Package ‘meta’

May 25, 2017

Title General Package for Meta-Analysis
Version 4.8-2
Depends R (>= 2.9.1)
Imports grid
Suggests metafor (>= 1.9-9), lme4, numDeriv, BiasedUrn
Date 2017-05-24


Description User-friendly general package providing standard methods for meta-
analysis and supporting Schwarzer, Carpenter, and Rücker <DOI:10.1007/978-3-319-21416-
0>, "Meta-Analysis with R" (2015):
- fixed effect and random effects meta-analysis;
- several plots (forest, funnel, Galbraith / radial, L'Abbe, Baujat, bubble);
- statistical tests and trim-and-fill method to evaluate bias in meta-analysis;
- import data from 'RevMan 5';
- prediction interval, Hartung-Knapp and Paule-Mandel method for random effects model;
- cumulative meta-analysis and leave-one-out meta-analysis;
- meta-regression (if R package 'metafor' is installed);
- generalised linear mixed models (if R packages 'metafor', 'lme4', 'numDeriv', and 'BiasedUrn' are installed).

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Author Guido Schwarzer [cre, aut]
Maintainer Guido Schwarzer <sc@imbi.uni-freiburg.de>
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R topics documented:

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Details

R package **meta** (Schwarzer, 2007) provides the following meta-analysis methods:

- Fixed effect and random effects meta-analysis (functions `metabin`, `metacont`, `metacor`, `metagen`, `metainc`, `metaprop`, and `metarate`)
- Several plots (`forest`, `funnel`, `Galbraith / radial`, `labbe`, `baujat`, `bubble`)
- Statistical tests (`metabias`) and trim-and-fill method (`trimfill`) to evaluate bias in meta-analysis
- Import data from 'RevMan 5' (`read.rm5`; see also `metacr`)
- Prediction interval, Hartung-Knapp and Paule-Mandel method for random effects model (arguments in meta-analysis functions)
- Cumulative meta-analysis (`metacum`) and leave-one-out meta-analysis (`metainf`)
- Meta-regression (`metareg`; if R package `metafor` is installed)
- Generalised linear mixed models (`metabin`, `metainc`, `metaprop`, and `metarate`; if R packages `metafor`, `lme4`, `numDeriv`, and `BiasedUrn` are installed)

The following more advanced statistical methods are provided by add-on R packages:

- Frequentist methods for network meta-analysis (R package `netmeta`)
- Advanced methods to model and adjust for bias in meta-analysis (R package `metasens`)

See **settingsNmeta** to learn how to print and specify default meta-analysis methods used during your R session. For example, the function can be used to specify general settings:

- `settingsNmeta("revman5")`
- `settingsNmeta("jama")`

The first command can be used to reproduce meta-analyses from Cochrane reviews conducted with **Review Manager 5** (RevMan 5, [http://community.cochrane.org/tools/review-production-tools/revman-5](http://community.cochrane.org/tools/review-production-tools/revman-5)) and specifies to use a RevMan 5 layout in forest plots. The second command can be used to generate forest plots following instructions for authors of the **Journal of the American Medical Association** ([http://jamanetwork.com/journals/jama/pages/instructions-for-authors](http://jamanetwork.com/journals/jama/pages/instructions-for-authors)).

In addition, **settings.meta** can be used to change individual settings. For example, the following R command specifies the use of the Hartung-Knapp and Paule-Mandel methods, and the printing of prediction intervals in the current R session for any meta-analysis generated after execution of this command:

- `settings.meta(hakn=TRUE, method.tau="PM", prediction=TRUE)`

Type `help(package = "meta")` for a listing of R functions available in **meta**. Schwarzer (2007) is the preferred citation in publications for **meta**. Type `citation("meta")` for a BibTeX entry of this publication.

To report problems and bugs

- type `bug.report(package = "meta")` if you do not use RStudio,
- send an email to Guido Schwarzer <sc@imbi.uni-freiburg.de> if you use RStudio.

The development version of **meta** is available on GitHub [https://github.com/guido-s/meta](https://github.com/guido-s/meta).
Author(s)
Guido Schwarzer <sc@imbi.uni-freiburg.de>

References

amlodipine Amlodipine for Work Capacity

Description
Meta-analysis on the effect of amlodipine on work capacity.
This meta-analysis is used as a data example in Hartung and Knapp (2001).

Usage
data(amlodipine)

Format
A data frame with the following columns:

- study Study label
- n.amlo Number of observations in amlodipine group
- mean.amlo Estimated mean in amlodipine group
- var.amlo Variance in amlodipine group
- n.plac Number of observations in placebo group
- mean.plac Estimated mean in placebo group
- var.plac Variance in placebo group

Source

See Also
metacont
as.data.frame.meta

Examples

```r
data(amlodipine)
  m <- metacont(n.amlo, mean.amlo, sqrt(var.amlo),
                n.plac, mean.plac, sqrt(var.plac),
                data=amlo, studlab=study)

m.hakn <- metacont(n.amlo, mean.amlo, sqrt(var.amlo),
                    n.plac, mean.plac, sqrt(var.plac),
                    data=amlo, studlab=study,
                    hakn=TRUE)

# Results for mean difference - see Table III in Hartung and Knapp (2001)
#
res.md <- rbind(data.frame(summary(m)$fixed)[c("TE", "lower", "upper")],
                data.frame(summary(m)$random)[c("TE", "lower", "upper")],
                data.frame(summary(m.hakn)$random)[c("TE", "lower", "upper")])

#
res.md <- round(res.md, 5)
#
row.names(res.md) <- c("FE", "RE", "RE (HaKn)"
names(res.md) <- c("Absolute difference", "CI lower", "CI upper")
#
res.md
```

Description

The `as.data.frame` method returns a data frame containing information on individual studies, e.g., estimated treatment effect and its standard error.

Usage

```r
## S3 method for class 'meta'
as.data.frame(x, row.names=NULL, optional=FALSE, ...)
```

Arguments

- `x` An object of class `meta`.
- `row.names` NULL or a character vector giving the row names for the data frame.
- `optional` logical. If TRUE, setting row names and converting column names (to syntactic names) is optional.
- `...` other arguments


Value

A data frame is returned by the function as.data.frame.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

See Also

metabin, metacont, metagen, forest.meta

Examples

data(Fleiss93cont)
# # Generate additional variable with grouping information
# Fleiss93cont$group <- c(1,2,1,1,2)
# # Do meta-analysis without grouping information
# meta1 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c, study,
#                   data=Fleiss93cont, sm="SMD")
# # Update meta-analysis object and do subgroup analyses
# summary(update(metal, byvar=group))
#
# # Same result using metacont function directly
# meta2 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c, study,
#                   data=Fleiss93cont, sm="SMD", byvar=group)
# summary(meta2)
#
# # Compare printout of the following two commands
# as.data.frame(metal)
# metal$data

baujat.meta

Baujat plot to explore heterogeneity in meta-analysis

Description

Draw a Baujat plot to explore heterogeneity in meta-analysis.
Usage

`baujat(x, ...)

## S3 method for class 'meta'
`baujat(x, yscale=1, xlim, ylim,

  xlab="Contribution to overall heterogeneity",
  ylab="Influence on overall result",
  pch=21, cex=1, col="black", bg="darkgray",
  studlab=TRUE, cex.studlab=0.8,
  xin=0, yin=0, pos=2, offset=0.5,
  grid=TRUE, col.grid="lightgray", lty.grid="dotted", lwd.grid=par("lwd"),
  pty="s", ...)

Arguments

x An object of class meta.
yscale Scaling factor for values on y-axis.
xlim The x limits (min,max) of the plot.
ylim The y limits (min,max) of the plot.
xlab A label for the x-axis.
ylab A label for the y-axis.
pch The plotting symbol used for individual studies.
cex The magnification to be used for plotting symbol.
col A vector with colour of plotting symbols.
bg A vector with background colour of plotting symbols (only used if pch in 21:25).
studlab A logical indicating whether study labels should be printed in the graph. A vector with study labels can also be provided (must be of same length as x$TE then).
cex.studlab The magnification for study labels.
xmin A numeric specifying minimal value to print study labels (on x-axis).
ymin A numeric specifying minimal value to print study labels (on y-axis).
pos A position specifier for study labels (see text).
offset Offset for study labels (see text).
grid A logical indicating whether a grid is printed in the plot.
col.grid Colour for grid lines.
lty.grid The line type for grid lines.
lwd.grid The line width for grid lines.
pty A character specifying type of plot region (see par).
...
Graphical arguments as in par may also be passed as arguments.
Details

Baujat et al. (2002) introduced a scatter plot to explore heterogeneity in meta-analysis. On the x-axis the contribution of each study to the overall heterogeneity statistic (see list object \( Q \) of the meta-analysis object \( x \)) is plotted. On the y-axis the standardised difference of the overall treatment effect with and without each study is plotted; this quantity describes the influence of each study on the overall treatment effect.

Internally, the \texttt{metainf} function is used to calculate the values on the y-axis.

Value

A data.frame with the following variables:

\begin{itemize}
  \item \texttt{x} Coordinate on x-axis (contribution to heterogeneity statistic).
  \item \texttt{y} Coordinate on y-axis (influence on overall treatment effect).
\end{itemize}

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

References


See Also

\texttt{metagen}, \texttt{metainf}

Examples

data(olkin95)

ml <- metabin(event.e, n.e, event.c, n.c, data=olkin95,
  studlab=author, sm="OR", method="I")

# Generate Baujat plot
baujat(ml)

# Do not print study labels if the x-value is smaller than 4 and the
# y-value is smaller than 1.
baujat(ml, yscale=1, xmin=4, ymin=1)

# Change position of study labels
baujat(ml, yscale=1, xmin=4, ymin=1,
  pos=1, xlim=c(0, 6.5))

# Generate Baujat plot and assign x- and y- coordinates to R object b1
b1 <- baujat(ml)

# Calculate overall heterogeneity statistic
bubble.metareg

sum(b1$x)

m1$Q

bubble.metareg  Bubble plot to display the result of a meta-regression

Description

Draw a bubble plot to display the result of a meta-regression.

Usage

bubble(x, ...)

## S3 method for class 'metareg'
bubble(x,
xlim, ylim, xlab, ylab,
cex, min.cex=0.5, max.cex=5,
pch=21, col="black", bg="darkgray",
lty=1, lwd=1, col.line="black",
studlab=FALSE, cex.studlab=0.8,
pos=2, offset=0.5,
regline=TRUE,
axes=TRUE, box=TRUE,
...)

Arguments

x  An object of class metareg.
xlim  The x limits (min,max) of the plot.
ylim  The y limits (min,max) of the plot.
xlab  A label for the x-axis.
ylab  A label for the y-axis.
cex  The magnification to be used for plotting symbols.
min.cex  Minimal magnification for plotting symbols.
max.cex  Maximal magnification for plotting symbols.
pch  The plotting symbol used for individual studies.
col  A vector with colour of plotting symbols.
bg  A vector with background colour of plotting symbols (only used if pch in 21:25).
lty  The line type for the meta-regression line.
lwd  The line width for the meta-regression line.
col.line  Colour for the meta-regression line.
bubble.metareg

studlab A logical indicating whether study labels should be printed in the graph. A vector with study labels can also be provided (must be of same length as the number of studies in the meta-analysis then).

cex.studlab The magnification for study labels.

pos A position specifier for study labels (see text).

offset Offset for study labels (see text).

regline A logical indicating whether a regression line should be added to the bubble plot.

axes A logical indicating whether axes should be printed.

box A logical indicating whether a box should be printed.

... Graphical arguments as in par may also be passed as arguments.

Details

A bubble plot can be used to display the result of a meta-regression. It is a scatter plot with the treatment effect for each study on the y-axis and the covariate used in the meta-regression on the x-axis. Typically, the size of the plotting symbol is inversely proportional to the variance of the estimated treatment effect (Thompson & Higgins, 2002).

Argument cex specifies the plotting size for each individual study. If this argument is missing the weights from the meta-regression model will be used (which typically is a random effects model). Use weight="fixed" in order to utilise weights from a fixed effect model to define the size of the plotted symbols (even for a random effects meta-regression). If a vector with individual study weights is provided, the length of this vector must be of the same length as the number of studies.

Arguments min.cex and max.cex can be used to define the size of the smallest and largest plotting symbol. The plotting size of the most precise study is set to max.cex whereas the plotting size of all studies with a plotting size smaller than min.cex will be set to min.cex.

