <- fitReitsma(data = anticcp,
                          TP = TP,
                          FP = FP,
                          FN = FN,
                          TN = TN,
                          study = study,
                          constrain = "sigma_AB")
summary(reitsmacons)$estimates
#>           Estimate Std_Error
#> mu_A.sens      0.6585174 0.1294998
#> mu_B.spec      3.1045241 0.1475005
#> sigma2_A.sens  0.5601893 0.1530546
#> sigma2_B.spec  0.5814819 0.1913425
#> sigma_AB       0.0000000 0.0000000

```

fixed the between-study random-effects covariance at zero. Other options include `constrain="sigma2_A"`, `constrain=sigma2_B`, or `constrain=all`.

The Rutter and Gatsonis model allows for the constraint  $\sigma_\alpha^2 = 0$ ,  $\sigma_\theta^2 = 0$  and/or  $\beta = 0$  (shape parameter). For example

```

ruttergatsoniscons <- fitRutterGatsonis(data = RF,
                                         TP = TP,
                                         FP = FP,
                                         FN = FN,
                                         TN = TN,
                                         study = study,
                                         constrain = c("sigma2_theta","shape"))
summary(ruttergatsoniscons)$estimates
#>           Estimate Std. Error
#> Lambda      2.474558e+00 0.16458526
#> Theta      -4.756828e-01 0.02219305
#> beta        0.000000e+00 0.00000000
#> sigma2_alpha 1.212172e+00 0.27567963
#> sigma2_theta 4.930381e-32 0.00000000
#> logitsens   6.002630e-01 0.16458526
#> sens        6.457165e-01 0.03765163

```

Note that we can also compare the constrained model with the full model using likelihood ratio tests.

```
anova(ruttergatsoniscons,ruttergatsonis)
#>      Df  logLik Df.diff Chisq Pr(>Chisq)
#> Model 1   3 -683.02
#> Model 2   5 -403.47      2 559.1 < 2.2e-16 ***
#> ---
#> Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

## How do I use the Hoyer model?

The Hoyer model assumes that the diagnostic test measurement arises from a latent continuous variable  $Y_j$ , with  $j = 0$  for the non-diseased individuals and  $j = 1$  for the diseased, which follows a parametric survival distribution. The observed test results correspond to interval-censored observations of this latent variable due to the use of thresholds.

## Which distributions does dtametaTMB support?

The latent variable  $Y_j$  is assumed to follow a location-scale family:

$$Y_j \sim F(\mu_j, \phi_j),$$

where:

- $\mu_j$  is a study-specific location parameter
- $\phi_j$  is a scale parameter

Common choices for  $F$  include:

### Weibull distribution

$$f(y; \mu_j, \phi_j) = \mu_j \phi_j y^{\phi_j - 1} \exp(-\mu_j y^{\phi_j})$$

### Log-normal distribution

$$f(y; \mu_j, \phi_j) = \frac{1}{\phi_j y} \phi \left( \frac{\log(y) - \mu_j}{\phi_j} \right)$$

## Log-logistic distribution

$$f(y; \mu_j, \phi_j) = \frac{\mu_j \phi_j y^{\phi_j - 1}}{(1 + \mu_j y^{\phi_j})^2}$$

## Random effects structure

To account for between-study heterogeneity and the correlation between diseased and non-diseased groups, we introduce study-specific random effects:

$$\log(y_0) = \beta_0 + \varepsilon_0 + u_{0i}, \quad \log(y_1) = \beta_1 + \varepsilon_1 + u_{1i},$$

with

$$\begin{pmatrix} u_{0i} \\ u_{1i} \end{pmatrix} \sim \mathcal{N} \left( \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_0^2 & \rho\sigma_0\sigma_1 \\ \rho\sigma_0\sigma_1 & \sigma_1^2 \end{pmatrix} \right).$$

## Censoring mechanism

Because only thresholded outcomes (TN, TP, FN, FP) are observed, the latent variable  $Y_j$  is subject to censoring.

- Left censoring:  $(-\infty, y_k^R]$
- Interval censoring between adjacent thresholds
- Right censoring:  $(y_k^L, +\infty)$

where  $y_k^L$  and  $y_k^R$  denote finite threshold values.

## How do I compute sensitivities and specificities?

We can model the ROC curve by predicting sensitivities and specificities (1 - false positive rates) at several threshold values  $y$ .

## Weibull distribution

$$\begin{aligned} S_1(y) &= \exp(-(y \exp(-\beta_1))^{1/\lambda_1}), & \text{with } \beta_1 &= -\log(\mu_1), \quad \lambda_1 = 1/\phi_1, \\ S_0(y) &= \exp(-(y \exp(-\beta_0))^{1/\lambda_0}), & \text{with } \beta_0 &= -\log(\mu_0), \quad \lambda_0 = 1/\phi_0. \end{aligned}$$

### Log-normal distribution

$$S_1(y) = 1 - \Phi\left(\frac{1}{\lambda_1}(\log(y) - \beta_1)\right), \quad \text{with } \beta_1 = \mu_1, \quad \lambda_1 = \phi_1,$$
$$S_0(y) = 1 - \Phi\left(\frac{1}{\lambda_0}(\log(y) - \beta_0)\right), \quad \text{with } \beta_0 = \mu_0, \quad \lambda_0 = \phi_0.$$

### Log-logistic distribution

$$S_1(y) = 1 / (1 + \exp(-\beta_1/\lambda_1) y^{1/\lambda_1}), \quad \text{with } \beta_1 = -\phi^{-1} \log(\mu_1), \quad \lambda_1 = 1/\phi_1,$$
$$S_0(y) = 1 / (1 + \exp(-\beta_0/\lambda_0) y^{1/\lambda_0}), \quad \text{with } \beta_0 = -\phi^{-1} \log(\mu_0), \quad \lambda_0 = 1/\phi_0.$$

### How do I interpret test direction?

For tests where larger values indicate disease (`testdirection` = "greater"):

- $S_1(y)$  corresponds to **sensitivity** at threshold  $y$
- $S_0(y)$  corresponds to the **false positive rate (FPR) = 1 - specificity**

For tests where smaller values indicate disease (`testdirection` = "less"):

- $S_1(y)$  corresponds to the **false negative rate (FNR) = 1 - sensitivity**
- $S_0(y)$  corresponds to **specificity**

### In a nutshell

By modelling the diagnostic marker as a latent continuous outcome, the Hoyer model:

- naturally accommodates **multiple thresholds per study**
- provides a unified framework for **interval-censored diagnostic data**
- preserves the correlation between sensitivity and specificity

The following parameters have to be estimated:  $\beta_0$ ,  $\beta_1$ ,  $\lambda_0$ ,  $\lambda_1$ ,  $\sigma_0^2$ ,  $\sigma_1^2$ , and  $\rho$ , where  $\lambda_0$  and  $\lambda_1$  are transformations of  $\phi_0$  and  $\phi_1$ .

To obtain initial values, it is necessary to specify a smallest (« min  $y$ ) and largest (» max  $y$ ) value across all studies, essentially replacing negative and positive infinity for the left and right censored intervals.

## How do I fit the Hoyer model?

```
data("diabetes")
head(diabetes)
#>      study threshold  TP   TN   FP  FN   D   H originally_published
#> 1 Study 01         5.9 574 1389  682 262 836 2071                1
#> 2 Study 02         5.0 617 1005 7735  18 635 8740                0
#> 3 Study 02         5.1 607 1617 7123  28 635 8740                0
#> 4 Study 02         5.2 600 2438 6302  35 635 8740                0
#> 5 Study 02         5.3 581 3409 5331  54 635 8740                0
#> 6 Study 02         5.4 563 4422 4318  72 635 8740                0
summary(diabetes$threshold)
#>      Min. 1st Qu.  Median      Mean 3rd Qu.      Max.
#>   3.900   5.500   5.800   5.837   6.100   7.600
```

The argument `eval_threshold` specifies the values at which sensitivities and specificities are evaluated after model fitting.

```
hoyer <- fitHoyer(data=diabetes,
                  TP=TP,
                  FP=FP,
                  FN=FN,
                  TN=TN,
                  threshold=threshold,
                  study=study,
                  dist="loglogistic",
                  testdirection="greater",
                  eval_threshold=c(5.0,5.5,6.0,6.5,7.0,7.5),
                  smallest=2,
                  largest=10)
```

```
hoyer
#>
#> Hoyer Model
#> -----
#>
#> Number of studies : 38
#> Model fit          : Converged
#> -2 log likelihood : 209322 ( df = 7 )
#> AIC                : 209336
#> BIC                : 209347.4
```

```

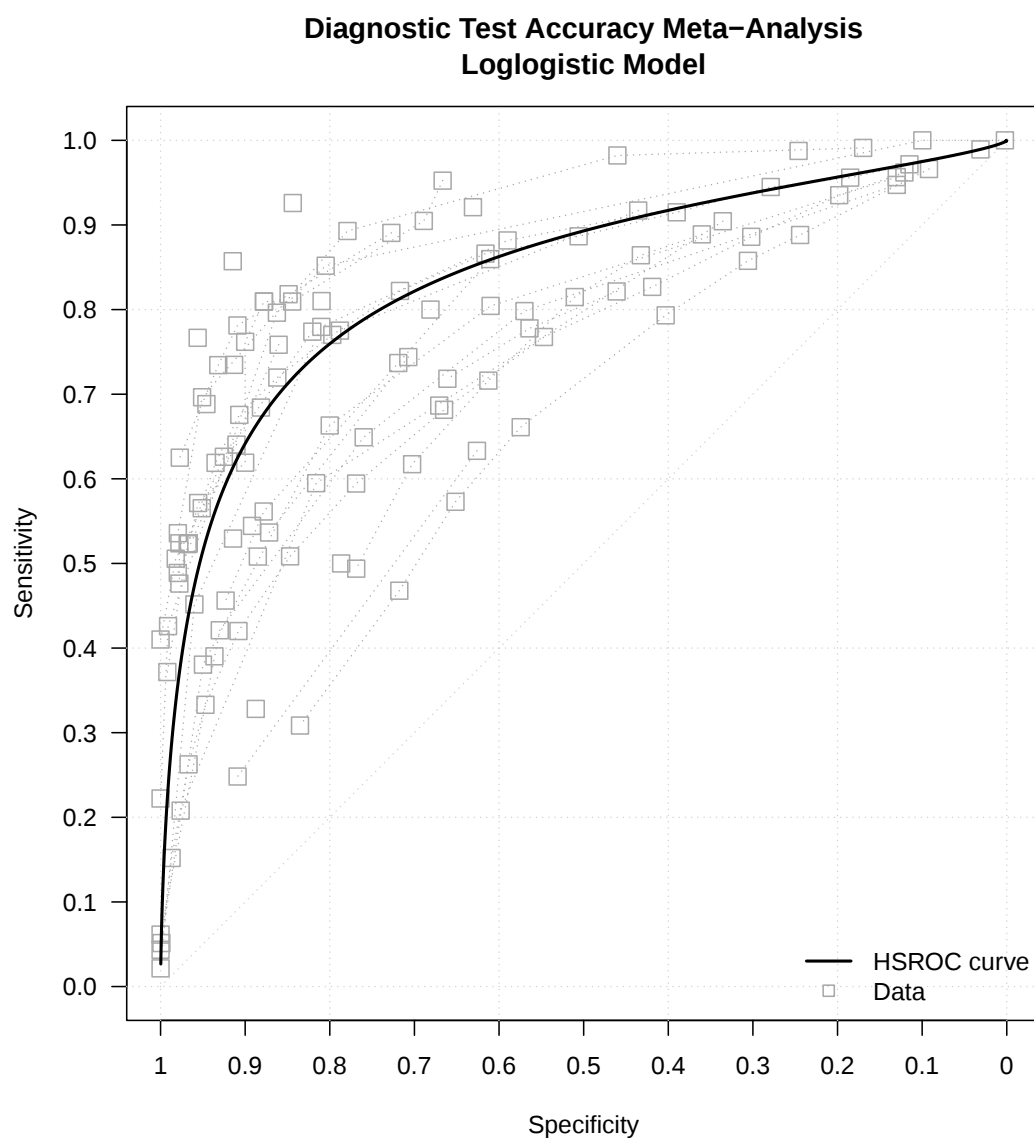
#>
#> Distribution      : Loglogistic
#> Test direction    : greater
#>
#> Use summary() for parameter estimates.
summary(hoyer)
#> $sdreport2
#>
#>      Estimate   Std. Error
#> beta0      1.705691148 0.0095630146
#> lambda0    0.039502004 0.0001857265
#> su0        0.058648679 0.0067784870
#> beta1      1.825337107 0.0145652403
#> lambda1    0.056398479 0.0009244722
#> su1        0.088320631 0.0109564611
#> rho        0.863032573 0.0454410883
#> covu0u1    0.004470412 0.0011417200
#> logitSurv1 3.828103143 0.2635035151
#> logitSurv1 2.138160760 0.2593347627
#> logitSurv1 0.595364241 0.2580790576
#> logitSurv1 -0.823870980 0.2591073990
#> logitSurv1 -2.137877556 0.2619046729
#> logitSurv1 -3.361188412 0.2660542694
#> logitSurv0 2.436667140 0.2426039991
#> logitSurv0 0.023873625 0.2420917690
#> logitSurv0 -2.178834277 0.2420878132
#> logitSurv0 -4.205129122 0.2424751080
#> logitSurv0 -6.081185122 0.2431661379
#> logitSurv0 -7.827751473 0.2440943827
#>
#> $sensspec
#>   threshold conflevel      Sens SensCI_Lower SensCI_Upper      Spec
#> 1      5.0      0.95 0.97871219  0.96482617  0.98718904 0.08041904
#> 2      5.5      0.95 0.89455725  0.83615237  0.93379170 0.49403188
#> 3      6.0      0.95 0.64459500  0.52236970  0.75048299 0.89833265
#> 4      6.5      0.95 0.30494258  0.20887630  0.42164362 0.98530044
#> 5      7.0      0.95 0.10546947  0.06591501  0.16457780 0.99771974
#> 6      7.5      0.95 0.03353069  0.02018063  0.05521454 0.99960164
#>   SpecCI_Lower SpecCI_Upper
#> 1   0.0515556   0.1233403
#> 2   0.3779250   0.6107860
#> 3   0.8461021   0.9342152
#> 4   0.9765667   0.9908097