For a meta-regression with more than one covariate. Only a scatter plot of the first covariate in the regression model is shown. In this case the effect of the first covariate adjusted for other covariates in the meta-regression model is shown.

For a factor or categorical covariate separate bubble plots for each group compared to the baseline group are plotted.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

References


See Also

metagen, metainf
Examples

data(fleiss93cont)

# Add some (fictious) grouping variables:
Fleiss93cont$age <- c(55, 65, 52, 65, 58)
Fleiss93cont$region <- c("Europe", "Europe", "Asia", "Asia", "Europe")

metal <- metacont(n.e, mean.e, sd.e,
       n.c, mean.c, sd.c,
       data=Fleiss93cont, sm="MD")

mr1 <- metareg(metal, region)
mr1

bubble(mr1)
bubble(mr1, lwd=2, col.line="blue")

mr2 <- metareg(metal, age)
mr2

bubble(mr2, lwd=2, col.line="blue", xlim=c(50, 70))
bubble(mr2, lwd=2, col.line="blue", xlim=c(50, 70), cex="fixed")

# Do not print regression line
#
bubble(mr2, lwd=2, col.line="blue", xlim=c(50, 70), regline=FALSE)

---

**ci**  
*Calculation of confidence intervals (based on normal approximation or t-distribution)*

Description  
Calculation of confidence intervals; based on normal approximation or t-distribution.

Usage  
`ci(TE, seTE, level=0.95, df=NULL, null.effect = 0)`

Arguments  
- **TE**: Estimated treatment effect.
- **seTE**: Standard error of treatment estimate.
- **level**: The confidence level required.
- **df**: Degrees of freedom (for confidence intervals based on t-distribution).
- **null.effect**: A numeric value specifying the effect under the null hypothesis.
Value

List with components

- **TE**: Estimated treatment effect.
- **seTE**: Standard error of treatment estimate.
- **lower**: Lower confidence limits.
- **upper**: Upper confidence limits.
- **z**: Test statistic (either z-score or t-score).
- **p**: P-value of test with null hypothesis TE=0.
- **level**: The confidence level required.
- **df**: Degrees of freedom (t-distribution).

Note

This function is primarily called from other functions of the library `meta`, e.g., `forest.Nmeta`, `summary.meta`.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

Examples

data.frame(ci(170, 10))
data.frame(ci(170, 10, 0.99))
data.frame(ci(1.959964, 1))
data.frame(ci(2.2621571628, 1, df=9))

cisapride  

*Description*

Meta-analysis on cisapride in non-ulcer dispepsia.

This meta-analysis is used as a data example in Hartung and Knapp (2001).

Usage

data(cisapride)
Format

A data frame with the following columns:

- **study** Study label
- **event.cisa** Number of events in cisapride group
- **n.cisa** Number of observations in cisapride group
- **event.plac** Number of events in placebo group
- **n.plac** Number of observations in placebo group

Source


See Also

- `metabin`

Examples

```r
data(cisapride)

m.or <- metabin(event.cisa, n.cisa, event.plac, n.plac,
  data=cisapride, sm="OR", method="Inverse",
  studlab=study, addincr=TRUE)

m.rr <- metabin(event.cisa, n.cisa, event.plac, n.plac,
  data=cisapride, sm="RR", method="Inverse",
  studlab=study, addincr=TRUE)

m.or.hakn <- metabin(event.cisa, n.cisa, event.plac, n.plac,
  data=cisapride, sm="OR", method="Inverse",
  studlab=study, addincr=TRUE,
  hakn=TRUE)

m.rr.hakn <- metabin(event.cisa, n.cisa, event.plac, n.plac,
  data=cisapride, sm="RR", method="Inverse",
  studlab=study, addincr=TRUE,
  hakn=TRUE)

# Results for log risk ratio - see Table VII in Hartung and Knapp (2001)
#
res.rr <- rbind(data.frame(summary(m.rr)$fixed)[c("TE", "lower", "upper")],
  data.frame(summary(m.rr)$random)[c("TE", "lower", "upper")],
  data.frame(summary(m.rr.hakn)$random)[c("TE", "lower", "upper")])

#
row.names(res.rr) <- c("FE", "RE", "RE (HaKn)"
names(res.rr) <- c("Log risk ratio", "CI lower", "CI upper")
#
res.rr
```
Description

Meta-analysis on aspirin in preventing death after myocardial infarction.

Data example in Fleiss (1993) for meta-analysis with binary outcomes.

Usage

data(Fleiss93)

Format

A data frame with the following columns:

`study` Study label
`year` Year of publication
`event.e` Number of deaths in aspirin group
`n.e` Number of observations in aspirin group
`event.c` Number of deaths in placebo group
`n.c` Number of observations in placebo group

Source


Examples

data(Fleiss93)
metabin(event.e, n.e, event.c, n.c,
data=Fleiss93,
studlab=paste(study, year),
sm="OR", comb.random=FALSE)
Description

Meta-analysis on the Effect of Mental Health Treatment on Medical Utilisation.
Data example in Fleiss (1993) for meta-analysis with continuous outcomes.

Usage

data(Fleiss93cont)

Format

A data frame with the following columns:

study  Study label
year   Year of publication
n.e    Number of observations in psychotherapy group
mean.e Estimated mean in psychotherapy group
sd.e   Standard deviation in psychotherapy group
n.c    Number of observations in control group
mean.c Estimated mean in control group
sd.c   Standard deviation in control group

Source


See Also

Fleiss93

Examples

data(Fleiss93cont)
metacont(n.e, mean.e, sd.e, 
n.c, mean.c, sd.c, 
data=Fleiss93cont, 
studlab=paste(study, year), 
comb.random=FALSE)
forest.meta

Forest plot to display the result of a meta-analysis

Description

Draws a forest plot in the active graphics window (using grid graphics system).

Usage

forest(x, ...)

## S3 method for class 'meta'
forest(x, sortvar, studlab=TRUE,
  layout=gs("layout"),
  comb.fixed=x$comb.fixed, comb.random=x$comb.random,
  overall=TRUE,
  text.fixed=NULL,
  text.random=NULL,
  lty.fixed=2, lty.random=3,
  prediction=x$prediction,
  text.predict=NULL,
  print.subgroup.labels=TRUE,
  bylab=x$bylab, print.byvar=x$print.byvar,
  byseparator=gs("byseparator"),
  text.fixed.w=text.fixed, text.random.w=text.random, bysort=FALSE,
  pooled.totals=comb.fixed|comb.random, pooled.events=FALSE,
  pooled.times=FALSE, study.results=TRUE,
  xlab="", xlab.pos,
  smlab=NULL, smlab.pos, xlim="symmetric",
  allstudies=TRUE,
  weight.study, weight.subgroup,
  pscale=x$pscale, irscale=x$irscale, irunit=x$irunit,
  ref=ifelse(backtransf & is.relative.effect(x$sm), 1, 0),
  leftcols=NULL, rightcols=NULL,
  leftlabs=NULL, rightlabs=NULL,
  lab.e=x$label.e, lab.c=x$label.c,
  lab.e.attach.to.col=NULL, lab.c.attach.to.col=NULL,
  label.right=x$label.right, label.left=x$label.left, bottom.lr=TRUE,
  lab.NA="",
  lab.NA.effect="",
  lwd=1,
  at=NULL, label=TRUE,
  type.study="square", type.fixed="diamond", type.random=type.fixed,
  type.subgroup=ifelse(study.results, "diamond", "square"),
  col.study="black",
  col.square="gray", col.square.lines=col.square,
  col.inside="white",

col.diamond="gray",
col.diamond.fixed=col.diamond, col.diamond.random=col.diamond,
col.diamond.lines="black",
col.diamond.lines.fixed=col.diamond.lines, col.diamond.lines.random=col.diamond.lines,
col.inside.fixed=col.inside, col.inside.random=col.inside,
col.predict="red", col.predict.lines="black",
col.by="darkgray",
col.label.right="black", col.label.left="black",
hetstat = print.I2 | print.tau2 | print.Q | print.pval.Q | print.Rb,
overall.hetstat = overall & hetstat,
hetlab = "Heterogeneity: ",
print.I2 = comb.fixed | comb.random,
print.I2.ci = FALSE,
print.tau2 = comb.fixed | comb.random,
print.Q = FALSE,
print.pval.Q = comb.fixed | comb.random,
print.Rb = FALSE,
print.Rb.ci = FALSE,
text.subgroup.nohet = "not applicable",
##
test.overall=gs("test.overall"),
test.overall.fixed=comb.fixed&overall&test.overall,
test.overall.random=comb.random&overall&test.overall,
label.test.overall.fixed, label.test.overall.random,
print.zval=TRUE,
##
test.subgroup,
test.subgroup.fixed, test.subgroup.random,
print.Q.subgroup=TRUE,
label.test.subgroup.fixed, label.test.subgroup.random,
##
test.effect.subgroup,
test.effect.subgroup.fixed, test.effect.subgroup.random,
label.test.effect.subgroup.fixed,
label.test.effect.subgroup.random,
##
fontsize=12,
fs.heading = fontsize,
fs.fixed, fs.random, fs.predict,
fs.fixed.labels, fs.random.labels, fs.predict.labels,
fs.study = fontsize, fs.study.labels = fs.study,
fs.hetstat, fs.test.overall,
fs.test.subgroup, fs.test.effect.subgroup,
fs.axis = fontsize, fs.smlab = fontsize, fs.xlab = fontsize,
fs.lr = fontsize,
ff.heading = "bold",

ff.fixed, ff.random, ff.predict,
ff.fixed.labels, ff.random.labels, ff.predict.labels,
ff.study = "plain", ff.study.labels = ff.study,
ff.hetstat, ff.test.overall,
ff.test.subgroup, ff.test.effect.subgroup,
ff.axis = "plain", ff.smlab = "bold", ff.xlab = "plain",
ff.lr = "plain",
#
squaresize=0.8,
#
plotwidth = if (layout != "JAMA") "6cm" else "8cm",
colgap = "2mm",
colgap.left = colgap, colgap.right = colgap,
colgap.studlab = colgap.left, colgap.forest = colgap,
colgap.forest.left = colgap.forest,
colgap.forest.right = colgap.forest,
#
calcwidth.pooled=TRUE,
calcwidth.fixed=calcwidth.pooled,
calcwidth.random=calcwidth.pooled,
calcwidth.predict=FALSE,
calcwidth.hetstat=FALSE, calcwidth.tests=FALSE,
#
just=if (layout != "JAMA") "right" else "left",
just.studlab="left", just.addcols="center",
just.addcols.left=just.addcols, just.addcols.right=just.addcols,
#
addrow, addrow.overall, addrow.subgroups,
#
new=TRUE,
#
backtransf=x$backtransf,
digits=gs("digits.forest"), digits.se=gs("digits.se"),
digits.zval=gs("digits.zval"),
digits.pval=gs("digits.pval"),
digits.pval=max(gs("digits.pval")-2, 2),
digits.pval.Q=max(gs("digits.pval.Q")-2, 2),
digits.Q=gs("digits.Q"),
digits.tau2=gs("digits.tau2"),
digits.I2=max(gs("digits.I2")-1, 0),
digits.weight=gs("digits.weight"),
#
digits.mean = NULL, digits.sd = NULL,
digits.cor = NULL, digits.time = NULL,
#
scientific.pval = gs("scientific.pval"),
#
col.i=col.study, weight=weight.study,
...
Arguments

x
An object of class `meta`.

sortvar
An optional vector used to sort the individual studies (must be of same length as `x$TE`).

studlab
A logical indicating whether study labels should be printed in the graph. A vector with study labels can also be provided (must be of same length as `x$TE` then).

layout
A character string specifying the layout of the forest plot (see Details).

comb.fixed
A logical indicating whether fixed effect estimate should be plotted.

comb.random
A logical indicating whether random effects estimate should be plotted.

overall
A logical indicating whether overall summaries should be plotted. This argument is useful in a meta-analysis with subgroups if summaries should only be plotted on group level.

text.fixed
A character string used in the plot to label the pooled fixed effect estimate.

text.random
A character string used in the plot to label the pooled random effects estimate.

lty.fixed
Line type (pooled fixed effect estimate).

lty.random
Line type (pooled random effects estimate).

prediction
A logical indicating whether a prediction interval should be printed.

text.predict
A character string used in the plot to label the prediction interval.

print.subgroup.labels
A logical indicating whether subgroup label should be printed.

bylab
A character string with a label for the grouping variable.

print.byvar
A logical indicating whether the name of the grouping variable should be printed in front of the group labels.

byseparator
A character string defining the separator between label and levels of grouping variable.

text.fixed.w
A character string to label the pooled fixed effect estimate within subgroups, or a character vector of same length as number of subgroups with corresponding labels.

text.random.w
A character string to label the pooled random effect estimate within subgroups, or a character vector of same length as number of subgroups with corresponding labels.

bysort
A logical indicating whether groups should be ordered alphabetically.

pooled.totals
A logical indicating whether total number of observations should be given in the figure.

pooled.events
A logical indicating whether total number of events should be given in the figure.

pooled.times
A logical indicating whether total person time at risk should be given in the figure.

study.results
A logical indicating whether results for individual studies should be shown in the figure (useful to only plot subgroup results).

xlab
A label for the x-axis.
xlab.pos
A numeric specifying the center of the label on the x-axis.

smlab
A label for the summary measure (printed at top of figure).

smlab.pos
A numeric specifying the center of the label for the summary measure.

xlim
The x limits (min, max) of the plot, or the character "s" to produce symmetric forest plots.

allstudies
A logical indicating whether studies with inestimable treatment effects should be plotted.

weight.study
A character string indicating weighting used to determine size of squares or diamonds (argument type.study) to plot individual study results. One of missing, "same", "fixed", or "random", can be abbreviated. Plot symbols have the same size for all studies or represent study weights from fixed effect or random effects model.

weight.subgroup
A character string indicating weighting used to determine size of squares or diamonds (argument type.subgroup) to plot subgroup results. One of missing, "same", or "weight", can be abbreviated. Plot symbols have the same size for all subgroup results or represent subgroup weights from fixed effect or random effects model.

pscale
A numeric giving scaling factor for printing of single event probabilities, i.e. if argument sm is equal to "PLOGIT", "PLN", "PRAW", "PAS", or "PFT".

irscale
A numeric defining a scaling factor for printing of rates, i.e. if argument sm is equal to "IR", "IRLN", "IRS", or "IRFT".

irunit
A character specifying the time unit used to calculate rates, e.g. person-years.

ref
A numerical giving the reference value to be plotted as a line in the forest plot. No reference line is plotted if argument ref is equal to NA.

leftcols
A character vector specifying (additional) columns to be plotted on the left side of the forest plot or a logical value (see Details).

rightcols
A character vector specifying (additional) columns to be plotted on the right side of the forest plot or a logical value (see Details).

leftlabs
A character vector specifying labels for (additional) columns on left side of the forest plot (see Details).

rightlabs
A character vector specifying labels for (additional) columns on right side of the forest plot (see Details).

lab.e
Label to be used for experimental group in table heading.

lab.c
Label to be used for control group in table heading.

lab.e.attach.to.col
A character specifying the column name where label lab.e should be attached to in table heading.

lab.c.attach.to.col
A character specifying the column name where label lab.c should be attached to in table heading.

label.left
Graph label on left side of forest plot.

label.right
Graph label on right side of forest plot.
bottom.lr  A logical indicating whether labels on right and left side should be printed at bottom or top of forest plot.
lab.NA  A character string to label missing values.
lab.NA.effect  A character string to label missing values in individual treatment estimates and confidence intervals.
lwd  The line width, see `par`.
at  The points at which tick-marks are to be drawn, see `grid.xaxis`.
label  A logical value indicating whether to draw the labels on the tick marks, or an expression or character vector which specify the labels to use. See `grid.xaxis`.
type.study  A character string or vector specifying how to plot treatment effects and confidence intervals for individual studies (see Details).
type.fixed  A character string specifying how to plot treatment effect and confidence interval for fixed effect meta-analysis (see Details).
type.random  A character string specifying how to plot treatment effect and confidence interval for random effects meta-analysis (see Details).
type.subgroup  A character string specifying how to plot treatment effect and confidence interval for subgroup results (see Details).
col.study  The colour for individual study results and confidence limits.
col.inside  The colour for individual study results and confidence limits if confidence limits are completely within squares.
col.square  The colour for squares reflecting study’s weight in the meta-analysis.
col.square.lines  The colour for the outer lines of squares reflecting study’s weight in the meta-analysis.
col.diamond  The colour of diamonds representing the results for fixed effect and random effects models.
col.diamond.fixed  The colour of diamonds for fixed effect estimates.
col.diamond.random  The colour of diamonds for random effects estimates.
col.diamond.lines  The colour of the outer lines of diamonds representing the results for fixed effect and random effects models.
col.diamond.lines.fixed  The colour of the outer lines of diamond for fixed effect estimate.
col.diamond.lines.random  The colour of the outer lines of diamond for random effects estimate.
col.inside.fixed  The colour for result of fixed effect meta-analysis if confidence limit lies completely within square.
col.inside.random  The colour for result of random effects meta-analysis if confidence limit lies completely within square.
col.predict  Background colour of prediction interval.
col.predict.lines  
Colour of outer lines of prediction interval.

col.by  
The colour to print information on subgroups.

col.label.right  
The colour for label on right side of null effect.

col.label.left  
The colour for label on left side of null effect.

hetstat  
A logical value indicating whether to print results for heterogeneity measures at all.

overall.hetstat  
A logical value indicating whether to print results for heterogeneity measures for overall treatment comparisons. This argument is useful in a meta-analysis with subgroups if heterogeneity statistics should only be printed on subgroup level.

hetlab  
Label printed in front of results for heterogeneity measures.

print.I2  
A logical value indicating whether to print the value of the I-squared statistic.

print.I2.ci  
A logical value indicating whether to print the confidence interval of the I-squared statistic.

print.tau2  
A logical value indicating whether to print the value of the between-study variance tau-squared.

print.Q  
A logical value indicating whether to print the value of the heterogeneity statistic Q.

print.pval.Q  
A logical value indicating whether to print the p-value of the heterogeneity statistic Q.

print.Rb  
A logical value indicating whether to print the value of the I-squared statistic.

print.Rb.ci  
A logical value indicating whether to print the confidence interval of the I-squared statistic.

text.subgroup.nohet  
A logical value or character string which is printed to indicate subgroups with less than two studies contributing to meta-analysis (and thus without heterogeneity). If FALSE, heterogeneity statistics are printed (with NAs).

test.overall  
A logical value indicating whether to print results of test for overall effect.

test.overall.fixed  
A logical value indicating whether to print results of test for overall effect (based on fixed effect model).

test.overall.random  
A logical value indicating whether to print results of test for overall effect (based on random effects model).

label.test.overall.fixed  
Label printed in front of results of test for overall effect (based on fixed effect model).

label.test.overall.random  
Label printed in front of results of test for overall effect (based on random effects model).
print.zval A logical value indicating whether z-value for test of treatment effect should be printed.

test.subgroup A logical value indicating whether to print results of test for subgroup differences.

test.subgroup.fixed A logical value indicating whether to print results of test for subgroup differences (based on fixed effect model).

test.subgroup.random A logical value indicating whether to print results of test for subgroup differences (based on random effects model).

print.Q.subgroup A logical value indicating whether to print the value of the heterogeneity statistic Q (test for subgroup differences).

label.test.subgroup.fixed Label printed in front of results of test for subgroup differences (based on fixed effect model).

label.test.subgroup.random Label printed in front of results of test for subgroup differences (based on random effects model).

test.effect.subgroup A logical value indicating whether to print results of test for effect in subgroups.

test.effect.subgroup.fixed A logical value indicating whether to print results of test for effect in subgroups (based on fixed effect model).

test.effect.subgroup.random A logical value indicating whether to print results of test for effect in subgroups (based on random effects model).

label.test.effect.subgroup.fixed Label printed in front of results of test for effect in subgroups (based on fixed effect model).

label.test.effect.subgroup.random Label printed in front of results of test for effect in subgroups (based on random effects model).

fontsize The size of text (in points), see gpar.

fsheading The size of text for column headings, see gpar.

fsfixed The size of text for results of fixed effect model, see gpar.

fssubgroup The size of text for results of random effects model, see gpar.

fs.predict The size of text for results of prediction interval, see gpar.

fs.fixed.labels The size of text for label of fixed effect model, see gpar.

fs.random.labels The size of text for label of random effects model, see gpar.

fs.predict.labels The size of text for label of prediction interval, see gpar.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>fs.study</td>
<td>The size of text for results of individual studies, see <code>gpar</code>.</td>
</tr>
<tr>
<td>fs.study.labels</td>
<td>The size of text for labels of individual studies, see <code>gpar</code>.</td>
</tr>
<tr>
<td>fs.hetstat</td>
<td>The size of text for heterogeneity measures, see <code>gpar</code>.</td>
</tr>
<tr>
<td>fs.test.overall</td>
<td>The size of text of test for overall effect, see <code>gpar</code>.</td>
</tr>
<tr>
<td>fs.test.subgroup</td>
<td>The size of text of test of subgroup differences, see <code>gpar</code>.</td>
</tr>
<tr>
<td>fs.axis</td>
<td>The size of text on x-axis, see <code>gpar</code>.</td>
</tr>
<tr>
<td>fs.smlab</td>
<td>The size of text of label for summary measure, see <code>gpar</code>.</td>
</tr>
<tr>
<td>fs.xlab</td>
<td>The size of text of label on x-axis, see <code>gpar</code>.</td>
</tr>
<tr>
<td>fs.lr</td>
<td>The size of text of label on left and right side of forest plot, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.heading</td>
<td>The fontface for column headings, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.fixed</td>
<td>The fontface of text for results of fixed effect model, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.random</td>
<td>The fontface of text for results of random effects model, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.predict</td>
<td>The fontface of text for results of prediction interval, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.fixed.labels</td>
<td>The fontface of text for label of fixed effect model, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.random.labels</td>
<td>The fontface of text for label of random effects model, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.predict.labels</td>
<td>The fontface of text for label of prediction interval, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.study</td>
<td>The fontface of text for results of individual studies, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.study.labels</td>
<td>The fontface of text for labels of individual studies, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.hetstat</td>
<td>The fontface of text for heterogeneity measures, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.test.overall</td>
<td>The fontface of text of test for overall effect, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.test.subgroup</td>
<td>The fontface of text of test of subgroup differences, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.axis</td>
<td>The fontface of text on x-axis, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.smlab</td>
<td>The fontface of text of label for summary measure, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.xlab</td>
<td>The fontface of text of label on x-axis, see <code>gpar</code>.</td>
</tr>
<tr>
<td>ff.lr</td>
<td>The fontface of text of label on left and right side of forest plot, see <code>gpar</code>.</td>
</tr>
<tr>
<td>squaresize</td>
<td>A numeric used to increase or decrease the size of squares in the forest plot.</td>
</tr>
<tr>
<td>plotwidth</td>
<td>Either a character string, e.g., &quot;8cm&quot;, &quot;60mm&quot;, or &quot;3inch&quot;, or a <code>unit</code> object specifying width of the forest plot.</td>
</tr>
</tbody>
</table>
colgap
Either a character string or a **unit** object specifying gap between columns printed on left and right side of forest plot.

colgap.left
Either a character string or a **unit** object specifying gap between columns printed on left side of forest plot.

colgap.right
Either a character string or a **unit** object specifying gap between columns printed on right side of forest plot.

colgap.studlab
Either a character string or a **unit** object specifying gap between column with study labels and subsequent column.

colgap.forest
Either a character string or a **unit** object specifying gap between column adjacent to forest plot and the forest plot.

colgap.forest.left
Either a character string or a **unit** object specifying gap between column on the left side of forest plot and the forest plot.

colgap.forest.right
Either a character string or a **unit** object specifying gap between column on the right side of forest plot and the forest plot.

calcwidth.pooled
A logical indicating whether text for fixed effect and random effects model should be considered to calculate width of column with study labels, see next two arguments.

calcwidth.fixed
A logical indicating whether text given in arguments `text.fixed` and `text.fixed.w` should be considered to calculate width of column with study labels.

calcwidth.random
A logical indicating whether text given in arguments `text.random` and `text.random.w` should be considered to calculate width of column with study labels.

calcwidth.predict
A logical indicating whether text given in argument `text.predict` should be considered to calculate width of column with study labels.

calcwidth.hetstat
A logical indicating whether text for heterogeneity statistics should be considered to calculate width of column with study labels.

calcwidth.tests
A logical indicating whether text for tests of overall effect or subgroup differences should be considered to calculate width of column with study labels.

just
Justification of text in all columns but columns with study labels and additional variables (possible values: "left", "right", "center").

just.studlab
Justification of text for study labels (possible values: "left", "right", "center").

just.addcols
Justification of text for additional columns (possible values: "left", "right", "center").

just.addcols.left
Justification of text for additional columns on left side of forest plot (possible values: "left", "right", "center"). Can be of same length as number of additional columns on left side of forest plot.
### just.addcols.right
Justification of text for additional columns on right side of forest plot (possible values: "left", "right", "center"). Can be of same length as number of additional columns on right side of forest plot.