```

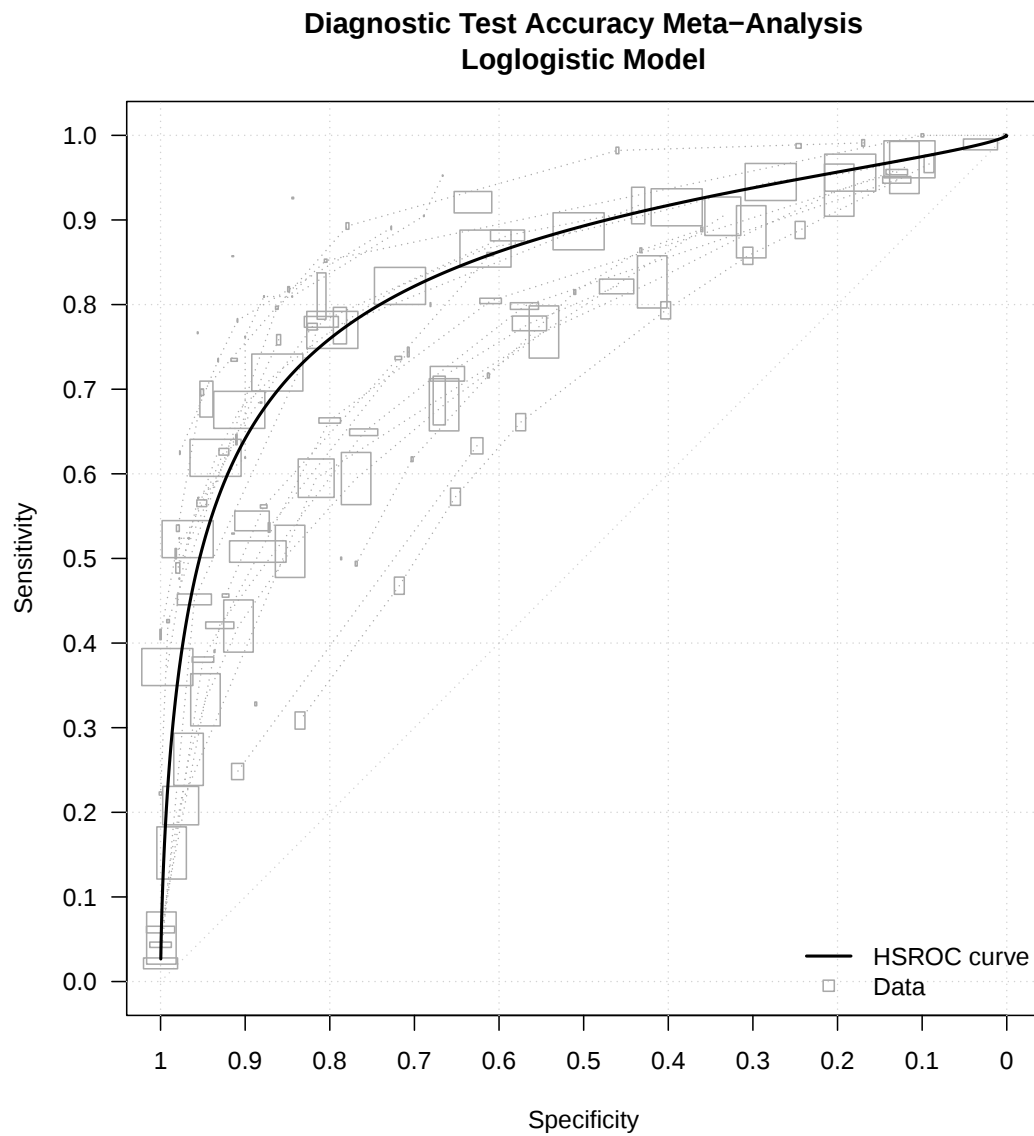
```
#> 5    0.9963326    0.9985830
#> 6    0.9993574    0.9997531
```

How do I get a summary plot of the Hoyer model?

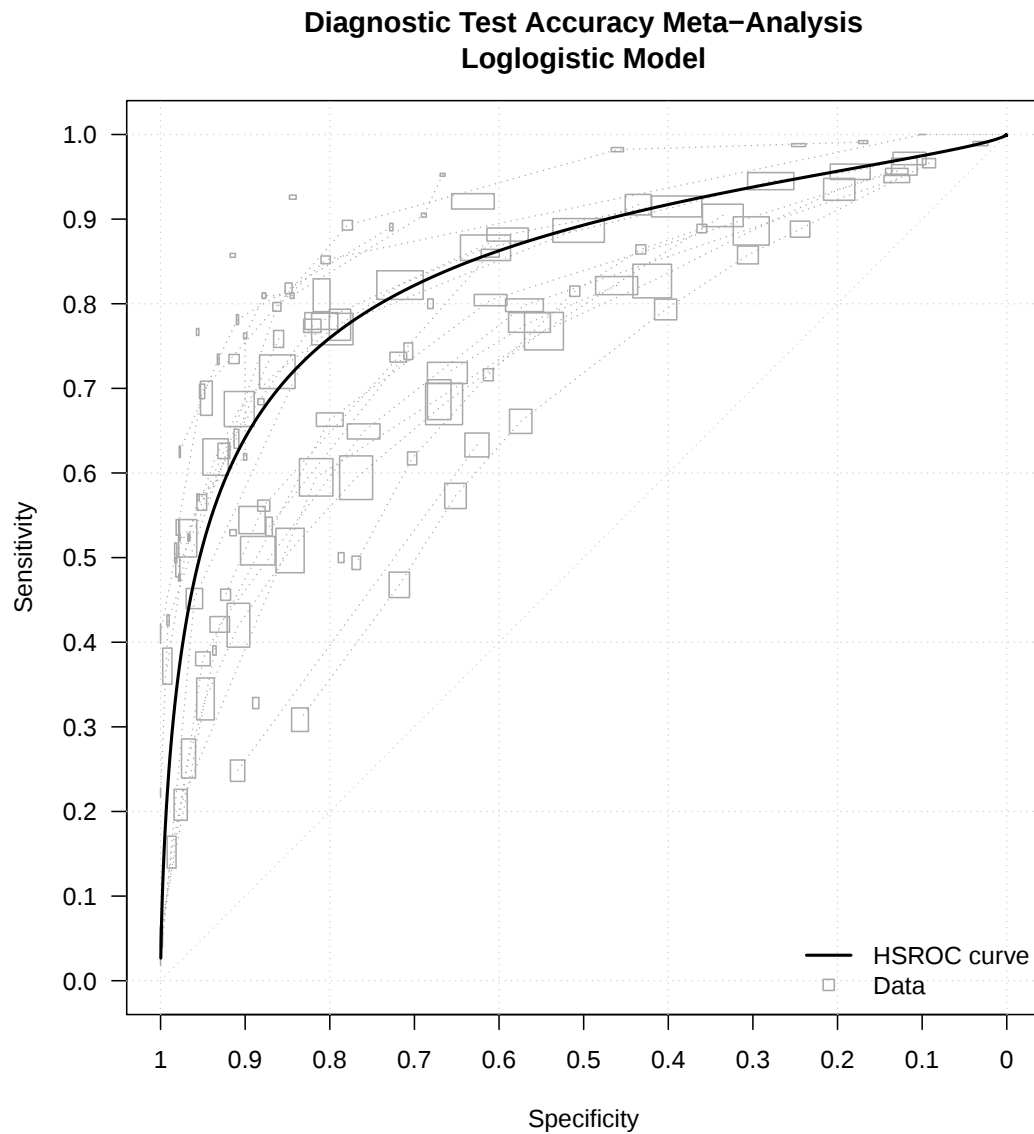
```
plot(hoyer,
      main="Diagnostic Test Accuracy Meta-Analysis\nLoglogistic Model")
```



```
plot(hoyer, size="sampsiz", scale=0.025,
     main="Diagnostic Test Accuracy Meta-Analysis\nLoglogistic Model")
```