### addrow
A logical value indicating whether an empty row is printed above and below study results.

### addrow.overall
A logical value indicating whether an empty row is above overall meta-analysis results.

### addrow.subgroups
A logical value indicating whether an empty row is printed between results for subgroups.

### new
A logical value indicating whether a new figure should be printed in an existing graphics window.

### backtransf
A logical indicating whether results should be back transformed in forest plots. If backtransf=TRUE, results for sm="OR" are presented as odds ratios rather than log odds ratios and results for sm="ZCOR" are presented as correlations rather than Fisher's z transformed correlations, for example.

### digits
Minimal number of significant digits for treatment effects, see print.default.

### digits.se
Minimal number of significant digits for standard errors, see print.default.

### digits.zval
Minimal number of significant digits for z- or t-statistic for test of overall effect, see print.default.

### digits.tau2
Minimal number of significant digits for between-study variance, see print.default.

### digits.pval
Minimal number of significant digits for p-value of overall treatment effect, see print.default.

### digits.pval.Q
Minimal number of significant digits for p-value of heterogeneity test, see print.default.

### digits.Q
Minimal number of significant digits for heterogeneity statistic Q, see print.default.

### digits.I2
Minimal number of significant digits for I-squared statistic, see print.default.

### digits.weight
Minimal number of significant digits for weights, see print.default. digits.cor = NULL, digits.time = NULL,

### digits.mean
Minimal number of significant digits for means; only applies to metacont objects.

### digits.sd
Minimal number of significant digits for standard deviations; only applies to metacont objects.

### digits.cor
Minimal number of significant digits for correlations; only applies to metacor objects.

### digits.time
Minimal number of significant digits for times; only applies to metainc and metarate objects.

### scientific.pval
A logical specifying whether p-values should be printed in scientific notation, e.g., 1.2345e-01 instead of 0.12345.

### col.i
Deprecated argument (replaced by col.study).

### weight
Deprecated argument (replaced by weight.study).

### ...
Additional graphical arguments (ignored at the moment).
Details

A forest plot, also called confidence interval plot, is drawn in the active graphics window. The forest function is based on the grid graphics system. In order to print the forest plot, (i) resize the graphics window, (ii) either use `dev.copy2eps` or `dev.copy2pdf`.

By default, treatment estimates and confidence intervals are plotted in the following way:

- For an individual study, a square with treatment estimate in the center and confidence interval as line extending either side of the square (`type.study="square"`)
- For meta-analysis results, a diamond with treatment estimate in the center and right and left side corresponding to lower and upper confidence limits (`type.fixed="diamond", type.random="diamond", and type.subgroup="diamond"`)

In a forest plot, size of the squares typically reflects the precision of individual treatment estimates based either on the fixed effect (`weight.study="fixed"`) or random effects meta-analysis (`weight.study="random"`). Information from meta-analysis object `x` is utilised if argument `weight.study` is missing. Weights from the fixed effect model are used if argument `x$comb.fixed` is TRUE; weights from the random effects model are used if argument `x$comb.random` is TRUE and `x$comb.fixed` is FALSE. The same square sizes are used if `weight.study="same"`.

Arguments `text.fixed`, `text.random`, and `text.predict` can be used to change the label to identify overall results (fixed effect and random effects model as well as prediction interval). By default the following text is printed:

- "Fixed effect model" (argument `text.fixed`)
- "Random effects model" (text.random)
- "Prediction interval" (text.predict)

If confidence interval levels are different for individual studies, meta-analysis, and prediction interval (arguments `level`, `level.comb`, `level.predict` in meta-analysis functions, e.g. `metabin`), additional information is printed, e.g. " (99%-CI)" for a 99% confidence interval in the meta-analysis.

The following arguments can be used to print results for various statistical tests:

<table>
<thead>
<tr>
<th>Argument</th>
<th>Statistical test</th>
</tr>
</thead>
<tbody>
<tr>
<td>test.overall.fixed</td>
<td>Test for overall effect (fixed effect model)</td>
</tr>
<tr>
<td>test.overall.random</td>
<td>Test for overall effect (random effects model)</td>
</tr>
<tr>
<td>test.effect.subgroup.fixed</td>
<td>Test for effect in subgroup (FE model)</td>
</tr>
<tr>
<td>test.effect.subgroup.random</td>
<td>Test for effect in subgroup (RE model)</td>
</tr>
<tr>
<td>test.subgroup.fixed</td>
<td>Test for subgroup differences (FE model)</td>
</tr>
<tr>
<td>test.subgroup.random</td>
<td>Test for subgroup differences (RE model)</td>
</tr>
</tbody>
</table>

By default, these arguments are FALSE. R function `settings.meta` can be used to change this default for the entire R session. For example, use the following command to always print results of tests for an overall effect:

```r
default
settings.meta(test.overall=TRUE)
```

The arguments `leftcols` and `rightcols` can be used to specify columns which are plotted on the left and right side of the forest plot, respectively. If argument `rightcols` is FALSE, no columns will
be plotted on the right side. By default, i.e. if arguments `leftcols` and `rightcols` are NULL and `layout="meta"`, the following columns will be printed on the right side of the forest plot:

<table>
<thead>
<tr>
<th>Meta-analysis results</th>
<th>Value of argument rightcols</th>
</tr>
</thead>
<tbody>
<tr>
<td>No summary</td>
<td>c(&quot;effect&quot;, &quot;ci&quot;)</td>
</tr>
<tr>
<td>Only fixed effect model</td>
<td>c(&quot;effect&quot;, &quot;ci&quot;, &quot;w.fixed&quot;)</td>
</tr>
<tr>
<td>Only random effects model</td>
<td>c(&quot;effect&quot;, &quot;ci&quot;, &quot;w.random&quot;)</td>
</tr>
<tr>
<td>Both models</td>
<td>c(&quot;effect&quot;, &quot;ci&quot;, &quot;w.fixed&quot;, &quot;w.random&quot;)</td>
</tr>
</tbody>
</table>

By default, estimated treatment effect and corresponding confidence interval will be printed. Depending on arguments `combNfixed` and `combNrandom`, weights of the fixed effect and/or random effects model will be given too. For an object of class `metacum` or `metainf` only the estimated treatment effect with confidence interval are plotted.

Depending on the class of the meta-analysis object (which is defined by the R function used to generate the object) a different set of columns is printed on the left side of the forest plot:

<table>
<thead>
<tr>
<th>Function</th>
<th>Value of argument leftcols</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>metabin</code></td>
<td>c(&quot;studlab&quot;, &quot;event.e&quot;, &quot;n.e&quot;, &quot;event.c&quot;, &quot;n.c&quot;)</td>
</tr>
<tr>
<td><code>metacont</code></td>
<td>c(&quot;studlab&quot;, &quot;n.e&quot;, &quot;mean.e&quot;, &quot;sd.e&quot;, &quot;n.c&quot;, &quot;mean.c&quot;, &quot;sd.c&quot;)</td>
</tr>
<tr>
<td><code>metacor</code></td>
<td>c(&quot;studlab&quot;, &quot;n&quot;)</td>
</tr>
<tr>
<td><code>metagen</code></td>
<td>c(&quot;studlab&quot;, &quot;TE&quot;, &quot;seTE&quot;)</td>
</tr>
<tr>
<td><code>metainc</code></td>
<td>c(&quot;studlab&quot;, &quot;event.e&quot;, &quot;time.e&quot;, &quot;event.c&quot;, &quot;time.c&quot;)</td>
</tr>
<tr>
<td><code>metaprop</code></td>
<td>c(&quot;studlab&quot;, &quot;event&quot;, &quot;n&quot;)</td>
</tr>
<tr>
<td><code>metarate</code></td>
<td>c(&quot;studlab&quot;, &quot;event&quot;, &quot;time&quot;)</td>
</tr>
<tr>
<td><code>metacum</code></td>
<td>&quot;studlab&quot;</td>
</tr>
<tr>
<td><code>metainf</code></td>
<td>&quot;studlab&quot;</td>
</tr>
</tbody>
</table>

The arguments `leftlabs` and `rightlabs` can be used to specify column headings which are plotted on left and right side of the forest plot, respectively. For certain columns predefined labels exist. If the arguments `leftlabs` and `rightlabs` are NULL, the following default labels will be used:

- **Column:** studlab, TE, seTE, n.e, n.c, n
  - **Label:** "Study", "TE", "seTE", "Total", "Total", "Total"
- **Column:** event.e, event.c, event, mean.e, mean.c
  - **Label:** "Events", "Events", "Events", "Mean", "Mean"
- **Column:** sd.e, sd.c, time.e, time.c, effect
  - **Label:** "SD", "SD", "Time", "Time", "Effect"
- **Column:** ci, effect.ci, w.fixed, w.random
  - **Label:** x$level"%CI", effect+ci, "W(fixed)", "W(random)"

For additional columns, the column name will be used as label. It is possible to only provide labels
forest.meta

for new columns (see Examples). Otherwise the length of leftlabs and rightlabs must be the same as the number of printed columns, respectively. The value NA can be used to specify columns which should use default labels (see Examples).

If argument layout="RevMan5" (and arguments leftcols and rightcols are NULL), the layout for forest plots used for Cochrane reviews (which are generated with Review Manager 5, http://community.cochrane.org/tools/review-production-tools/revman-5) is reproduced:

1. All columns are printed on the left side of the forest plot (see arguments leftcols and rightcols)
2. Tests for overall effect and subgroup differences are printed (test.overall, test.effect.subgroup, test.subgroup)
3. Diamonds representing meta-analysis results are printed in black (diamond.fixed, diamond.random)
4. Color of squares depends on the meta-analysis object (col.square, col.square.lines)
5. Information on effect measure and meta-analysis method is printed above the forest plot (smlab)
6. Label "Study or Subgroup" is printed for meta-analysis with subgroups (leftlabs)

If argument layout="JAMA" (and arguments leftcols and rightcols are NULL), instructions for authors of the Journal of the American Medical Association, see http://jamanetwork.com/journals/jama/pages/instructions-for-authors, are taken into account:

1. Graph labels on right and left side are printed in bold font at top of forest plot (see arguments bottom.lr and ff.lr)
2. Information on effect measure and level of confidence interval is printed at bottom of forest plot (xlab)
3. Tests for overall effect are printed (test.overall)
4. Diamonds representing meta-analysis results are printed in lightblue (diamond.fixed, diamond.random)
5. Squares representing individual study results are printed in darkblue (col.square, col.square.lines)
6. Between-study variance τ² is not printed
7. Empty rows are omitted (addrow)
8. Label "Source" is printed instead of "Study" (leftlabs)

The following changes are conducted if argument layout="subgroup" (and arguments leftcols and rightcols are NULL) and a subgroup analysis was conducted:

1. Individual study results are omitted (see argument study.results)
2. Total number of observations is not printed (pooled.totals)
3. Label "Subgroup" is printed instead of "Study" (leftlabs)

If arguments lab.e and lab.c are NULL, "Experimental" and "Control" are used as labels for experimental and control group, respectively.

Argument pscale can be used to rescale proportions, e.g. pscale=1000 means that proportions are expressed as events per 1000 observations. This is useful in situations with (very) low event probabilities.
A prediction interval for treatment effect of a new study (Higgins et al., 2009) is given in the forest plot if arguments prediction and comb.random are TRUE. For graphical presentation of prediction intervals the approach by Guddat et al. (2012) is used.

Note, in R package meta, version 3.0-0 the following arguments have been removed from R function forest.meta: byvar, level, level.comb, level.predict. This functionality is now provided by R function update.meta (or directly in R functions, e.g., metabin, metacont, metagen, metacor, and metaprop).

Author(s)
Guido Schwarzer <sc@imbi.uni-freiburg.de>

References

See Also
metabin, metacont, metagen, settings.meta

Examples

data(olkin95)
meta <- metabin(event.e, n.e, event.c, n.c, 
data=olkin95, subset=c(41,47,51,59),
sm="RR", method="I",
studlab=paste(author, year))

#
# Do standard (symmetric) forest plot
#
forest(meta)

#
# Layout of forest plot similar to Review Manager 5
# (see http://community.cochrane.org/tools/review-production-tools/revman-5)
#
# Furthermore, add labels on both sides of forest plot and prediction interval
#
forest(meta, layout="RevMan6", comb.fixed=FALSE, 
label.right="Favours control", col.label.right="red", 
label.left="Favours experimental", col.label.left="green", 
prediction=TRUE)
## Not run:

```r
# Sort studies by decreasing treatment effect within year subgroups
meta2 <- update(meta1, byvar=ifelse(year < 1987,
    "Before 1987", "1987 and later"),
    print.byvar=FALSE)
forest(meta2, sortvar=-TE, comb.random=FALSE)
```

```r
# Forest plot specifying argument xlim
forest(meta1, xlim=c(0.01, 10))
```

```r
# Print results of test for overall effect
forest(meta1, test.overall.fixed=TRUE, test.overall.random=TRUE)
```

```r
# Forest plot with 'classic' layout used in
# R package meta, version < 1.6-0
# forest(meta1, col.square="black", hetstat=FALSE)
```

```r
# Change set of columns printed on left side of forest plot
# forest(meta1, comb.random=FALSE, leftcols="studlab")
```

```r
# Do not print columns on right side of forest plot
# forest(meta1, rightcols=FALSE)
```

```r
# Change study label to "Author"
# forest(meta1, comb.random=FALSE, lefllabs=c("Author", NA, NA, NA, NA))
```

```r
# Just give effect estimate and 95
# on right side of forest plot (in one column)
#
forest(metal, rightcols=c("effect.ci"))

#
# Just give effect estimate and 95
# on right side of forest plot
#
forest(metal, rightcols=c("effect", "ci"))

#
# 1. Change order of columns on left side
# 2. Attach labels to columns 'event.e' and 'event.c'
#   instead of columns 'n.e' and 'n.c'
#
forest(metal,
  leftcols=c("studlab", "n.e", "event.e", "n.c", "event.c"),
  lab.e.attach.to.col="event.e",
  lab.c.attach.to.col="event.c")

#
# Specify column labels only for newly created variables
# 'year' and 'author' (which are part of dataset Olkin95)
#
forest(metal,
  leftcols=c("studlab", "event.e", "n.e", "event.c", "n.c",
            "author", "year"),
  leftlabs=c("Author", "Year of Publ"))

#
# Center text in all columns
#
forest(metal,
  leftcols=c("studlab", "event.e", "n.e", "event.c", "n.c",
            "author", "year"),
  leftlabs=c("Author", "Year of Publ"), hetstat=FALSE,
  just="center", just.addcols="center", just.studlab="center")

#
# Same result
#
forest(metal,
  leftcols=c("studlab", "event.e", "n.e", "event.c", "n.c",
            "author", "year"),
  leftlabs=c("Author", "Year of Publ"), hetstat=FALSE,
  just="c", just.addcols="c", just.studlab="c")

#
# Change some fontsizes and fontfaces
# forest(metal,
#   fs.study=10, ff.study="italic",
#   fs.study.label=11, ff.study.label="bold",
#   fs.axis=5, ff.axis="italic",
#   ff.smlab="bold italic",
#   ff.fixed="plain", ff.hetstat="plain")
#
# Change some colours
# forest(metal,
#   col.diamond="green", col.diamond.lines="red",
#   col.study=c("green", "blue", "red", "orange"),
#   col.square="pink", col.square.lines="black")
#
# Sort by weight in fixed effect model
# forest(metal, sortvar=1/w.fixed, comb.random=FALSE)
#
# Sort by decreasing weight in fixed effect model
# forest(metal, sortvar=-1/w.fixed, comb.random=FALSE)
#
# Sort by size of treatment effect
# forest(metal, sortvar=TE, comb.random=FALSE)
#
# Sort by size of treatment effect
# forest(metal, sortvar=-TE, comb.random=FALSE)
#
# Sort by decreasing year of publication
# forest(metal, sortvar=-year, comb.random=FALSE)
#
# Print results of test for subgroup differences (random effects model)
# forest(meta2,
funnel.meta

Plot to assess funnel plot asymmetry

Description

Draw a funnel plot or radial plot (also called Galbraith plot) to assess funnel plot asymmetry in the active graphics window.

A contour-enhanced funnel plot can be produced for assessing causes of funnel plot asymmetry.

Usage

funnel(x, ...)

radial(x, ...)

## Default S3 method:
funnel(x, y,
   xlim=NULL, ylim=NULL, xlab=NULL, ylab=NULL,
   comb.fixed=FALSE, comb.random=FALSE,
   axes=TRUE,
   pch=21, text=NULL, cex=1,
   lty.fixed=2, lty.random=9,
   lwd=1, lwd.fixed=lwd, lwd.random=lwd,
   col="black", bg="darkgray",
   col.fixed="black", col.random="black",
   log="", xaxis="se", sm="",
   contour.levels=NULL, col.contour,
   ref=ifelse(backtransf & is.relative.effect(sm), 1, 0),
   level=NULL,
   studlab=FALSE, cex.studlab=0.8, pos.studlab = 2,
   backtransf=TRUE, ...)

sortvar=TE, comb.fixed=FALSE,
test.subgroup.random=TRUE)

# # Print only subgroup results #
forest(meta2, layout = "subgroup")

# # Print only subgroup results # (and consider text for heterogeneity measures in width of subgroup # column)
forest(meta2, layout = "subgroup", calcwidth.hetstat = TRUE)

## End(Not run)
funnel.meta

# S3 method for class 'meta'
funnel(x, 
  xlim=NULL, ylim=NULL, xlab=NULL, ylab=NULL, 
  comb.fixed=x$comb.fixed, comb.random=x$comb.random, 
  axes=TRUE, 
  pch=if (!inherits(x, "trimfill")) 21 else ifelse(x$trimfill, 1, 21), 
  text=NULL, cex=1, 
  lty.fixed=2, lty.random=9, 
  lwd=1, lwd.fixed=lwd, lwd.random=lwd, 
  col="black", bg="darkgray", 
  col.fixed="black", col.random="black", 
  log="" , yaxis="se", 
  contour.levels=NULL, col.contour, 
  ref=ifelse(backtransf & is.relative.effect(x$sm), 1, 0), 
  level=x$level, 
  studlab=FALSE, cex.studlab=0.8, pos.studlab = 2, 
  backtransf=x$backtransf, ...)

# Default S3 method:
radial(x, y, xlim=NULL, ylim=NULL, 
  xlab="Inverse of standard error", 
  ylab="Standardised treatment effect (z-score)", 
  comb.fixed=TRUE, axes=TRUE, 
  pch=1, text=NULL, cex=1, col=NULL, 
  level=NULL, ...)

# S3 method for class 'meta'
radial(x, xlim=NULL, ylim=NULL, 
  xlab="Inverse of standard error", 
  ylab="Standardised treatment effect (z-score)", 
  comb.fixed=TRUE, axes=TRUE, 
  pch=1, text=NULL, cex=1, col=NULL, 
  level=NULL, ...)

Arguments

x  An object of class meta, or estimated treatment effect in individual studies.
y  Standard error of estimated treatment effect.
xlim  The x limits (min,max) of the plot.
ylim  The y limits (min,max) of the plot.
xlab  A label for the x-axis.
ylab  A label for the y-axis.
comb.fixed  A logical indicating whether the pooled fixed effect estimate should be plotted.
comb.random  A logical indicating whether the pooled random effects estimate should be plotted.
<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>axes</td>
<td>A logical indicating whether axes should be drawn on the plot.</td>
</tr>
<tr>
<td>pch</td>
<td>The plotting symbol used for individual studies.</td>
</tr>
<tr>
<td>text</td>
<td>A character vector specifying the text to be used instead of plotting symbol.</td>
</tr>
<tr>
<td>cex</td>
<td>The magnification to be used for plotting symbol.</td>
</tr>
<tr>
<td>lty.fixed</td>
<td>Line type (pooled fixed effect estimate).</td>
</tr>
<tr>
<td>lty.random</td>
<td>Line type (pooled random effects estimate).</td>
</tr>
<tr>
<td>col</td>
<td>A vector with colour of plotting symbols.</td>
</tr>
<tr>
<td>bg</td>
<td>A vector with background colour of plotting symbols (only used if pch in 21:25).</td>
</tr>
<tr>
<td>col.fixed</td>
<td>Color of line representing fixed effect estimate.</td>
</tr>
<tr>
<td>col.random</td>
<td>Color of line representing random effects estimate.</td>
</tr>
<tr>
<td>lwd</td>
<td>The line width for confidence intervals (if level is not NULL).</td>
</tr>
<tr>
<td>lwd.fixed</td>
<td>The line width for fixed effect estimate (if comb.fixed is not NULL).</td>
</tr>
<tr>
<td>lwd.random</td>
<td>The line width for random effects estimate (if comb.random is not NULL).</td>
</tr>
<tr>
<td>log</td>
<td>A character string which contains &quot;x&quot; if the x-axis is to be logarithmic, &quot;y&quot; if the y-axis is to be logarithmic and &quot;xy&quot; or &quot;yx&quot; if both axes are to be logarithmic (applies only to function funnel).</td>
</tr>
<tr>
<td>yaxis</td>
<td>A character string indicating which type of weights are to be used. Either &quot;se&quot;, &quot;invvar&quot;, &quot; inve&quot;, or &quot;size&quot; (applies only to function funnel).</td>
</tr>
<tr>
<td>sm</td>
<td>A character string indicating underlying summary measure, e.g., &quot;RD&quot;, &quot;RR&quot;, &quot;OR&quot;, &quot;ASD&quot;, &quot;HR&quot;, &quot;MD&quot;, &quot;SMD&quot;, or &quot;ROM&quot; (applies only to function funnel).</td>
</tr>
<tr>
<td>contour.levels</td>
<td>A numeric vector specifying contour levels to produce contour-enhanced funnel plot.</td>
</tr>
<tr>
<td>col.contour</td>
<td>Colour of contours.</td>
</tr>
<tr>
<td>ref</td>
<td>Reference value (null effect) used to produce contour-enhanced funnel plot.</td>
</tr>
<tr>
<td>level</td>
<td>The confidence level utilised in the plot. For the funnel plot, confidence limits are not drawn if yaxis=&quot;size&quot;.</td>
</tr>
<tr>
<td>studlab</td>
<td>A logical indicating whether study labels should be printed in the graph. A vector with study labels can also be provided (must be of same length as x$TE then).</td>
</tr>
<tr>
<td>cex.studlab</td>
<td>Size of study labels, see argument cex in text.</td>
</tr>
<tr>
<td>pos.studlab</td>
<td>Position of study labels, see argument pos in text.</td>
</tr>
<tr>
<td>backtransf</td>
<td>A logical indicating whether results for relative summary measures (argument sm equal to &quot;OR&quot;, &quot;RR&quot;, &quot;HR&quot;, or &quot;IRR&quot;) should be back transformed in funnel plots. If backtransf=TRUE, results for sm=&quot;OR&quot; are printed as odds ratios rather than log odds ratios, for example.</td>
</tr>
<tr>
<td>...</td>
<td>Graphical arguments as in par may also be passed as arguments.</td>
</tr>
</tbody>
</table>
funnel.meta

Details

A funnel plot or radial plot, also called Galbraith plot, is drawn in the active graphics window. If comb.fixed is TRUE, the pooled estimate of the fixed effect model is plotted. If level is not NULL, the corresponding confidence limits are drawn.

In the funnel plot, if yaxis is "se", the standard error of the treatment estimates is plotted on the y-axis which is likely to be the best choice (Sterne & Egger, 2001). Other possible choices for yaxis are "invvar" (inverse of the variance), "invse" (inverse of the standard error), and "size" (study size).

For yaxis!="size", contour-enhanced funnel plots can be produced (Peters et al., 2008) by specifying the contour levels (argument contour.levels). By default (argument col.contour missing), suitable gray levels will be used to distinguish the contours. Different colours can be chosen by argument col.contour.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>, Petra Graham <pgraham@efs.mq.edu.au>

References


Galbraith RF (1988b), A note on graphical presentation of estimated odds ratios from several clinical trials. Statistics in Medicine, 7, 889–894.


See Also

metabias, metabin, metagen

Examples

data(Olkin95)
meta <- metabin(event.e, n.e, event.c, n.c,
  data=Olkin95, subset=c(41,47,51,59),
  studlab=paste(author, year),
  sm="RR", method="I")

# # Radial plot
# radial(meta1, level=0.95)
oldpar <- par(mfrow=c(2, 2))

# # Funnel plots # funnel(metal) # # Same result as code above: # funnel(metal$TE, metal$seTE, sm="RR", 
comb.fixed=TRUE, level=0.95) # # Funnel plot with confidence intervals, # fixed effect estimate and contours # cc <- funnel(metal, comb.fixed=TRUE, 
level=0.95, contour=c(0.9, 0.95, 0.99))$col.contour 
legend(0.05, 0.05, 
c("0.1 > p > 0.05", "0.05 > p > 0.01", "< 0.01"), fill=cc) # # Contour-enhanced funnel plot with user-chosen colours # funnel(metal, comb.fixed=TRUE, 
level=0.95, contour=c(0.9, 0.95, 0.99), 
col.contour=c("darkgreen", "green", "lightgreen"), 
lwd=2, cex=2, pch=16, studlab=TRUE, cex.studlab=1.25) 
legend(0.05, 0.05, 
c("0.1 > p > 0.05", "0.05 > p > 0.01", "< 0.01"), 
fill=c("darkgreen", "green", "lightgreen"))

par(olddpar)

---

### gs

Get default for a meta-analysis setting.

#### Description

Get default for a meta-analysis setting in R package `meta`.

#### Usage