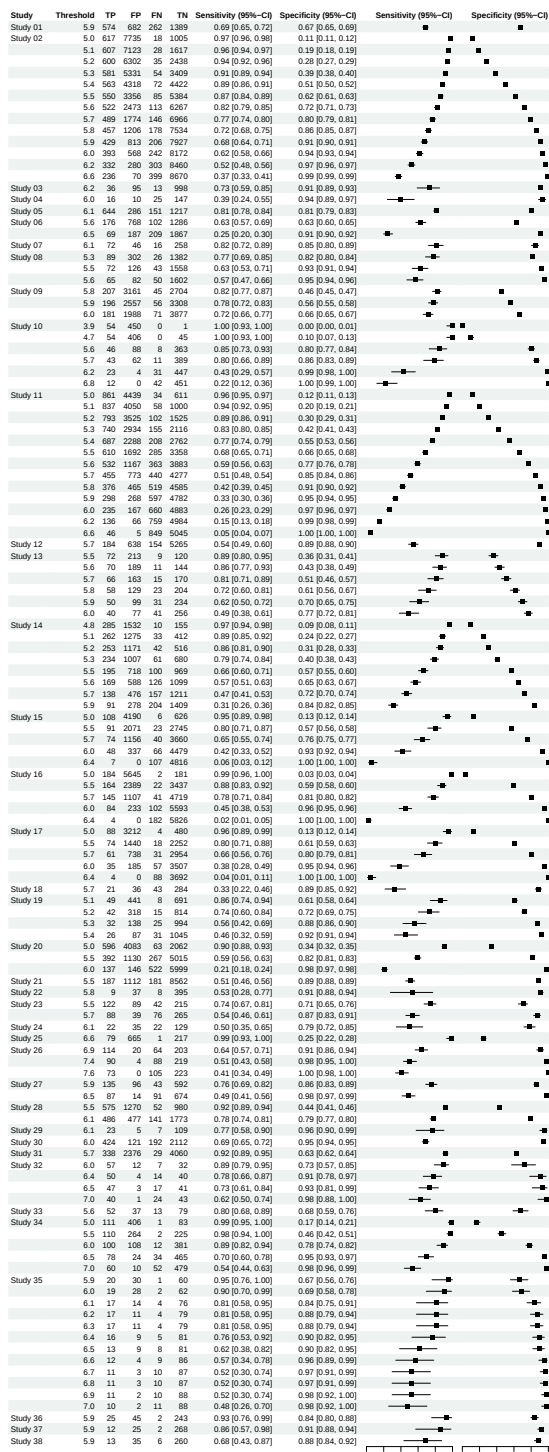
```
plot(hoyer, size="se", scale=0.025,
     main="Diagnostic Test Accuracy Meta-Analysis\nLoglogistic Model")
```



### How do I get a coupled forest plot?

*Note:* Rendering forest plots may take longer in an interactive R session due to the underlying grid graphics. Performance is typically faster when knitting the vignette (e.g. via RMarkdown or Quarto).

```
forest(hoyer)
```



## How do I fit the Hoyer model to the FeNO dataset?

*Note:* The FeNO data are reproduced from the original source and the supplementary material accompanying the Cochrane Handbook. However, the study ‘Schneider 2013’ contains inconsistent diseased counts (TP + FN). To illustrate the Hoyer analysis, we modify the TP counts in rows 118–120 from 39 to 38, restoring a constant total of 154 diseased individuals. Other corrections restoring internal consistency are also conceivable.

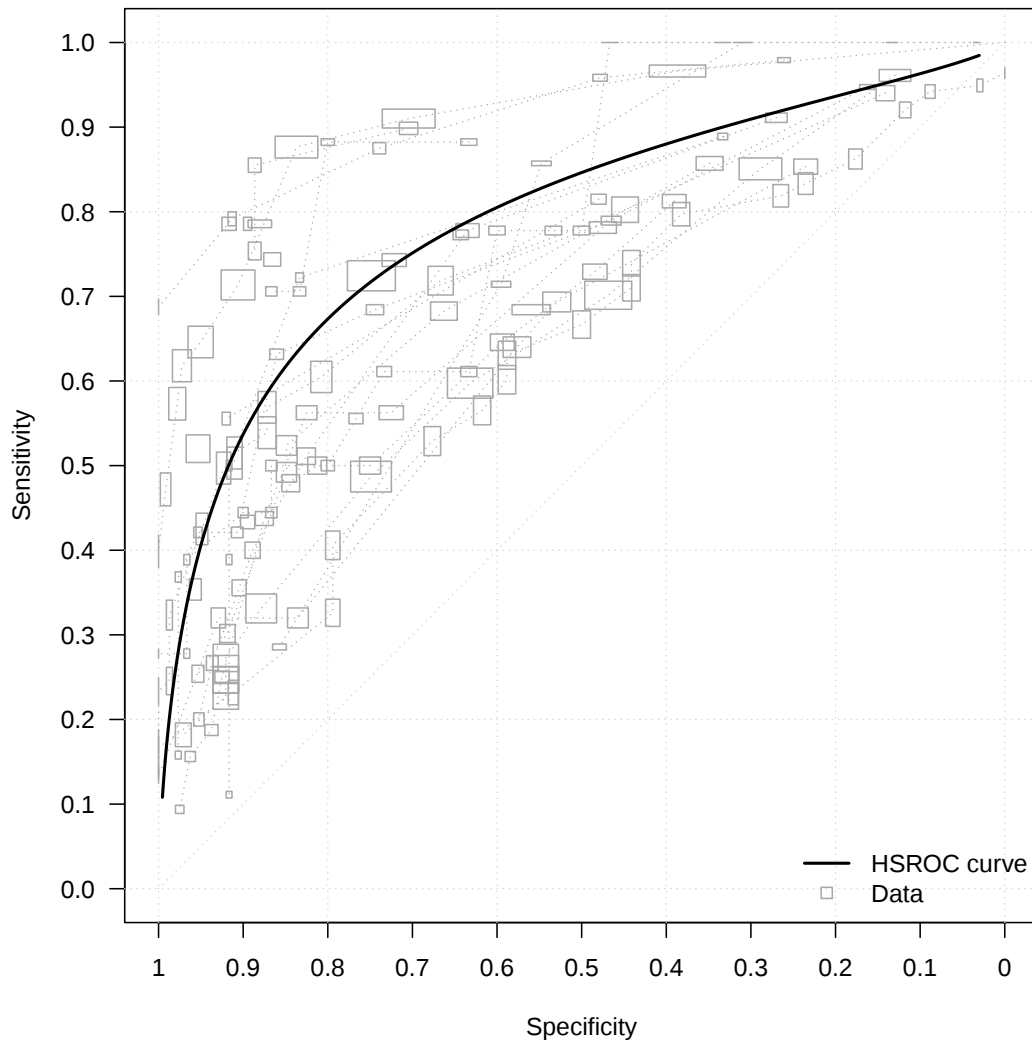
```
data("FENO")
head(FENO)
#>      study study_id cutoff  TP FN FP TN
#> 1 Arora 2006      1      6 133  5 34  0
#> 2 Arora 2006      1      7 131  7 33  1
#> 3 Arora 2006      1      8 130  8 31  3
#> 4 Arora 2006      1      9 127 11 30  4
#> 5 Arora 2006      1     10 119 19 28  6
#> 6 Arora 2006      1     11 115 23 26  8
summary(FENO$cutoff)
#>   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
#>   5.00  16.00  25.00  31.05  40.75  100.00
# feno <- fitHoyer(data=FENO,
#                   TP=TP,
#                   FP=FP,
#                   FN=FN,
#                   TN=TN,
#                   threshold=cutoff,
#                   study=study,
#                   dist="loglogistic",
#                   testdirection="greater",
#                   eval_threshold=seq(16,40,1),
#                   smallest=2,
#                   largest=120)
#Error in `FUN()`:
#| Inconsistent diseased counts (TP+FN) within study 'Schneider 2013'.
#Rows: 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122
#Counts: 154, 155
#
# Let's check the Schneider 2013 study
check_schneider <- FENO[110:122,]
check_schneider$n1 <- with(check_schneider,TP+FN)
check_schneider$n0 <- with(check_schneider,TN+FP)
check_schneider
#>      study study_id cutoff  TP  FN  FP  TN  n1  n0
```

```

#> 110 Schneider 2013      11      9 148   6 208   31 154 239
#> 111 Schneider 2013      11     12 131  23 170   69 154 239
#> 112 Schneider 2013      11     16 108  46 127  112 154 239
#> 113 Schneider 2013      11     20  92  62  88 151 154 239
#> 114 Schneider 2013      11     25  75  79  60 179 154 239
#> 115 Schneider 2013      11     35  51 103  29 210 154 239
#> 116 Schneider 2013      11     41  42 112  19 220 154 239
#> 117 Schneider 2013      11     42  40 114  19 220 154 239
#> 118 Schneider 2013      11     43  39 116  19 220 155 239
#> 119 Schneider 2013      11     44  39 116  19 220 155 239
#> 120 Schneider 2013      11     45  39 116  19 220 155 239
#> 121 Schneider 2013      11     46  35 119  19 220 154 239
#> 122 Schneider 2013      11     71  28 126   7 232 154 239
# Inspection suggests that the TP and/or FN counts
# in rows 118, 119, 120 may need to be changed.
# Let's redcue the TP counts from 39 to 38.
# But other corrections are conceivable as well.
FENO[118:120,"TP"] <- 38
### Let's try again
feno <- fitHoyer(data=FENO,
  TP=TP,
  FP=FP,
  FN=FN,
  TN=TN,
  threshold=cutoff,
  study=study,
  dist="loglogistic",
  testdirection="greater",
  eval_threshold=seq(16,40,1),
  smallest=2,
  largest=120)
plot(feno,size="se",scale=0.03,
  main="Diagnostic Test Accuracy Meta-Analysis\nLoglogistic Model")

```

### Diagnostic Test Accuracy Meta-Analysis Loglogistic Model



#### How does `testdirection="less"` work?

We use the synthetic anaemia data set. Smaller values in haemoglobin indicate disease.

```
data("anaemia")
summary(anaemia$threshold)
#>   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
#>   7.00   8.00   10.00  10.33  13.00   14.00
```

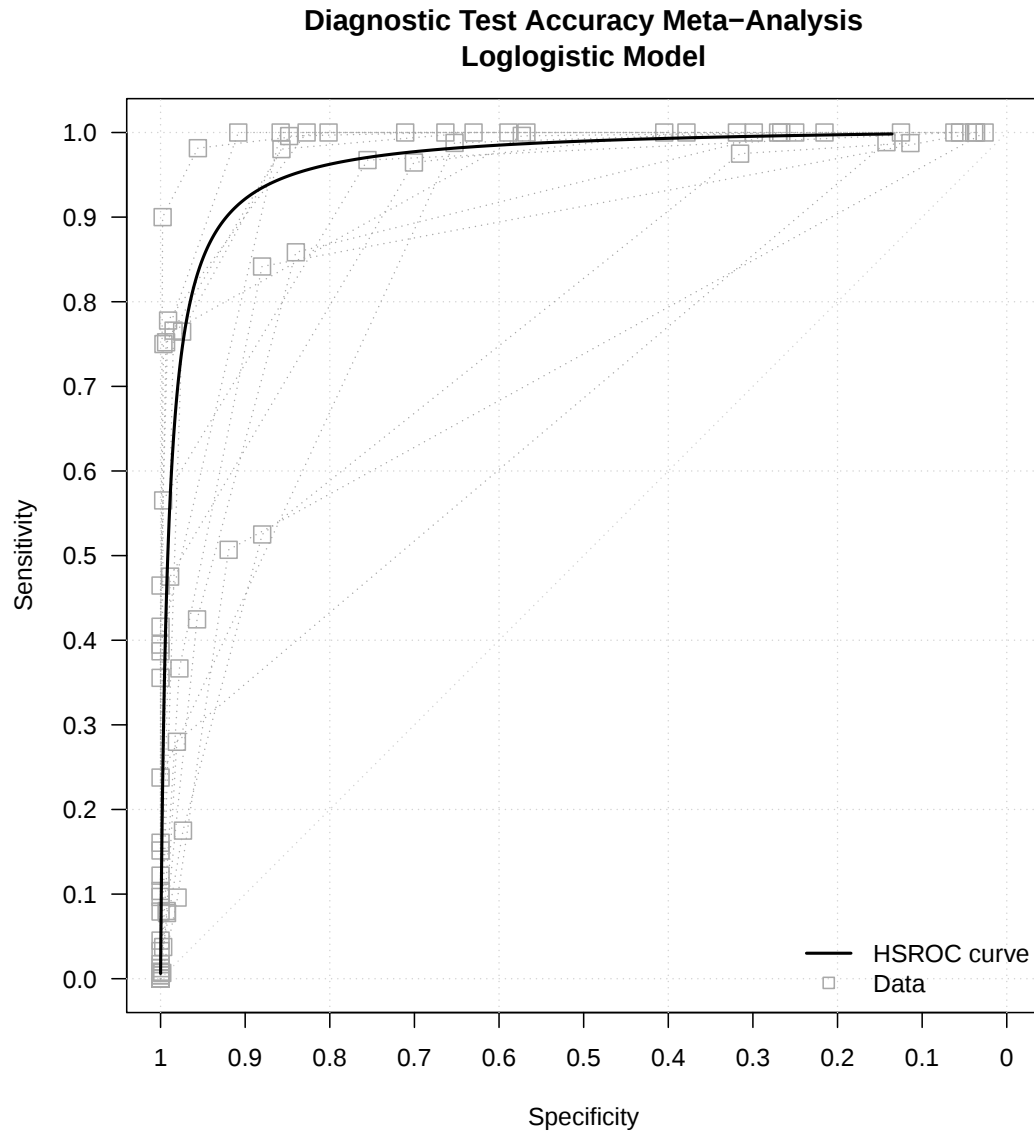
```
less <- fitHoyer(data=anaemia,
                 TP=TP,
                 FP=FP,
                 FN=FN,
                 TN=TN,
                 threshold=threshold,
                 study=study,
                 dist="loglogistic",
                 testdirection="less",
                 eval_threshold=c(8,9,10,11,12,13),
                 smallest=5,
                 largest=17)
```

```
less
#>
#> Hoyer Model
#> -----
#>
#> Number of studies : 15
#> Model fit          : Converged
#> -2 log likelihood : 19708.9 ( df = 7 )
#> AIC                : 19722.9
#> BIC                : 19727.86
#>
#> Distribution       : Loglogistic
#> Test direction     : less
#>
#> Use summary() for parameter estimates.
summary(less)
#> $sdreport2
#>
#>      Estimate   Std. Error
#> beta0      2.531071186 0.0169254101
#> lambda0    0.058309997 0.0007979991
#> su0        0.065266780 0.0120139561
#> beta1      2.253821209 0.0147254382
#> lambda1    0.060530034 0.0012263705
#> su1        0.056279481 0.0105351710
#> rho        -0.411758265 0.2194120812
#> covu0u1    -0.001512462 0.0010422566
#> logitSurv1 2.880878398 0.2497852789
#> logitSurv1 0.935017349 0.2438804386
#> logitSurv1 -0.805614673 0.2439346922
```

```

#> logitSurv1 -2.380207869 0.2483362272
#> logitSurv1 -3.817698831 0.2557856931
#> logitSurv1 -5.140062330 0.2652905618
#> logitSurv0 7.745320971 0.3083465399
#> logitSurv0 5.725375142 0.3001481581
#> logitSurv0 3.918472026 0.2948244780
#> logitSurv0 2.283929334 0.2917357077
#> logitSurv0 0.791708769 0.2903955841
#> logitSurv0 -0.581001083 0.2904281547
#>
#> $sensspec
#>   threshold conflevel      Sens SensCI_Lower SensCI_Upper      Spec
#> 1         8      0.95 0.05310695    0.0332319    0.08383789 0.9995674
#> 2         9      0.95 0.28190791    0.1957591    0.38769289 0.9967485
#> 3        10      0.95 0.69117423    0.5811538    0.78308198 0.9805157
#> 4        11      0.95 0.91530555    0.8691516    0.94618765 0.9075373
#> 5        12      0.95 0.97849434    0.9649861    0.98686211 0.6881981
#> 6        13      0.95 0.99417678    0.9902443    0.99652965 0.3587023
#>   SpecCI_Lower SpecCI_Upper
#> 1    0.9992086    0.9997636
#> 2    0.9941596    0.9981919
#> 3    0.9657965    0.9889730
#> 4    0.8471134    0.9456136
#> 5    0.5554075    0.7959017
#> 6    0.2404471    0.4970569
plot(less,main="Diagnostic Test Accuracy Meta-Analysis\nLoglogistic Model")

```



### How does `fitHoyer` work internally? – Optional advanced workflow

Most users should use the high-level `fitHoyer` function. The lower-level functions are provided for advanced use and transparency.

## Step 1: How do we restructure the data set?

```
res <- restructure_data(
  data = diabetes,
  TP = TP,
  FP = FP,
  FN = FN,
  TN = TN,
  study = study,
  threshold = threshold,
  testdirection = "greater",
  smallest = 2,
  largest = 10)
res
#> $restructured
#>
#>      study TP  TN  D  H threshold lowerB upperB events1 events0
#> Study 01.1 Study 01 574 1389 836 2071      5.9      NA      5.9      262      1389
#> Study 01.2 Study 01 574 1389 836 2071      5.9      5.9      NA      574      682
#> Study 02.1 Study 02 617 1005 635 8740      5.0      NA      5.0       18     1005
#> Study 02.2 Study 02 607 1617 635 8740      5.1      5.0      5.1       10      612
#> Study 02.3 Study 02 600 2438 635 8740      5.2      5.1      5.2        7      821
#> Study 02.4 Study 02 581 3409 635 8740      5.3      5.2      5.3       19      971
#> Study 02.5 Study 02 563 4422 635 8740      5.4      5.3      5.4       18     1013
#> Study 02.6 Study 02 550 5384 635 8740      5.5      5.4      5.5       13      962
#> Study 02.7 Study 02 522 6267 635 8740      5.6      5.5      5.6       28      883
#> Study 02.8 Study 02 489 6966 635 8740      5.7      5.6      5.7       33      699
#> Study 02.9 Study 02 457 7534 635 8740      5.8      5.7      5.8       32      568
#> Study 02.10 Study 02 429 7927 635 8740      5.9      5.8      5.9       28      393
#> Study 02.11 Study 02 393 8172 635 8740      6.0      5.9      6.0       36      245
#> Study 02.12 Study 02 332 8460 635 8740      6.2      6.0      6.2       61      288
#> Study 02.13 Study 02 236 8670 635 8740      6.6      6.2      6.6       96      210
#> Study 02.14 Study 02 236 8670 635 8740      6.6      6.6      NA      236       70
#> Study 03.1 Study 03  36  998  49 1093      6.2      NA      6.2       13      998
#> Study 03.2 Study 03  36  998  49 1093      6.2      6.2      NA       36       95
#> Study 04.1 Study 04  16  147  41  157      6.0      NA      6.0       25      147
#> Study 04.2 Study 04  16  147  41  157      6.0      6.0      NA       16       10
#> Study 05.1 Study 05 644 1217 795 1503      6.1      NA      6.1      151     1217
#> Study 05.2 Study 05 644 1217 795 1503      6.1      6.1      NA      644      286
#> Study 06.1 Study 06 176 1286 278 2054      5.6      NA      5.6      102     1286
#> Study 06.2 Study 06  69 1867 278 2054      6.5      5.6      6.5      107      581
#> Study 06.3 Study 06  69 1867 278 2054      6.5      6.5      NA       69      187
#> Study 07.1 Study 07  72  258  88  304      6.1      NA      6.1       16      258
```

|                |          |     |      |     |      |     |     |     |     |      |
|----------------|----------|-----|------|-----|------|-----|-----|-----|-----|------|
| #> Study 07.2  | Study 07 | 72  | 258  | 88  | 304  | 6.1 | 6.1 | NA  | 72  | 46   |
| #> Study 08.1  | Study 08 | 89  | 1382 | 115 | 1684 | 5.3 | NA  | 5.3 | 26  | 1382 |
| #> Study 08.2  | Study 08 | 72  | 1558 | 115 | 1684 | 5.5 | 5.3 | 5.5 | 17  | 176  |
| #> Study 08.3  | Study 08 | 65  | 1602 | 115 | 1684 | 5.6 | 5.5 | 5.6 | 7   | 44   |
| #> Study 08.4  | Study 08 | 65  | 1602 | 115 | 1684 | 5.6 | 5.6 | NA  | 65  | 82   |
| #> Study 09.1  | Study 09 | 207 | 2704 | 252 | 5865 | 5.8 | NA  | 5.8 | 45  | 2704 |
| #> Study 09.2  | Study 09 | 196 | 3308 | 252 | 5865 | 5.9 | 5.8 | 5.9 | 11  | 604  |
| #> Study 09.3  | Study 09 | 181 | 3877 | 252 | 5865 | 6.0 | 5.9 | 6.0 | 15  | 569  |
| #> Study 09.4  | Study 09 | 181 | 3877 | 252 | 5865 | 6.0 | 6.0 | NA  | 181 | 1988 |
| #> Study 10.1  | Study 10 | 54  | 1    | 54  | 451  | 3.9 | NA  | 3.9 | 0   | 1    |
| #> Study 10.2  | Study 10 | 54  | 45   | 54  | 451  | 4.7 | 3.9 | 4.7 | 0   | 44   |
| #> Study 10.3  | Study 10 | 46  | 363  | 54  | 451  | 5.6 | 4.7 | 5.6 | 8   | 318  |
| #> Study 10.4  | Study 10 | 43  | 389  | 54  | 451  | 5.7 | 5.6 | 5.7 | 3   | 26   |
| #> Study 10.5  | Study 10 | 23  | 447  | 54  | 451  | 6.2 | 5.7 | 6.2 | 20  | 58   |
| #> Study 10.6  | Study 10 | 12  | 451  | 54  | 451  | 6.8 | 6.2 | 6.8 | 11  | 4    |
| #> Study 10.7  | Study 10 | 12  | 451  | 54  | 451  | 6.8 | 6.8 | NA  | 12  | 0    |
| #> Study 11.1  | Study 11 | 861 | 611  | 895 | 5050 | 5.0 | NA  | 5.0 | 34  | 611  |
| #> Study 11.2  | Study 11 | 837 | 1000 | 895 | 5050 | 5.1 | 5.0 | 5.1 | 24  | 389  |
| #> Study 11.3  | Study 11 | 793 | 1525 | 895 | 5050 | 5.2 | 5.1 | 5.2 | 44  | 525  |
| #> Study 11.4  | Study 11 | 740 | 2116 | 895 | 5050 | 5.3 | 5.2 | 5.3 | 53  | 591  |
| #> Study 11.5  | Study 11 | 687 | 2762 | 895 | 5050 | 5.4 | 5.3 | 5.4 | 53  | 646  |
| #> Study 11.6  | Study 11 | 610 | 3358 | 895 | 5050 | 5.5 | 5.4 | 5.5 | 77  | 596  |
| #> Study 11.7  | Study 11 | 532 | 3883 | 895 | 5050 | 5.6 | 5.5 | 5.6 | 78  | 525  |
| #> Study 11.8  | Study 11 | 455 | 4277 | 895 | 5050 | 5.7 | 5.6 | 5.7 | 77  | 394  |
| #> Study 11.9  | Study 11 | 376 | 4585 | 895 | 5050 | 5.8 | 5.7 | 5.8 | 79  | 308  |
| #> Study 11.10 | Study 11 | 298 | 4782 | 895 | 5050 | 5.9 | 5.8 | 5.9 | 78  | 197  |
| #> Study 11.11 | Study 11 | 235 | 4883 | 895 | 5050 | 6.0 | 5.9 | 6.0 | 63  | 101  |
| #> Study 11.12 | Study 11 | 136 | 4984 | 895 | 5050 | 6.2 | 6.0 | 6.2 | 99  | 101  |
| #> Study 11.13 | Study 11 | 46  | 5045 | 895 | 5050 | 6.6 | 6.2 | 6.6 | 90  | 61   |
| #> Study 11.14 | Study 11 | 46  | 5045 | 895 | 5050 | 6.6 | 6.6 | NA  | 46  | 5    |
| #> Study 12.1  | Study 12 | 184 | 5265 | 338 | 5903 | 5.7 | NA  | 5.7 | 154 | 5265 |
| #> Study 12.2  | Study 12 | 184 | 5265 | 338 | 5903 | 5.7 | 5.7 | NA  | 184 | 638  |
| #> Study 13.1  | Study 13 | 72  | 120  | 81  | 333  | 5.5 | NA  | 5.5 | 9   | 120  |
| #> Study 13.2  | Study 13 | 70  | 144  | 81  | 333  | 5.6 | 5.5 | 5.6 | 2   | 24   |
| #> Study 13.3  | Study 13 | 66  | 170  | 81  | 333  | 5.7 | 5.6 | 5.7 | 4   | 26   |
| #> Study 13.4  | Study 13 | 58  | 204  | 81  | 333  | 5.8 | 5.7 | 5.8 | 8   | 34   |
| #> Study 13.5  | Study 13 | 50  | 234  | 81  | 333  | 5.9 | 5.8 | 5.9 | 8   | 30   |
| #> Study 13.6  | Study 13 | 40  | 256  | 81  | 333  | 6.0 | 5.9 | 6.0 | 10  | 22   |
| #> Study 13.7  | Study 13 | 40  | 256  | 81  | 333  | 6.0 | 6.0 | NA  | 40  | 77   |
| #> Study 14.1  | Study 14 | 285 | 155  | 295 | 1687 | 4.8 | NA  | 4.8 | 10  | 155  |
| #> Study 14.2  | Study 14 | 262 | 412  | 295 | 1687 | 5.1 | 4.8 | 5.1 | 23  | 257  |
| #> Study 14.3  | Study 14 | 253 | 516  | 295 | 1687 | 5.2 | 5.1 | 5.2 | 9   | 104  |