```r
gs(x)
```

#### Arguments

- **x**
  - A character string holding a settings name.
**labbe.metabin**

**Details**
This function can be used to get the default for a meta-analysis setting defined using `settings.meta`.
This function is primarily used to define default settings in meta-analysis functions, e.g. `metabin` or `metacont`. A list of all arguments with current settings is printed using the command `settings.meta("print")`.

**Author(s)**
Guido Schwarzer <sc@imbi.uni-freiburg.de>

**See Also**
`settings.meta`

**Examples**

```R
# Get default setting for Hartung-Knapp method
#
gs("hakn")

# Get default setting for summary measure in metabin()
#
gs("smbin")
```

**Description**
Draw a L’Abbé plot for meta-analysis with binary outcomes.

**Usage**

```R
labbe(x, ...)
```

## Default S3 method:
```
labbe(x, y, 
    xlim, ylim, 
    xlab = NULL, ylab = NULL, 
    TE.fixed = NULL, TE.random = NULL, 
    comb.fixed = !is.null(TE.fixed), comb.random = !is.null(TE.random), 
    backtransf = TRUE, 
    axes = TRUE, 
    pch = 21, text = NULL, cex = 1, 
    col = "black", bg = "lightgray", 
    lwd = 1, lwd.fixed = lwd, lwd.random = lwd, 
    lty.fixed = 2, lty.random = 9, 
    col.fixed = col, col.random = col,
```
nulleffect = TRUE,
  lwd.nulleffect = lwd, col.nulleffect = "lightgray",
  sm = NULL, weight,
  studlab = FALSE, cex.studlab = 0.8,
  label.e = NULL, label.c = NULL,
  ...
)

## S3 method for class 'metabin'
labbe(x,
  xlim, ylim,
  xlab = NULL, ylab = NULL,
  TE.fixed = x$TE.fixed,
  TE.random = x$TE.random,
  comb.fixed = x$comb.fixed,
  comb.random = x$comb.random,
  backtransf = x$backtransf,
  axes = TRUE,
  pch = 21, text = NULL, cex = 1,
  col = "black", bg = "lightgray",
  lwd = 1, lwd.fixed = lwd, lwd.random = lwd,
  lty.fixed = 2, lty.random = 9,
  col.fixed = col, col.random = col,
  nulleffect = TRUE,
  lwd.nulleffect = lwd, col.nulleffect = "lightgray",
  sm = x$sm, weight,
  studlab = FALSE, cex.studlab = 0.8,
  label.e = x$label.e, label.c = x$label.c,
  ...
)

Arguments

- **x**  
The x coordinates of points of the L'Abbé plot. Alternatively, an object of class `metabin`.

- **y**  
The y coordinates of the L’Abbé plot, optional if x is an appropriate structure.

- **xlim**  
The x limits (min, max) of the plot.

- **ylim**  
The y limits (min, max) of the plot.

- **xlab**  
A label for the x-axis.

- **ylab**  
A label for the y-axis.

- **TE.fixed**  
A numeric or vector specifying combined fixed effect estimate(s).

- **TE.random**  
A numeric or vector specifying combined random effects estimate(s).

- **comb.fixed**  
A logical indicating whether the pooled fixed effect estimate should be plotted.

- **comb.random**  
A logical indicating whether the pooled random effects estimate should be plotted.

- **backtransf**  
A logical indicating which values should be printed on x- and y-axis (see Details).

- **axes**  
A logical indicating whether axes should be drawn on the plot.
The plotting symbol used for individual studies.

text A character vector specifying the text to be used instead of plotting symbol.
cex The magnification to be used for plotting symbol.
col A vector with colour of plotting symbols.
bg A vector with background colour of plotting symbols (only used if pch in 21:25).
lwd The line width.
lwd.fixed The line width(s) for fixed effect estimate(s) (if comb.fixed is not NULL or FALSE).
lwd.random The line width(s) for random effects estimate(s) (if comb.random is not NULL or FALSE).
lty.fixed Line type(s) for fixed effect estimate(s).
lty.random Line type(s) for random effects estimate(s).
col.fixed Color of line(s) for fixed effect estimate(s).
col.random Color of line(s) for random effects estimate(s).
nulleffect A logical indicating whether line for null effect should be added to the plot.
lwd.nulleffect Width of line for null effect.
col.nulleffect Color of line for null effect.

A character string indicating underlying summary measure, i.e., "RD", "RR", "OR", or "ASD".

Either a numeric vector specifying relative sizes of plotting symbols or a character string indicating which type of plotting symbols is to be used for individual treatment estimates. One of missing (see Details), "same", "fixed", or "random", can be abbreviated. Plot symbols have the same size for all studies or represent study weights from fixed effect or random effects model.

A logical indicating whether study labels should be printed in the graph. A vector with study labels can also be provided (must be of same length as x$event.e then).

cexstudlab Size of study labels.
label.e Label for experimental group.
label.c Label for control group.

Graphical arguments as in par may also be passed as arguments.

Details

A L’Abbé plot is a scatter plot with the risk in the control group on the x-axis and the risk in the experimental group on the y-axis (L’Abbé et al., 1987). It can be used to evaluate heterogeneity in meta-analysis. Furthermore, this plot can aid to choose a summary measure (odds ratio, risk ratio, risk difference) that will result in more consistent results.

If argument backtransf is TRUE (default), event probabilities will be printed on x- and y-axis. Otherwise, transformed event probabilities will be printed as defined by the summary measure, i.e., log odds of probabilities for odds ratio as summary measure (sm = "OR"), log probabilities for sm = "RR", and arcsine-transformed probabilities for sm = "ASD".
If \texttt{comb\_fixed} is \texttt{TRUE}, the pooled estimate of the fixed effect model is plotted as a line. If \texttt{comb\_random} is \texttt{TRUE}, the pooled estimate of the random effects model is plotted as a line. Information from object \texttt{x} is utilised if argument \texttt{weight} is missing. Weights from the fixed effect model are used (\texttt{weight = "fixed"}) if argument \texttt{x$comb\_fixed} is \texttt{true}; weights from the random effects model are used (\texttt{weight = "random"}) if argument \texttt{x$comb\_random} is \texttt{TRUE} and \texttt{x$comb\_fixed} is \texttt{FALSE}.

\textbf{Author(s)}

Guido Schwarzer <sc@imbi.uni-freiburg.de>

\textbf{References}


\textbf{See Also}

\texttt{metabin}

\textbf{Examples}

\begin{verbatim}
data(Olkin95)
meta <- metabin(event.e, n.e, event.c, n.c,
data = Olkin95,
studlab = paste(author, year),
sm = "RR", method = "I")

# # L'Abbe plot for risk ratio
# labbe(meta)

# L'Abbe plot for odds ratio
# labbe(meta, sm = "OR")
# same plot
labbe(update(meta, sm = "OR"))

# L'Abbe plot for risk difference
# labbe(meta, sm = "RD")

# L'Abbe plot on log odds scale
# labbe(meta, sm = "OR", backtransf = FALSE)

# L'Abbe plot for odds ratio with coloured lines for various treatment
# effects (defined as log odds ratios)
# mycols <- c("blue", "yellow", "green", "red",

\end{verbatim}
Test for funnel plot asymmetry

Description

Test for funnel plot asymmetry, based on rank correlation or linear regression method.

Usage

```r
metabias(x, ...)  
## S3 method for class 'meta'
metabias(x, method.bias=x$method.bias,  
         plotit=FALSE, correct=FALSE, k.min=10, ...)

## Default S3 method:
metabias(x, seTE, method.bias="linreg",  
         plotit=FALSE, correct=FALSE, k.min=10, ...)
```

Arguments

- **x**: An object of class `meta` or estimated treatment effect in individual studies.
- **seTE**: Standard error of estimated treatment effect (mandatory if `x` not of class `meta`).
- **method.bias**: A character string indicating which test is to be used. Either "rank", "linreg", "mm", "count", "score", or "peters", can be abbreviated.
- **plotit**: A logical indicating whether a plot should be produced for `method.bias` "rank", "linreg", "mm", or "score".
- **correct**: A logical indicating whether a continuity corrected statistic is used for rank correlation methods "rank" and "count".
- **k.min**: Minimum number of studies to perform test for funnel plot asymmetry.
- **...**: Additional arguments (ignored at the moment).
Details

Following recommendations by Sterne et al. (2011), by default, a test for funnel plot asymmetry is only conducted if the number of studies is ten or larger (argument \(k_{\min}=10\)). This behaviour can be changed by setting a smaller value for argument \(k_{\min}\). Note, the minimum number of studies is three.

If argument method.bias is "rank", the test statistic is based on the rank correlation between standardised treatment estimates and variance estimates of estimated treatment effects; Kendall’s tau is used as correlation measure (Begg & Mazumdar, 1994). The test statistic follows a standard normal distribution. By default (if \(correct\) is FALSE), no continuity correction is utilised (Kendall & Gibbons, 1990).

If argument method.bias is "linreg", the test statistic is based on a weighted linear regression of the treatment effect on its standard error (Egger et al., 1997). The test statistic follows a \(t\) distribution with number of studies - 2 degrees of freedom.

If argument method.bias is "mm", the test statistic is based on a weighted linear regression of the treatment effect on its standard error using the method of moments estimator for the additive between-study variance component (method 3a in Thompson, Sharp, 1999). The test statistic follows a \(t\) distribution with number of studies - 2 degrees of freedom.

If argument method.bias is "peters", the test statistic is based on a weighted linear regression of the treatment effect on the inverse of the total sample size using the variance of the average event rate as weights (Peters et al., 2006). The test statistic follows a \(t\) distribution with number of studies - 2 degrees of freedom. This test is available for meta-analyses comparing two binary outcomes or combining single proportions, i.e. generated with functions \texttt{metabin} and \texttt{metaprop}.

The following tests for funnel plot asymmetry are only available for meta-analyses comparing two binary outcomes, i.e. meta-analyses generated with the \texttt{metabin} function.

If argument method.bias is "count", the test statistic is based on the rank correlation between a standardised cell frequency and the inverse of the variance of the cell frequency; Kendall’s tau is used as correlation measure (Schwarzer et al., 2007). The test statistic follows a standard normal distribution. By default (if \(correct\) is FALSE), no continuity correction is utilised (Kendall & Gibbons, 1990).

If argument method.bias is "score", the test statistic is based on a weighted linear regression utilising efficient score and score variance (Harbord et al., 2006). The test statistic follows a \(t\) distribution with number of studies - 2 degrees of freedom.

In order to calculate an arcsine test for funnel plot asymmetry (Rücker et al., 2008), one has to use the \texttt{metabin} function with argument \texttt{sm="ASD"} as input to the \texttt{metabias} command. The three arcsine tests described in Rücker et al. (2008) can be calculated by setting \texttt{method.bias} to "rank", "linreg" and "mm", respectively.

If argument method.bias is missing, the Harbord test (\texttt{method.bias=\"score\"}) is used for the odds ratio as effect measure and the Egger test (\texttt{method.bias=\"linreg\"}) for other effect measures (Sterne et al., 2011).

No test for funnel plot asymmetry is conducted in meta-analyses with subgroups.

Value

A list with class “htest” containing the following components if a test for funnel plot asymmetry is conducted:
estimate The estimated degree of funnel plot asymmetry, with name "ks" or "bias" corresponding to the method employed, i.e., rank correlation or regression method.
statistic The value of the test statistic.
parameters The degrees of freedom of the test statistic in the case that it follows a t distribution.
p.value The p-value for the test.
alternative A character string describing the alternative hypothesis.
method A character string indicating what type of test was used.
data.name A character string giving the names of the data.
title Title of Cochrane review.
complab Comparison label.
outclab Outcome label.
version Version of R package meta used to create object.

Or a list with the following elements if test is not conducted due to the number of studies:
k Number of studies in meta-analysis.
k.min Minimum number of studies to perform test for funnel plot asymmetry.
version Version of R package meta used to create object.

Author(s)
Guido Schwarzer <sc@imbi.uni-freiburg.de>

References


Kendall M & Gibbons JD (1990), Rank Correlation Methods. London: Edward Arnold.


Schwarzer G, Antes G & Schumacher M (2007), A test for publication bias in meta-analysis with sparse binary data. Statistics in Medicine, 26, 721–733.


See Also

funnel, funnel.meta, metabin, metacont, metagen

Examples

data(01kin95)
meta1 <- metabin(event.e, n.e, event.c, n.c,
data=01kin95, subset=1:10,
sm="RR", method="I")

metabias(meta1)
metabias(meta1, plotit=TRUE)

metabias(meta1, method.bias="rank")
metabias(meta1, method.bias="rank", correct=TRUE)

metabias(meta1, method.bias="count")
metabias(meta1, method.bias="linreg")$p.value

#
# Arcsine test (based on linear regression):
#
#meta1.as <- metabin(event.e, n.e, event.c, n.c,
data=01kin95, subset=1:10,
sm="ASD", method="I")

metabias(meta1.as)
#
# Same result (using function metabias.default):
#
metabias(meta1.as$TE, meta1.as$seTE)

#
# No test for funnel plot asymmetry calculated:
#
meta2 <- metabin(event.e, n.e, event.c, n.c,
data=01kin95, subset=1:5,
sm="RR", method="I")

metabias(meta2)

meta3 <- metabin(event.e, n.e, event.c, n.c,
data=01kin95, subset=1:2,
sm="RR", method="I")

metabias(meta3)

# Test for funnel plot asymmetry calculated (use of argument k.min):
#
metabias(meta2, k.min=5)
**Description**

Calculation of fixed effect and random effects estimates (risk ratio, odds ratio, risk difference, or arcsine difference) for meta-analyses with binary outcome data. Mantel-Haenszel, inverse variance, Peto method, and generalised linear mixed model (GLMM) are available for pooling. For GLMMs, the `rma.glmm` function from R package `metafor` (Viechtbauer 2010) is called internally.

**Usage**