|               |          |     |      |     |      |     |     |     |     |      |
|---------------|----------|-----|------|-----|------|-----|-----|-----|-----|------|
| #> Study 14.4 | Study 14 | 234 | 680  | 295 | 1687 | 5.3 | 5.2 | 5.3 | 19  | 164  |
| #> Study 14.5 | Study 14 | 195 | 969  | 295 | 1687 | 5.5 | 5.3 | 5.5 | 39  | 289  |
| #> Study 14.6 | Study 14 | 169 | 1099 | 295 | 1687 | 5.6 | 5.5 | 5.6 | 26  | 130  |
| #> Study 14.7 | Study 14 | 138 | 1211 | 295 | 1687 | 5.7 | 5.6 | 5.7 | 31  | 112  |
| #> Study 14.8 | Study 14 | 91  | 1409 | 295 | 1687 | 5.9 | 5.7 | 5.9 | 47  | 198  |
| #> Study 14.9 | Study 14 | 91  | 1409 | 295 | 1687 | 5.9 | 5.9 | NA  | 91  | 278  |
| #> Study 15.1 | Study 15 | 108 | 626  | 114 | 4816 | 5.0 | NA  | 5.0 | 6   | 626  |
| #> Study 15.2 | Study 15 | 91  | 2745 | 114 | 4816 | 5.5 | 5.0 | 5.5 | 17  | 2119 |
| #> Study 15.3 | Study 15 | 74  | 3660 | 114 | 4816 | 5.7 | 5.5 | 5.7 | 17  | 915  |
| #> Study 15.4 | Study 15 | 48  | 4479 | 114 | 4816 | 6.0 | 5.7 | 6.0 | 26  | 819  |
| #> Study 15.5 | Study 15 | 7   | 4816 | 114 | 4816 | 6.4 | 6.0 | 6.4 | 41  | 337  |
| #> Study 15.6 | Study 15 | 7   | 4816 | 114 | 4816 | 6.4 | 6.4 | NA  | 7   | 0    |
| #> Study 16.1 | Study 16 | 184 | 181  | 186 | 5826 | 5.0 | NA  | 5.0 | 2   | 181  |
| #> Study 16.2 | Study 16 | 164 | 3437 | 186 | 5826 | 5.5 | 5.0 | 5.5 | 20  | 3256 |
| #> Study 16.3 | Study 16 | 145 | 4719 | 186 | 5826 | 5.7 | 5.5 | 5.7 | 19  | 1282 |
| #> Study 16.4 | Study 16 | 84  | 5593 | 186 | 5826 | 6.0 | 5.7 | 6.0 | 61  | 874  |
| #> Study 16.5 | Study 16 | 4   | 5826 | 186 | 5826 | 6.4 | 6.0 | 6.4 | 80  | 233  |
| #> Study 16.6 | Study 16 | 4   | 5826 | 186 | 5826 | 6.4 | 6.4 | NA  | 4   | 0    |
| #> Study 17.1 | Study 17 | 88  | 480  | 92  | 3692 | 5.0 | NA  | 5.0 | 4   | 480  |
| #> Study 17.2 | Study 17 | 74  | 2252 | 92  | 3692 | 5.5 | 5.0 | 5.5 | 14  | 1772 |
| #> Study 17.3 | Study 17 | 61  | 2954 | 92  | 3692 | 5.7 | 5.5 | 5.7 | 13  | 702  |
| #> Study 17.4 | Study 17 | 35  | 3507 | 92  | 3692 | 6.0 | 5.7 | 6.0 | 26  | 553  |
| #> Study 17.5 | Study 17 | 4   | 3692 | 92  | 3692 | 6.4 | 6.0 | 6.4 | 31  | 185  |
| #> Study 17.6 | Study 17 | 4   | 3692 | 92  | 3692 | 6.4 | 6.4 | NA  | 4   | 0    |
| #> Study 18.1 | Study 18 | 21  | 284  | 64  | 320  | 5.7 | NA  | 5.7 | 43  | 284  |
| #> Study 18.2 | Study 18 | 21  | 284  | 64  | 320  | 5.7 | 5.7 | NA  | 21  | 36   |
| #> Study 19.1 | Study 19 | 49  | 691  | 57  | 1132 | 5.1 | NA  | 5.1 | 8   | 691  |
| #> Study 19.2 | Study 19 | 42  | 814  | 57  | 1132 | 5.2 | 5.1 | 5.2 | 7   | 123  |
| #> Study 19.3 | Study 19 | 32  | 994  | 57  | 1132 | 5.3 | 5.2 | 5.3 | 10  | 180  |
| #> Study 19.4 | Study 19 | 26  | 1045 | 57  | 1132 | 5.4 | 5.3 | 5.4 | 6   | 51   |
| #> Study 19.5 | Study 19 | 26  | 1045 | 57  | 1132 | 5.4 | 5.4 | NA  | 26  | 87   |
| #> Study 20.1 | Study 20 | 596 | 2062 | 659 | 6145 | 5.0 | NA  | 5.0 | 63  | 2062 |
| #> Study 20.2 | Study 20 | 392 | 5015 | 659 | 6145 | 5.5 | 5.0 | 5.5 | 204 | 2953 |
| #> Study 20.3 | Study 20 | 137 | 5999 | 659 | 6145 | 6.0 | 5.5 | 6.0 | 255 | 984  |
| #> Study 20.4 | Study 20 | 137 | 5999 | 659 | 6145 | 6.0 | 6.0 | NA  | 137 | 146  |
| #> Study 21.1 | Study 21 | 187 | 8562 | 368 | 9674 | 5.5 | NA  | 5.5 | 181 | 8562 |
| #> Study 21.2 | Study 21 | 187 | 8562 | 368 | 9674 | 5.5 | 5.5 | NA  | 187 | 1112 |
| #> Study 22.1 | Study 22 | 9   | 395  | 17  | 432  | 5.8 | NA  | 5.8 | 8   | 395  |
| #> Study 22.2 | Study 22 | 9   | 395  | 17  | 432  | 5.8 | 5.8 | NA  | 9   | 37   |
| #> Study 23.1 | Study 23 | 122 | 215  | 164 | 304  | 5.5 | NA  | 5.5 | 42  | 215  |
| #> Study 23.2 | Study 23 | 88  | 265  | 164 | 304  | 5.7 | 5.5 | 5.7 | 34  | 50   |
| #> Study 23.3 | Study 23 | 88  | 265  | 164 | 304  | 5.7 | 5.7 | NA  | 88  | 39   |

|               |          |     |      |     |      |     |     |     |     |      |
|---------------|----------|-----|------|-----|------|-----|-----|-----|-----|------|
| #> Study 24.1 | Study 24 | 22  | 129  | 44  | 164  | 6.1 | NA  | 6.1 | 22  | 129  |
| #> Study 24.2 | Study 24 | 22  | 129  | 44  | 164  | 6.1 | 6.1 | NA  | 22  | 35   |
| #> Study 25.1 | Study 25 | 79  | 217  | 80  | 882  | 6.6 | NA  | 6.6 | 1   | 217  |
| #> Study 25.2 | Study 25 | 79  | 217  | 80  | 882  | 6.6 | 6.6 | NA  | 79  | 665  |
| #> Study 26.1 | Study 26 | 114 | 203  | 178 | 223  | 6.9 | NA  | 6.9 | 64  | 203  |
| #> Study 26.2 | Study 26 | 90  | 219  | 178 | 223  | 7.4 | 6.9 | 7.4 | 24  | 16   |
| #> Study 26.3 | Study 26 | 73  | 223  | 178 | 223  | 7.6 | 7.4 | 7.6 | 17  | 4    |
| #> Study 26.4 | Study 26 | 73  | 223  | 178 | 223  | 7.6 | 7.6 | NA  | 73  | 0    |
| #> Study 27.1 | Study 27 | 135 | 592  | 178 | 688  | 5.9 | NA  | 5.9 | 43  | 592  |
| #> Study 27.2 | Study 27 | 87  | 674  | 178 | 688  | 6.5 | 5.9 | 6.5 | 48  | 82   |
| #> Study 27.3 | Study 27 | 87  | 674  | 178 | 688  | 6.5 | 6.5 | NA  | 87  | 14   |
| #> Study 28.1 | Study 28 | 575 | 980  | 627 | 2250 | 5.5 | NA  | 5.5 | 52  | 980  |
| #> Study 28.2 | Study 28 | 486 | 1773 | 627 | 2250 | 6.1 | 5.5 | 6.1 | 89  | 793  |
| #> Study 28.3 | Study 28 | 486 | 1773 | 627 | 2250 | 6.1 | 6.1 | NA  | 486 | 477  |
| #> Study 29.1 | Study 29 | 23  | 109  | 30  | 114  | 6.1 | NA  | 6.1 | 7   | 109  |
| #> Study 29.2 | Study 29 | 23  | 109  | 30  | 114  | 6.1 | 6.1 | NA  | 23  | 5    |
| #> Study 30.1 | Study 30 | 424 | 2112 | 616 | 2233 | 6.0 | NA  | 6.0 | 192 | 2112 |
| #> Study 30.2 | Study 30 | 424 | 2112 | 616 | 2233 | 6.0 | 6.0 | NA  | 424 | 121  |
| #> Study 31.1 | Study 31 | 338 | 4060 | 367 | 6436 | 5.7 | NA  | 5.7 | 29  | 4060 |
| #> Study 31.2 | Study 31 | 338 | 4060 | 367 | 6436 | 5.7 | 5.7 | NA  | 338 | 2376 |
| #> Study 32.1 | Study 32 | 57  | 32   | 64  | 44   | 6.0 | NA  | 6.0 | 7   | 32   |
| #> Study 32.2 | Study 32 | 50  | 40   | 64  | 44   | 6.4 | 6.0 | 6.4 | 7   | 8    |
| #> Study 32.3 | Study 32 | 47  | 41   | 64  | 44   | 6.5 | 6.4 | 6.5 | 3   | 1    |
| #> Study 32.4 | Study 32 | 40  | 43   | 64  | 44   | 7.0 | 6.5 | 7.0 | 7   | 2    |
| #> Study 32.5 | Study 32 | 40  | 43   | 64  | 44   | 7.0 | 7.0 | NA  | 40  | 1    |
| #> Study 33.1 | Study 33 | 52  | 79   | 65  | 116  | 5.6 | NA  | 5.6 | 13  | 79   |
| #> Study 33.2 | Study 33 | 52  | 79   | 65  | 116  | 5.6 | 5.6 | NA  | 52  | 37   |
| #> Study 34.1 | Study 34 | 111 | 83   | 112 | 489  | 5.0 | NA  | 5.0 | 1   | 83   |
| #> Study 34.2 | Study 34 | 110 | 225  | 112 | 489  | 5.5 | 5.0 | 5.5 | 1   | 142  |
| #> Study 34.3 | Study 34 | 100 | 381  | 112 | 489  | 6.0 | 5.5 | 6.0 | 10  | 156  |
| #> Study 34.4 | Study 34 | 78  | 465  | 112 | 489  | 6.5 | 6.0 | 6.5 | 22  | 84   |
| #> Study 34.5 | Study 34 | 60  | 479  | 112 | 489  | 7.0 | 6.5 | 7.0 | 18  | 14   |
| #> Study 34.6 | Study 34 | 60  | 479  | 112 | 489  | 7.0 | 7.0 | NA  | 60  | 10   |
| #> Study 35.1 | Study 35 | 20  | 60   | 21  | 90   | 5.9 | NA  | 5.9 | 1   | 60   |
| #> Study 35.2 | Study 35 | 19  | 62   | 21  | 90   | 6.0 | 5.9 | 6.0 | 1   | 2    |
| #> Study 35.3 | Study 35 | 17  | 76   | 21  | 90   | 6.1 | 6.0 | 6.1 | 2   | 14   |
| #> Study 35.4 | Study 35 | 17  | 79   | 21  | 90   | 6.2 | 6.1 | 6.2 | 0   | 3    |
| #> Study 35.5 | Study 35 | 17  | 79   | 21  | 90   | 6.3 | 6.2 | 6.3 | 0   | 0    |
| #> Study 35.6 | Study 35 | 16  | 81   | 21  | 90   | 6.4 | 6.3 | 6.4 | 1   | 2    |
| #> Study 35.7 | Study 35 | 13  | 81   | 21  | 90   | 6.5 | 6.4 | 6.5 | 3   | 0    |
| #> Study 35.8 | Study 35 | 12  | 86   | 21  | 90   | 6.6 | 6.5 | 6.6 | 1   | 5    |
| #> Study 35.9 | Study 35 | 11  | 87   | 21  | 90   | 6.7 | 6.6 | 6.7 | 1   | 1    |

```

#> Study 35.10 Study 35 11 87 21 90 6.8 6.7 6.8 0 0
#> Study 35.11 Study 35 11 88 21 90 6.9 6.8 6.9 0 1
#> Study 35.12 Study 35 10 88 21 90 7.0 6.9 7.0 1 0
#> Study 35.13 Study 35 10 88 21 90 7.0 7.0 NA 10 2
#> Study 36.1 Study 36 25 243 27 288 5.9 NA 5.9 2 243
#> Study 36.2 Study 36 25 243 27 288 5.9 5.9 NA 25 45
#> Study 37.1 Study 37 12 268 14 293 5.9 NA 5.9 2 268
#> Study 37.2 Study 37 12 268 14 293 5.9 5.9 NA 12 25
#> Study 38.1 Study 38 13 260 19 295 5.9 NA 5.9 6 260
#> Study 38.2 Study 38 13 260 19 295 5.9 5.9 NA 13 35
#> ctype lcutmean
#> Study 01.1 1 1.234050
#> Study 01.2 3 2.038769
#> Study 02.1 1 1.151293
#> Study 02.2 2 1.619339
#> Study 02.3 2 1.638950
#> Study 02.4 2 1.658183
#> Study 02.5 2 1.677053
#> Study 02.6 2 1.695574
#> Study 02.7 2 1.713757
#> Study 02.8 2 1.731616
#> Study 02.9 2 1.749162
#> Study 02.10 2 1.766405
#> Study 02.11 2 1.783356
#> Study 02.12 2 1.808154
#> Study 02.13 2 1.855809
#> Study 02.14 3 2.094827
#> Study 03.1 1 1.258848
#> Study 03.2 3 2.063567
#> Study 04.1 1 1.242453
#> Study 04.2 3 2.047172
#> Study 05.1 1 1.250718
#> Study 05.2 3 2.055437
#> Study 06.1 1 1.207957
#> Study 06.2 2 1.797284
#> Study 06.3 3 2.087194
#> Study 07.1 1 1.250718
#> Study 07.2 3 2.055437
#> Study 08.1 1 1.180427
#> Study 08.2 2 1.686227
#> Study 08.3 2 1.713757
#> Study 08.4 3 2.012676

```

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#> Study 09.1      1 1.225503
#> Study 09.2      2 1.766405
#> Study 09.3      2 1.783356
#> Study 09.4      3 2.047172
#> Study 10.1      1 1.027062
#> Study 10.2      2 1.454270
#> Study 10.3      2 1.635165
#> Study 10.4      2 1.731616
#> Study 10.5      2 1.782508
#> Study 10.6      2 1.870736
#> Study 10.7      3 2.109754
#> Study 11.1      1 1.151293
#> Study 11.2      2 1.619339
#> Study 11.3      2 1.638950
#> Study 11.4      2 1.658183
#> Study 11.5      2 1.677053
#> Study 11.6      2 1.695574
#> Study 11.7      2 1.713757
#> Study 11.8      2 1.731616
#> Study 11.9      2 1.749162
#> Study 11.10     2 1.766405
#> Study 11.11     2 1.783356
#> Study 11.12     2 1.808154
#> Study 11.13     2 1.855809
#> Study 11.14     3 2.094827
#> Study 12.1      1 1.216807
#> Study 12.2      3 2.021526
#> Study 13.1      1 1.198948
#> Study 13.2      2 1.713757
#> Study 13.3      2 1.731616
#> Study 13.4      2 1.749162
#> Study 13.5      2 1.766405
#> Study 13.6      2 1.783356
#> Study 13.7      3 2.047172
#> Study 14.1      1 1.130882
#> Study 14.2      2 1.598928
#> Study 14.3      2 1.638950
#> Study 14.4      2 1.658183
#> Study 14.5      2 1.686227
#> Study 14.6      2 1.713757
#> Study 14.7      2 1.731616
#> Study 14.8      2 1.757709

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#> Study 14.9      3 2.038769
#> Study 15.1      1 1.151293
#> Study 15.2      2 1.657093
#> Study 15.3      2 1.722607
#> Study 15.4      2 1.766113
#> Study 15.5      2 1.824029
#> Study 15.6      3 2.079442
#> Study 16.1      1 1.151293
#> Study 16.2      2 1.657093
#> Study 16.3      2 1.722607
#> Study 16.4      2 1.766113
#> Study 16.5      2 1.824029
#> Study 16.6      3 2.079442
#> Study 17.1      1 1.151293
#> Study 17.2      2 1.657093
#> Study 17.3      2 1.722607
#> Study 17.4      2 1.766113
#> Study 17.5      2 1.824029
#> Study 17.6      3 2.079442
#> Study 18.1      1 1.216807
#> Study 18.2      3 2.021526
#> Study 19.1      1 1.161194
#> Study 19.2      2 1.638950
#> Study 19.3      2 1.658183
#> Study 19.4      2 1.677053
#> Study 19.5      3 1.994492
#> Study 20.1      1 1.151293
#> Study 20.2      2 1.657093
#> Study 20.3      2 1.748254
#> Study 20.4      3 2.047172
#> Study 21.1      1 1.198948
#> Study 21.2      3 2.003667
#> Study 22.1      1 1.225503
#> Study 22.2      3 2.030222
#> Study 23.1      1 1.198948
#> Study 23.2      2 1.722607
#> Study 23.3      3 2.021526
#> Study 24.1      1 1.250718
#> Study 24.2      3 2.055437
#> Study 25.1      1 1.290108
#> Study 25.2      3 2.094827
#> Study 26.1      1 1.312334

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```

#> Study 26.2      2 1.966501
#> Study 26.3      2 2.014814
#> Study 26.4      3 2.165367
#> Study 27.1      1 1.234050
#> Study 27.2      2 1.823377
#> Study 27.3      3 2.087194
#> Study 28.1      1 1.198948
#> Study 28.2      2 1.756518
#> Study 28.3      3 2.055437
#> Study 29.1      1 1.250718
#> Study 29.2      3 2.055437
#> Study 30.1      1 1.242453
#> Study 30.2      3 2.047172
#> Study 31.1      1 1.216807
#> Study 31.2      3 2.021526
#> Study 32.1      1 1.242453
#> Study 32.2      2 1.824029
#> Study 32.3      2 1.864050
#> Study 32.4      2 1.908856
#> Study 32.5      3 2.124248
#> Study 33.1      1 1.207957
#> Study 33.2      3 2.012676
#> Study 34.1      1 1.151293
#> Study 34.2      2 1.657093
#> Study 34.3      2 1.748254
#> Study 34.4      2 1.831781
#> Study 34.5      2 1.908856
#> Study 34.6      3 2.124248
#> Study 35.1      1 1.234050
#> Study 35.2      2 1.783356
#> Study 35.3      2 1.800024
#> Study 35.4      2 1.816419
#> Study 35.5      2 1.832549
#> Study 35.6      2 1.848424
#> Study 35.7      2 1.864050
#> Study 35.8      2 1.879436
#> Study 35.9      2 1.894589
#> Study 35.10     2 1.909515
#> Study 35.11     2 1.924222
#> Study 35.12     2 1.938716
#> Study 35.13     3 2.124248
#> Study 36.1      1 1.234050

```