```r
metabin(event.e, n.e, event.c, n.c, studlab,
  data=NULL, subset=NULL,
  method=ifelse(tau.common, "Inverse", gs("method")),
  sm=
    ifelse(!is.na(charmatch(tolower(method), c("peto", "glmm"),
                       nomatch = NA)),
    "OR", gs("smbin")),
  incr=gs("incr"), allincr=gs("allincr"),
  addincr=gs("addincr"), allstudies=gs("allstudies"),
  MH.exact=gs("MH.exact"), RR.cochrane=gs("RR.cochrane"),
  model.glmm = "UM.FS",
  level=gs("level"), level.comb=gs("level.comb"),
  comb.fixed=gs("comb.fixed"), comb.random=gs("comb.random"),
  hakn=gs("hakn"),
  method.tau=
    ifelse(!is.na(charmatch(tolower(method), "glmm", nomatch = NA)),
         "ML", gs("method.tau")),
  tau.preset=NULL, TE.tau=NULL,
  tau.common=gs("tau.common"),
  prediction=gs("prediction"), level.predict=gs("level.predict"),
  method.bias=ifelse(sm="OR", "score", gs("method.bias")),
  backtransf=gs("backtransf"),
  title=gs("title"), complab=gs("complab"), outclab="",
  label.e=gs("label.e"), label.c=gs("label.c"),
  label.left=gs("label.left"), label.right=gs("label.right"),
  byvar, bylab, print.byvar=gs("print.byvar"),
  byseparator = gs("byseparator"),
  print.CMH=gs("print.CMH"),
  keepdata=gs("keepdata"),
  warn=gs("warn"),
...)
```

**Arguments**

- `event.e` Number of events in experimental group.
n.e Number of observations in experimental group.

event.c Number of events in control group.

n.c Number of observations in control group.

studlab An optional vector with study labels.

data An optional data frame containing the study information, i.e., event.e, n.e, event.c, and n.c.

subset An optional vector specifying a subset of studies to be used.

method A character string indicating which method is to be used for pooling of studies. One of "Inverse", "MH", "Peto", or "GLMM", can be abbreviated.

sm A character string indicating which summary measure ("RR", "OR", "RD", or "ASD") is to be used for pooling of studies, see Details.

incr Could be either a numerical value which is added to each cell frequency for studies with a zero cell count or the character string "TACC" which stands for treatment arm continuity correction, see Details.

allincr A logical indicating if incr is added to each cell frequency of all studies if at least one study has a zero cell count. If FALSE (default), incr is added only to each cell frequency of studies with a zero cell count.

addincr A logical indicating if incr is added to each cell frequency of all studies irrespective of zero cell counts.

allstudies A logical indicating if studies with zero or all events in both groups are to be included in the meta-analysis (applies only if sm is equal to "RR" or "OR").

MH.exact A logical indicating if incr is not to be added to all cell frequencies for studies with a zero cell count to calculate the pooled estimate based on the Mantel-Haenszel method.

RR.cochrane A logical indicating if 2*incr instead of 1*incr is to be added to n.e and n.c in the calculation of the risk ratio (i.e., sm="RR") for studies with a zero cell. This is used in RevMan 5, the Cochrane Collaboration's program for preparing and maintaining Cochrane reviews.

model.glmm A character string indicating which GLMM should be used. One of "UM.FS", "UM.RS", "CM.EL", and "CM.AL", see Details.

level The level used to calculate confidence intervals for individual studies.

level.comb The level used to calculate confidence intervals for pooled estimates.

comb.fixed A logical indicating whether a fixed effect meta-analysis should be conducted.

comb.random A logical indicating whether a random effects meta-analysis should be conducted.

prediction A logical indicating whether a prediction interval should be printed.

level.predict The level used to calculate prediction interval for a new study.

hakn A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.

method.tau A character string indicating which method is used to estimate the between-study variance $\tau^2$. Either "DL", "PM", "REML", "ML", "HS", "SJ", "HE", or "EB", can be abbreviated.
**metabin**

- `tau.preset` Prespecified value for the square-root of the between-study variance $\tau^2$.
- `TE.tau` Overall treatment effect used to estimate the between-study variance $\tau^2$.
- `tau.common` A logical indicating whether tau-squared should be the same across subgroups.
- `method.bias` A character string indicating which test for funnel plot asymmetry is to be used. Either "rank", "linreg", "mm", "count", "score", or "peters", can be abbreviated. See function `metabias`.
- `backtransf` A logical indicating whether results for odds ratio (sm="OR") and risk ratio (sm="RR") should be back transformed in printouts and plots. If TRUE (default), results will be presented as odds ratios and risk ratios; otherwise log odds ratios and log risk ratios will be shown.
- `title` Title of meta-analysis / systematic review.
- `complab` Comparison label.
- `outclab` Outcome label.
- `label.e` Label for experimental group.
- `label.c` Label for control group.
- `label.left` Graph label on left side of forest plot.
- `label.right` Graph label on right side of forest plot.
- `byvar` An optional vector containing grouping information (must be of same length as `event.e`).
- `bylab` A character string with a label for the grouping variable.
- `print.byvar` A logical indicating whether the name of the grouping variable should be printed in front of the group labels.
- `byseparator` A character string defining the separator between label and levels of grouping variable.
- `print.CMH` A logical indicating whether result of the Cochran-Mantel-Haenszel test for overall effect should be printed.
- `keepdata` A logical indicating whether original data (set) should be kept in meta object.
- `warn` A logical indicating whether warnings should be printed (e.g., if `incr` is added to studies with zero cell frequencies).

Details

Treatment estimates and standard errors are calculated for each study. The following measures of treatment effect are available:

- Risk ratio (sm="RR")
- Odds ratio (sm="OR")
- Risk difference (sm="RD")
- Arcsine difference (sm="ASD")
For several arguments defaults settings are utilised (assignments using \textit{gs} function). These defaults can be changed using the \texttt{settings.meta} function.

Internally, both fixed effect and random effects models are calculated regardless of values chosen for arguments \texttt{comb\_fixed} and \texttt{comb\_random}. Accordingly, the estimate for the random effects model can be extracted from component \texttt{TE\_random} of an object of class "\textit{meta}" even if argument \texttt{comb\_random}=FALSE. However, all functions in R package \texttt{meta} will adequately consider the values for \texttt{comb\_fixed} and \texttt{comb\_random}. E.g. function \texttt{print.meta} will not print results for the random effects model if \texttt{comb\_random}=FALSE.

By default, both fixed effect and random effects models are considered (see arguments \texttt{comb\_fixed} and \texttt{comb\_random}). If \texttt{method} is "\textit{MH}" (default), the Mantel-Haenszel method is used to calculate the fixed effect estimate; if \texttt{method} is "\textit{Inverse}", inverse variance weighting is used for pooling; if \texttt{method} is "\textit{Peto}" the Peto method is used for pooling. For the Peto method, Peto's log odds ratio, i.e. \((O - E) / V\) and its standard error \(\sqrt{O \div E \times V}\) with \(O \div E\) and \(V\) denoting "Observed minus Expected" and "\(V\)", are utilised in the random effects model. Accordingly, results of a random effects model using \texttt{sm="Peto"} can be (slightly) different to results from a random effects model using \texttt{sm="MH"} or \texttt{sm="Inverse"}.

A distinctive and frequently overlooked advantage of binary endpoints is that individual patient data (IPD) can be extracted from a two-by-two table. Accordingly, statistical methods for IPD, i.e., logistic regression and generalised linear mixed models, can be utilised in a meta-analysis of binary outcomes (Stijnen et al., 2010; Simmonds et al., 2014). These methods are available (argument \texttt{method} = "\textit{GLMM}"") for the odds ratio as summary measure by calling the \texttt{rma.glmm} function from R package \texttt{metafor} internally. Four different GLMMs are available for meta-analysis with binary outcomes using argument \texttt{model.glmm} (which corresponds to argument \texttt{model} in the \texttt{rma.glmm} function):

- Logistic regression model with fixed study effects (default)
  \(\texttt{model.glmm} = \"UM.FS\"\), i.e., \textit{Unconditional Model - Fixed Study effects}
- Mixed-effects logistic regression model with random study effects
  \(\texttt{model.glmm} = \"UM.RS\"\), i.e., \textit{Unconditional Model - Random Study effects}
- Generalised linear mixed model (conditional Hypergeometric-Normal)
  \(\texttt{model.glmm} = \"CM.EL\"\), i.e., \textit{Conditional Model - Exact Likelihood}
- Generalised linear mixed model (conditional Binomial-Normal)
  \(\texttt{model.glmm} = \"CM.AL\"\), i.e., \textit{Conditional Model - Approximate Likelihood}

Details on these four GLMMs as well as additional arguments which can be provided using argument '...' in \texttt{metabin} are described in \texttt{rma.glmm} where you can also find information on the iterative algorithms used for estimation. Note, regardless of which value is used for argument \texttt{model.glmm}, results for two different GLMMs are calculated: fixed effect model (with fixed treatment effect) and random effects model (with random treatment effects).

For studies with a zero cell count, by default, 0.5 is added to all cell frequencies of these studies; if \texttt{incr} is "\texttt{TACC}" a treatment arm continuity correction is used instead (Sweeting et al., 2004; Diamond et al., 2007). For odds ratio and risk ratio, treatment estimates and standard errors are only calculated for studies with zero or all events in both groups if \texttt{allstudies} is \texttt{TRUE}. This continuity correction is used both to calculate individual study results with confidence limits and to conduct meta-analysis based on the inverse variance method. For Peto method and GLMMs no continuity correction is used. For the Mantel-Haenszel method, by default (if \texttt{MH.exact} is \texttt{FALSE}),
incr is added to all cell frequencies of a study with a zero cell count in the calculation of the pooled risk ratio or odds ratio as well as the estimation of the variance of the pooled risk difference, risk ratio or odds ratio. This approach is also used in other software, e.g. RevMan 5 and the Stata procedure metan. According to Fleiss (in Cooper & Hedges, 1994), there is no need to add 0.5 to a cell frequency of zero to calculate the Mantel-Haenszel estimate and he advocates the exact method (MH.exact=TRUE). Note, estimates based on exact Mantel-Haenszel method or GLMM are not defined if the number of events is zero in all studies either in the experimental or control group.

Argument byvar can be used to conduct subgroup analysis for all methods but GLMMs. Instead use the metareg function for GLMMs which can also be used for continuous covariates.

A prediction interval for treatment effect of a new study is calculated (Higgins et al., 2009) if arguments prediction and comb.random are TRUE.

R function update.meta can be used to redo the meta-analysis of an existing metabin object by only specifying arguments which should be changed.

For the random effects, the method by Hartung and Knapp (2001) is used to adjust test statistics and confidence intervals if argument hakn=TRUE. For GLMMs, a method similar to Knapp and Hartung (2003) is implemented, see description of argument tdist in rma.glmm.

The DerSimonian-Laird estimate (1986) is used in the random effects model if method.tau="DL". The iterative Paule-Mandel method (1982) to estimate the between-study variance is used if argument method.tau="PM". Internally, R function paulemandel is called which is based on R function mpaule.default from R package metRology from S.L.R. Ellison <s.ellison at lgc.co.uk>.

If R package metafor (Viechtbauer 2010) is installed, the following methods to estimate the between-study variance \( \tau^2 \) (argument method.tau) are also available:

- Restricted maximum-likelihood estimator (method.tau="REML")
- Maximum-likelihood estimator (method.tau="ML")
- Hunter-Schmidt estimator (method.tau="HS")
- Sidik-Jonkman estimator (method.tau="SJ")
- Hedges estimator (method.tau="HE")
- Empirical Bayes estimator (method.tau="EB").

For these methods the R function rma.uni of R package metafor is called internally. See help page of R function rma.uni for more details on these methods to estimate between-study variance.

**Value**

An object of class c("metabin", "meta") with corresponding print, summary, plot function. The object is a list containing the following components:

- event.e, n.e, event.c, n.c, studlab,
- sm, method, incr, allincr, addincr,
- allstudies, MH.exact, RR.cochrane, model.glmm, warn,
- level, level.comb, comb.fixed, comb.random,
hakn, method.tau, tau.preset, TE.tau, method.bias,

tau.common, title, complab, outlab,

label.e, label.c, label.left, label.right,

byvar, bylab, print.byvar, byseparator
   As defined above.

TE, seTE    Estimated treatment effect and standard error of individual studies.
lower, upper Lower and upper confidence interval limits for individual studies.
zval, pval   z-value and p-value for test of treatment effect for individual studies.
w.fixed, w.random Weight of individual studies (in fixed and random effects model).

TE.fixed, seTE.fixed Estimated overall treatment effect and standard error (fixed effect model).
lower.fixed, upper.fixed Lower and upper confidence interval limits (fixed effect model).
zval.fixed, pval.fixed z-value and p-value for test of overall treatment effect (fixed effect model).

TE.random, seTE.random Estimated overall treatment effect and standard error (random effects model).
lower.random, upper.random Lower and upper confidence interval limits (random effects model).
zval.random, pval.random z-value or t-value and corresponding p-value for test of overall treatment effect (random effects model).

prediction, level.predict As defined above.

seTE.predict Standard error utilised for prediction interval.
lower.predict, upper.predict Lower and upper limits of prediction interval.

k         Number of studies combined in meta-analysis.
Q         Heterogeneity statistic Q.
df.Q      Degrees of freedom for heterogeneity statistic.
Q.LRT     Heterogeneity statistic for likelihood-ratio test (only if method = "GLMM").
tau       Square-root of between-study variance.
se.tau    Standard error of square-root of between-study variance.
C         Scaling factor utilised internally to calculate common tau-squared across subgroups.
Q.CMH     Cochran-Mantel-Haenszel test statistic for overall effect.
incr.e, incr.c Increment added to cells in the experimental and control group, respectively.
sparse    Logical flag indicating if any study included in meta-analysis has any zero cell frequencies.
Logical flag indicating if any study has zero cell frequencies in both treatment groups.

Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if hakn=TRUE).

Number of studies combined in meta-analysis using Mantel-Haenszel method.

Levels of grouping variable - if byvar is not missing.

Estimated treatment effect and standard error in subgroups (fixed effect model) - if byvar is not missing.

Lower and upper confidence interval limits in subgroups (fixed effect model) - if byvar is not missing.

z-value and p-value for test of treatment effect in subgroups (fixed effect model) - if byvar is not missing.

Estimated treatment effect and standard error in subgroups (random effects model) - if byvar is not missing.

Lower and upper confidence interval limits in subgroups (random effects model) - if byvar is not missing.

z-value or t-value and corresponding p-value for test of treatment effect in subgroups (random effects model) - if byvar is not missing.

Weight of subgroups (in fixed and random effects model) - if byvar is not missing.

Degrees of freedom for test of treatment effect for Hartung-Knapp method in subgroups - if byvar is not missing and hakn=TRUE.

Harmonic mean of number of observations in subgroups (for back transformation of Freeman-Tukey Double arcsine transformation) - if byvar is not missing.

Number of events in experimental group in subgroups - if byvar is not missing.

Number of observations in experimental group in subgroups - if byvar is not missing.

Number of events in control group in subgroups - if byvar is not missing.

Number of observations in control group in subgroups - if byvar is not missing.

Number of studies combined within subgroups - if byvar is not missing.

Number of all studies in subgroups - if byvar is not missing.

Heterogeneity statistics within subgroups - if byvar is not missing.

Overall within subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.
Overall within subgroups heterogeneity statistic $Q$ (based on random effects model) - if `byvar` is not missing (only calculated if argument `tau.common` is TRUE).

Degrees of freedom for test of overall within subgroups heterogeneity - if `byvar` is not missing.

Overall between subgroups heterogeneity statistic $Q$ (based on fixed effect model) - if `byvar` is not missing.

Overall between subgroups heterogeneity statistic $Q$ (based on random effects model) - if `byvar` is not missing.

Degrees of freedom for test of overall between subgroups heterogeneity - if `byvar` is not missing.

Square-root of between-study variance within subgroups - if `byvar` is not missing.

Scaling factor utilised internally to calculate common tau-squared across subgroups - if `byvar` is not missing.

Heterogeneity statistic $H$ within subgroups - if `byvar` is not missing.

Lower and upper confidence limits for heterogeneity statistic $H$ within subgroups - if `byvar` is not missing.

Heterogeneity statistic $I^2$ within subgroups - if `byvar` is not missing.

Lower and upper confidence limits for heterogeneity statistic $I^2$ within subgroups - if `byvar` is not missing.

As defined above.

Original data (set) used in function call (if `keepdata`=TRUE).

Information on subset of original data used in meta-analysis (if `keepdata`=TRUE).

GLMM object generated by call of `rma.glmm` function (fixed effect model).

GLMM object generated by call of `rma.glmm` function (random effects model).

Function call.

Version of R package `meta` used to create object.

Version of R package `metafor` used for GLMMs.

Guido Schwarzer <sc@imbi.uni-freiburg.de>


StataCorp. 2011. *Stata Statistical Software: Release 12*. College Station, TX: StataCorp LP.


See Also