```

#> Study 36.2      3 2.038769
#> Study 37.1      1 1.234050
#> Study 37.2      3 2.038769
#> Study 38.1      1 1.234050
#> Study 38.2      3 2.038769
#>
#> $original
#>      study TP   TN   FP  FN threshold  n1   n0 testdirection      sens
#> 1  Study 01 574 1389  682 262      5.9 836 2071      greater 0.68660287
#> 2  Study 02 617 1005 7735  18      5.0 635 8740      greater 0.97165354
#> 3  Study 02 607 1617 7123  28      5.1 635 8740      greater 0.95590551
#> 4  Study 02 600 2438 6302  35      5.2 635 8740      greater 0.94488189
#> 5  Study 02 581 3409 5331  54      5.3 635 8740      greater 0.91496063
#> 6  Study 02 563 4422 4318  72      5.4 635 8740      greater 0.88661417
#> 7  Study 02 550 5384 3356  85      5.5 635 8740      greater 0.86614173
#> 8  Study 02 522 6267 2473 113      5.6 635 8740      greater 0.82204724
#> 9  Study 02 489 6966 1774 146      5.7 635 8740      greater 0.77007874
#> 10 Study 02 457 7534 1206 178      5.8 635 8740      greater 0.71968504
#> 11 Study 02 429 7927  813 206      5.9 635 8740      greater 0.67559055
#> 12 Study 02 393 8172  568 242      6.0 635 8740      greater 0.61889764
#> 13 Study 02 332 8460  280 303      6.2 635 8740      greater 0.52283465
#> 14 Study 02 236 8670   70 399      6.6 635 8740      greater 0.37165354
#> 15 Study 03  36  998   95  13      6.2  49 1093      greater 0.73469388
#> 16 Study 04  16  147   10  25      6.0  41  157      greater 0.39024390
#> 17 Study 05 644 1217  286 151      6.1 795 1503      greater 0.81006289
#> 18 Study 06 176 1286  768 102      5.6 278 2054      greater 0.63309353
#> 19 Study 06  69 1867  187 209      6.5 278 2054      greater 0.24820144
#> 20 Study 07  72  258   46  16      6.1  88  304      greater 0.81818182
#> 21 Study 08  89 1382  302  26      5.3 115 1684      greater 0.77391304
#> 22 Study 08  72 1558  126  43      5.5 115 1684      greater 0.62608696
#> 23 Study 08  65 1602   82  50      5.6 115 1684      greater 0.56521739
#> 24 Study 09 207 2704 3161  45      5.8 252 5865      greater 0.82142857
#> 25 Study 09 196 3308 2557  56      5.9 252 5865      greater 0.77777778
#> 26 Study 09 181 3877 1988  71      6.0 252 5865      greater 0.71825397
#> 27 Study 10  54   1  450   0      3.9  54  451      greater 1.00000000
#> 28 Study 10  54  45  406   0      4.7  54  451      greater 1.00000000
#> 29 Study 10  46 363   88   8      5.6  54  451      greater 0.85185185
#> 30 Study 10  43 389   62  11      5.7  54  451      greater 0.79629630
#> 31 Study 10  23 447    4  31      6.2  54  451      greater 0.42592593
#> 32 Study 10  12 451    0  42      6.8  54  451      greater 0.22222222
#> 33 Study 11 861 611 4439  34      5.0 895 5050      greater 0.96201117
#> 34 Study 11 837 1000 4050  58      5.1 895 5050      greater 0.93519553

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|       |          |     |      |      |     |     |     |      |         |            |
|-------|----------|-----|------|------|-----|-----|-----|------|---------|------------|
| #> 35 | Study 11 | 793 | 1525 | 3525 | 102 | 5.2 | 895 | 5050 | greater | 0.88603352 |
| #> 36 | Study 11 | 740 | 2116 | 2934 | 155 | 5.3 | 895 | 5050 | greater | 0.82681564 |
| #> 37 | Study 11 | 687 | 2762 | 2288 | 208 | 5.4 | 895 | 5050 | greater | 0.76759777 |
| #> 38 | Study 11 | 610 | 3358 | 1692 | 285 | 5.5 | 895 | 5050 | greater | 0.68156425 |
| #> 39 | Study 11 | 532 | 3883 | 1167 | 363 | 5.6 | 895 | 5050 | greater | 0.59441341 |
| #> 40 | Study 11 | 455 | 4277 | 773  | 440 | 5.7 | 895 | 5050 | greater | 0.50837989 |
| #> 41 | Study 11 | 376 | 4585 | 465  | 519 | 5.8 | 895 | 5050 | greater | 0.42011173 |
| #> 42 | Study 11 | 298 | 4782 | 268  | 597 | 5.9 | 895 | 5050 | greater | 0.33296089 |
| #> 43 | Study 11 | 235 | 4883 | 167  | 660 | 6.0 | 895 | 5050 | greater | 0.26256983 |
| #> 44 | Study 11 | 136 | 4984 | 66   | 759 | 6.2 | 895 | 5050 | greater | 0.15195531 |
| #> 45 | Study 11 | 46  | 5045 | 5    | 849 | 6.6 | 895 | 5050 | greater | 0.05139665 |
| #> 46 | Study 12 | 184 | 5265 | 638  | 154 | 5.7 | 338 | 5903 | greater | 0.54437870 |
| #> 47 | Study 13 | 72  | 120  | 213  | 9   | 5.5 | 81  | 333  | greater | 0.88888889 |
| #> 48 | Study 13 | 70  | 144  | 189  | 11  | 5.6 | 81  | 333  | greater | 0.86419753 |
| #> 49 | Study 13 | 66  | 170  | 163  | 15  | 5.7 | 81  | 333  | greater | 0.81481481 |
| #> 50 | Study 13 | 58  | 204  | 129  | 23  | 5.8 | 81  | 333  | greater | 0.71604938 |
| #> 51 | Study 13 | 50  | 234  | 99   | 31  | 5.9 | 81  | 333  | greater | 0.61728395 |
| #> 52 | Study 13 | 40  | 256  | 77   | 41  | 6.0 | 81  | 333  | greater | 0.49382716 |
| #> 53 | Study 14 | 285 | 155  | 1532 | 10  | 4.8 | 295 | 1687 | greater | 0.96610169 |
| #> 54 | Study 14 | 262 | 412  | 1275 | 33  | 5.1 | 295 | 1687 | greater | 0.88813559 |
| #> 55 | Study 14 | 253 | 516  | 1171 | 42  | 5.2 | 295 | 1687 | greater | 0.85762712 |
| #> 56 | Study 14 | 234 | 680  | 1007 | 61  | 5.3 | 295 | 1687 | greater | 0.79322034 |
| #> 57 | Study 14 | 195 | 969  | 718  | 100 | 5.5 | 295 | 1687 | greater | 0.66101695 |
| #> 58 | Study 14 | 169 | 1099 | 588  | 126 | 5.6 | 295 | 1687 | greater | 0.57288136 |
| #> 59 | Study 14 | 138 | 1211 | 476  | 157 | 5.7 | 295 | 1687 | greater | 0.46779661 |
| #> 60 | Study 14 | 91  | 1409 | 278  | 204 | 5.9 | 295 | 1687 | greater | 0.30847458 |
| #> 61 | Study 15 | 108 | 626  | 4190 | 6   | 5.0 | 114 | 4816 | greater | 0.94736842 |
| #> 62 | Study 15 | 91  | 2745 | 2071 | 23  | 5.5 | 114 | 4816 | greater | 0.79824561 |
| #> 63 | Study 15 | 74  | 3660 | 1156 | 40  | 5.7 | 114 | 4816 | greater | 0.64912281 |
| #> 64 | Study 15 | 48  | 4479 | 337  | 66  | 6.0 | 114 | 4816 | greater | 0.42105263 |
| #> 65 | Study 15 | 7   | 4816 | 0    | 107 | 6.4 | 114 | 4816 | greater | 0.06140351 |
| #> 66 | Study 16 | 184 | 181  | 5645 | 2   | 5.0 | 186 | 5826 | greater | 0.98924731 |
| #> 67 | Study 16 | 164 | 3437 | 2389 | 22  | 5.5 | 186 | 5826 | greater | 0.88172043 |
| #> 68 | Study 16 | 145 | 4719 | 1107 | 41  | 5.7 | 186 | 5826 | greater | 0.77956989 |
| #> 69 | Study 16 | 84  | 5593 | 233  | 102 | 6.0 | 186 | 5826 | greater | 0.45161290 |
| #> 70 | Study 16 | 4   | 5826 | 0    | 182 | 6.4 | 186 | 5826 | greater | 0.02150538 |
| #> 71 | Study 17 | 88  | 480  | 3212 | 4   | 5.0 | 92  | 3692 | greater | 0.95652174 |
| #> 72 | Study 17 | 74  | 2252 | 1440 | 18  | 5.5 | 92  | 3692 | greater | 0.80434783 |
| #> 73 | Study 17 | 61  | 2954 | 738  | 31  | 5.7 | 92  | 3692 | greater | 0.66304348 |
| #> 74 | Study 17 | 35  | 3507 | 185  | 57  | 6.0 | 92  | 3692 | greater | 0.38043478 |
| #> 75 | Study 17 | 4   | 3692 | 0    | 88  | 6.4 | 92  | 3692 | greater | 0.04347826 |
| #> 76 | Study 18 | 21  | 284  | 36   | 43  | 5.7 | 64  | 320  | greater | 0.32812500 |

|        |       |    |     |      |      |     |     |     |      |         |            |
|--------|-------|----|-----|------|------|-----|-----|-----|------|---------|------------|
| #> 77  | Study | 19 | 49  | 691  | 441  | 8   | 5.1 | 57  | 1132 | greater | 0.85964912 |
| #> 78  | Study | 19 | 42  | 814  | 318  | 15  | 5.2 | 57  | 1132 | greater | 0.73684211 |
| #> 79  | Study | 19 | 32  | 994  | 138  | 25  | 5.3 | 57  | 1132 | greater | 0.56140351 |
| #> 80  | Study | 19 | 26  | 1045 | 87   | 31  | 5.4 | 57  | 1132 | greater | 0.45614035 |
| #> 82  | Study | 20 | 596 | 2062 | 4083 | 63  | 5.0 | 659 | 6145 | greater | 0.90440061 |
| #> 81  | Study | 20 | 392 | 5015 | 1130 | 267 | 5.5 | 659 | 6145 | greater | 0.59484067 |
| #> 83  | Study | 20 | 137 | 5999 | 146  | 522 | 6.0 | 659 | 6145 | greater | 0.20789074 |
| #> 84  | Study | 21 | 187 | 8562 | 1112 | 181 | 5.5 | 368 | 9674 | greater | 0.50815217 |
| #> 85  | Study | 22 | 9   | 395  | 37   | 8   | 5.8 | 17  | 432  | greater | 0.52941176 |
| #> 86  | Study | 23 | 122 | 215  | 89   | 42  | 5.5 | 164 | 304  | greater | 0.74390244 |
| #> 87  | Study | 23 | 88  | 265  | 39   | 76  | 5.7 | 164 | 304  | greater | 0.53658537 |
| #> 88  | Study | 24 | 22  | 129  | 35   | 22  | 6.1 | 44  | 164  | greater | 0.50000000 |
| #> 89  | Study | 25 | 79  | 217  | 665  | 1   | 6.6 | 80  | 882  | greater | 0.98750000 |
| #> 90  | Study | 26 | 114 | 203  | 20   | 64  | 6.9 | 178 | 223  | greater | 0.64044944 |
| #> 91  | Study | 26 | 90  | 219  | 4    | 88  | 7.4 | 178 | 223  | greater | 0.50561798 |
| #> 92  | Study | 26 | 73  | 223  | 0    | 105 | 7.6 | 178 | 223  | greater | 0.41011236 |
| #> 93  | Study | 27 | 135 | 592  | 96   | 43  | 5.9 | 178 | 688  | greater | 0.75842697 |
| #> 94  | Study | 27 | 87  | 674  | 14   | 91  | 6.5 | 178 | 688  | greater | 0.48876404 |
| #> 95  | Study | 28 | 575 | 980  | 1270 | 52  | 5.5 | 627 | 2250 | greater | 0.91706539 |
| #> 96  | Study | 28 | 486 | 1773 | 477  | 141 | 6.1 | 627 | 2250 | greater | 0.77511962 |
| #> 97  | Study | 29 | 23  | 109  | 5    | 7   | 6.1 | 30  | 114  | greater | 0.76666667 |
| #> 98  | Study | 30 | 424 | 2112 | 121  | 192 | 6.0 | 616 | 2233 | greater | 0.68831169 |
| #> 99  | Study | 31 | 338 | 4060 | 2376 | 29  | 5.7 | 367 | 6436 | greater | 0.92098093 |
| #> 100 | Study | 32 | 57  | 32   | 12   | 7   | 6.0 | 64  | 44   | greater | 0.89062500 |
| #> 101 | Study | 32 | 50  | 40   | 4    | 14  | 6.4 | 64  | 44   | greater | 0.78125000 |
| #> 102 | Study | 32 | 47  | 41   | 3    | 17  | 6.5 | 64  | 44   | greater | 0.73437500 |
| #> 103 | Study | 32 | 40  | 43   | 1    | 24  | 7.0 | 64  | 44   | greater | 0.62500000 |
| #> 104 | Study | 33 | 52  | 79   | 37   | 13  | 5.6 | 65  | 116  | greater | 0.80000000 |
| #> 105 | Study | 34 | 111 | 83   | 406  | 1   | 5.0 | 112 | 489  | greater | 0.99107143 |
| #> 106 | Study | 34 | 110 | 225  | 264  | 2   | 5.5 | 112 | 489  | greater | 0.98214286 |
| #> 107 | Study | 34 | 100 | 381  | 108  | 12  | 6.0 | 112 | 489  | greater | 0.89285714 |
| #> 108 | Study | 34 | 78  | 465  | 24   | 34  | 6.5 | 112 | 489  | greater | 0.69642857 |
| #> 109 | Study | 34 | 60  | 479  | 10   | 52  | 7.0 | 112 | 489  | greater | 0.53571429 |
| #> 110 | Study | 35 | 20  | 60   | 30   | 1   | 5.9 | 21  | 90   | greater | 0.95238095 |
| #> 111 | Study | 35 | 19  | 62   | 28   | 2   | 6.0 | 21  | 90   | greater | 0.90476190 |
| #> 112 | Study | 35 | 17  | 76   | 14   | 4   | 6.1 | 21  | 90   | greater | 0.80952381 |
| #> 113 | Study | 35 | 17  | 79   | 11   | 4   | 6.2 | 21  | 90   | greater | 0.80952381 |
| #> 114 | Study | 35 | 17  | 79   | 11   | 4   | 6.3 | 21  | 90   | greater | 0.80952381 |
| #> 115 | Study | 35 | 16  | 81   | 9    | 5   | 6.4 | 21  | 90   | greater | 0.76190476 |
| #> 116 | Study | 35 | 13  | 81   | 9    | 8   | 6.5 | 21  | 90   | greater | 0.61904762 |
| #> 117 | Study | 35 | 12  | 86   | 4    | 9   | 6.6 | 21  | 90   | greater | 0.57142857 |
| #> 118 | Study | 35 | 11  | 87   | 3    | 10  | 6.7 | 21  | 90   | greater | 0.52380952 |

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#> 119 Study 35 11 87 3 10 6.8 21 90 greater 0.52380952
#> 120 Study 35 11 88 2 10 6.9 21 90 greater 0.52380952
#> 121 Study 35 10 88 2 11 7.0 21 90 greater 0.47619048
#> 122 Study 36 25 243 45 2 5.9 27 288 greater 0.92592593
#> 123 Study 37 12 268 25 2 5.9 14 293 greater 0.85714286
#> 124 Study 38 13 260 35 6 5.9 19 295 greater 0.68421053
#> spec fpr
#> 1 0.670690488 0.329309512
#> 2 0.114988558 0.885011442
#> 3 0.185011442 0.814988558
#> 4 0.278947368 0.721052632
#> 5 0.390045767 0.609954233
#> 6 0.505949657 0.494050343
#> 7 0.616018307 0.383981693
#> 8 0.717048055 0.282951945
#> 9 0.797025172 0.202974828
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#> 11 0.906979405 0.093020595
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#> 16 0.936305732 0.063694268
#> 17 0.809713906 0.190286094
#> 18 0.626095424 0.373904576
#> 19 0.908958130 0.091041870
#> 20 0.848684211 0.151315789
#> 21 0.820665083 0.179334917
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#> 26 0.661040068 0.338959932
#> 27 0.002217295 0.997782705
#> 28 0.099778271 0.900221729
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#> 34 0.198019802 0.801980198
#> 35 0.301980198 0.698019802

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#> 36 0.419009901 0.580990099
#> 37 0.546930693 0.453069307
#> 38 0.664950495 0.335049505
#> 39 0.768910891 0.231089109
#> 40 0.846930693 0.153069307
#> 41 0.907920792 0.092079208
#> 42 0.946930693 0.053069307
#> 43 0.966930693 0.033069307
#> 44 0.986930693 0.013069307
#> 45 0.999009901 0.000990099
#> 46 0.891919363 0.108080637
#> 47 0.360360360 0.639639640
#> 48 0.432432432 0.567567568
#> 49 0.510510511 0.489489489
#> 50 0.612612613 0.387387387
#> 51 0.702702703 0.297297297
#> 52 0.768768769 0.231231231
#> 53 0.091879075 0.908120925
#> 54 0.244220510 0.755779490
#> 55 0.305868405 0.694131595
#> 56 0.403082395 0.596917605
#> 57 0.574392413 0.425607587
#> 58 0.651452282 0.348547718
#> 59 0.717842324 0.282157676
#> 60 0.835210433 0.164789567
#> 61 0.129983389 0.870016611
#> 62 0.569975083 0.430024917
#> 63 0.759966777 0.240033223
#> 64 0.930024917 0.069975083
#> 65 1.000000000 0.000000000
#> 66 0.031067628 0.968932372
#> 67 0.589941641 0.410058359
#> 68 0.809989701 0.190010299
#> 69 0.960006866 0.039993134
#> 70 1.000000000 0.000000000
#> 71 0.130010834 0.869989166
#> 72 0.609967497 0.390032503
#> 73 0.800108342 0.199891658
#> 74 0.949891658 0.050108342
#> 75 1.000000000 0.000000000
#> 76 0.887500000 0.112500000
#> 77 0.610424028 0.389575972
```

```
#> 78 0.719081272 0.280918728
#> 79 0.878091873 0.121908127
#> 80 0.923144876 0.076855124
#> 82 0.335557364 0.664442636
#> 81 0.816110659 0.183889341
#> 83 0.976240846 0.023759154
#> 84 0.885052719 0.114947281
#> 85 0.914351852 0.085648148
#> 86 0.707236842 0.292763158
#> 87 0.871710526 0.128289474
#> 88 0.786585366 0.213414634
#> 89 0.246031746 0.753968254
#> 90 0.910313901 0.089686099
#> 91 0.982062780 0.017937220
#> 92 1.000000000 0.000000000
#> 93 0.860465116 0.139534884
#> 94 0.979651163 0.020348837
#> 95 0.435555556 0.564444444
#> 96 0.788000000 0.212000000
#> 97 0.956140351 0.043859649
#> 98 0.945812808 0.054187192
#> 99 0.630826600 0.369173400
#> 100 0.727272727 0.272727273
#> 101 0.909090909 0.090909091
#> 102 0.931818182 0.068181818
#> 103 0.977272727 0.022727273
#> 104 0.681034483 0.318965517
#> 105 0.169734151 0.830265849
#> 106 0.460122699 0.539877301
#> 107 0.779141104 0.220858896
#> 108 0.950920245 0.049079755
#> 109 0.979550102 0.020449898
#> 110 0.666666667 0.333333333
#> 111 0.688888889 0.311111111
#> 112 0.844444444 0.155555556
#> 113 0.877777778 0.122222222
#> 114 0.877777778 0.122222222
#> 115 0.900000000 0.100000000
#> 116 0.900000000 0.100000000
#> 117 0.955555556 0.044444444
#> 118 0.966666667 0.033333333
#> 119 0.966666667 0.033333333
```

```
#> 120 0.977777778 0.022222222
#> 121 0.977777778 0.022222222
#> 122 0.843750000 0.156250000
#> 123 0.914675768 0.085324232
#> 124 0.881355932 0.118644068
```

## Step 2: How do we get initial values?

```
init <- initHoyerAFT(res$restructured,
                     dist="loglogistic")
init
#>               beta0_init lambda0_init beta1_init lambda1_init su0_init
#> Initial value   1.681153    0.04964348   1.815414    0.08091965 0.1552818
#>               su1_init coru0u1_init distcode
#> Initial value 0.1284618    0.3948626         3
```

## Step 3: How do we fit the model?

```
hoyerAFT <- fitHoyerAFT(data=res,
                        init=init,
                        eval_threshold=c(5.0,5.5,6.0,6.5,7.0,7.5))
```

```
hoyerAFT
#>
#> Hoyer Model
#> -----
#>
#> Number of studies : 38
#> Model fit          : Converged
#> -2 log likelihood : 209322 ( df = 7 )
#> AIC                : 209336
#> BIC                : 209347.4
#>
#> Distribution       : Loglogistic
#> Test direction     : greater
#>
#> Use summary() for parameter estimates.
summary(hoyerAFT)
```

```

#> $sdreport2
#>
#>      Estimate Std. Error
#> beta0      1.705691148 0.0095630146
#> lambda0    0.039502004 0.0001857265
#> su0        0.058648679 0.0067784870
#> beta1      1.825337107 0.0145652403
#> lambda1    0.056398479 0.0009244722
#> su1        0.088320631 0.0109564611
#> rho        0.863032573 0.0454410883
#> covu0u1    0.004470412 0.0011417200
#> logitSurv1 3.828103143 0.2635035151
#> logitSurv1 2.138160760 0.2593347627
#> logitSurv1 0.595364241 0.2580790576
#> logitSurv1 -0.823870980 0.2591073990
#> logitSurv1 -2.137877556 0.2619046729
#> logitSurv1 -3.361188412 0.2660542694
#> logitSurv0 2.436667140 0.2426039991
#> logitSurv0 0.023873625 0.2420917690
#> logitSurv0 -2.178834277 0.2420878132
#> logitSurv0 -4.205129122 0.2424751080
#> logitSurv0 -6.081185122 0.2431661379
#> logitSurv0 -7.827751473 0.2440943827
#>
#> $sensspec
#> threshold conflevel      Sens SensCI_Lower SensCI_Upper      Spec
#> 1      5.0      0.95 0.97871219 0.96482617 0.98718904 0.08041904
#> 2      5.5      0.95 0.89455725 0.83615237 0.93379170 0.49403188
#> 3      6.0      0.95 0.64459500 0.52236970 0.75048299 0.89833265
#> 4      6.5      0.95 0.30494258 0.20887630 0.42164362 0.98530044
#> 5      7.0      0.95 0.10546947 0.06591501 0.16457780 0.99771974
#> 6      7.5      0.95 0.03353069 0.02018063 0.05521454 0.99960164
#> SpecCI_Lower SpecCI_Upper
#> 1      0.0515556 0.1233403
#> 2      0.3779250 0.6107860
#> 3      0.8461021 0.9342152
#> 4      0.9765667 0.9908097
#> 5      0.9963326 0.9985830
#> 6      0.9993574 0.9997531

```

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