```
update.meta, forest, funnel, metabias, metacont, metagen, metareg, print.meta
```

Examples

```
# Calculate odds ratio and confidence interval for a single study
#
metabin(10, 20, 15, 20, sm = "OR")

#
# Different results (due to handling of studies with double zeros)
#
```
```r
metabin(0, 10, 0, 10, sm = "OR")
metabin(0, 10, 0, 10, sm = "OR", allstudies = TRUE)

# Use subset of Olkin (1995) to conduct meta-analysis based on inverse variance method (with risk ratio as summary measure)
# data(Olkin95)
meta1 <- metabin(event.e, n.e, event.c, n.c,
                 data = Olkin95, subset = c(41, 47, 51, 59),
                 method = "Inverse")
summary(meta1)
funnel(meta1)

# Use different subset of Olkin (1995)
# meta2 <- metabin(event.e, n.e, event.c, n.c,
#                 data = Olkin95, subset = Olkin95$year < 1970,
#                 method = "Inverse", studlab = author)
# summary(meta2)
# forest(meta2)
#
# Meta-analysis with odds ratio as summary measure
# meta3 <- metabin(event.e, n.e, event.c, n.c,
#                 data = Olkin95, subset = Olkin95$year < 1970,
#                 sm = "OR", method = "Inverse", studlab = author)
# Same meta-analysis result using 'update.meta' function
# meta3 <- update(meta2, sm = "OR")
# summary(meta3)
#
# Meta-analysis based on Mantel-Haenszel method
# (with odds ratio as summary measure)
# meta4 <- update(meta3, method = "MHi")
# summary(meta4)
#
# Meta-analysis based on Peto method
# (only available for odds ratio as summary measure)
# meta5 <- update(meta3, method = "Peto")
# summary(meta5)

## Not run:
#
# Meta-analysis using generalised linear mixed models
# (only if R packages 'metafor' and 'lme4' are available)
# if (suppressMessages(require(metafor, quietly = TRUE, warn = FALSE)) &
```
require(lme4, quietly = TRUE)) {

  # Logistic regression model with (k = 4) fixed study effects
  # (default: model.glmm = "UM.FS")
  #
  meta6 <- metabin(event.e, n.e, event.c, n.c,
                   data = Olkin95, subset = Olkin95$year < 1970,
                   method = "GLMM")

  # Same results:
  meta6 <- update(meta2, method = "GLMM")
  summary(meta6)

  # Mixed-effects logistic regression model with random study effects
  # (warning message printed due to argument 'nAGQ')
  #
  meta7 <- update(meta6, model.glmm = "UM.RS")

  # Use additional argument 'nAGQ' for internal call of 'rma.glmm' function
  #
  meta7 <- update(meta6, model.glmm = "UM.RS", nAGQ = 1)
  summary(meta7)

  # Generalised linear mixed model (conditional Hypergeometric-Normal)
  # (R package 'BiasedUrn' must be available)
  #
  if (require(BiasedUrn, quietly = TRUE)) {
    meta8 <- update(meta6, model.glmm = "CM.EL")
    summary(meta8)
  }

  # Generalised linear mixed model (conditional Binomial-Normal)
  #
  meta9 <- update(meta6, model.glmm = "CM.AL")
  summary(meta9)

  # Logistic regression model with (k = 70) fixed study effects
  # (about 18 seconds with Intel Core i7-3667U, 2.0GHz)
  #
  meta10 <- metabin(event.e, n.e, event.c, n.c,
                     data = Olkin95, method = "GLMM")
  summary(meta10)

  # Mixed-effects logistic regression model with random study effects
  # - about 50 seconds with Intel Core i7-3667U, 2.0GHz
  # - several warning messages, e.g. "failure to converge, ..."
  #
  summary(update(meta10, model.glmm = "UM.RS"))

  # Conditional Hypergeometric-Normal GLMM
  # - long computation time (about 12 minutes with Intel Core i7-3667U, 2.0GHz)
  # - estimation problems for this very large dataset:
  # * warning that Choleski factorization of Hessian failed
metacont

Meta-analysis of continuous outcome data

Description

Calculation of fixed and random effects estimates for meta-analyses with continuous outcome data; inverse variance weighting is used for pooling.

Usage

metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c, studlab, 
  data=NULL, subset=NULL, 
  sm=gs("smcont"), pooledvar=gs("pooledvar"), 
  method.smd=gs("method.smd"), sd.glass=gs("sd.glass"), 
  exact.smd=gs("exact.smd"), 
  level=gs("level"), level.comb=gs("level.comb"), 
  comb.fixed=gs("comb.fixed"), comb.random=gs("comb.random"), 
  hakn=gs("hakn"), 
  method.tau=gs("method.tau"), tau.preset=NULL, TE.tau=NULL, 
  tau.common=gs("tau.common"), 
  prediction=gs("prediction"), level.predict=gs("level.predict"), 
  method.bias=gs("method.bias"), 
  backtransf=gs("backtransf"), 
  title=gs("title"), complab=gs("complab"), outclab="", 
  label.e=gs("label.e"), label.c=gs("label.c"), 
  label.left=gs("label.left"), label.right=gs("label.right"), 
  byvar, bylab, print.byvar=gs("print.byvar"), 
  byseparator=gs("byseparator"), 
  keepdata=gs("keepdata"), 
  warn=gs("warn"))
### Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>n.e</td>
<td>Number of observations in experimental group.</td>
</tr>
<tr>
<td>mean.e</td>
<td>Estimated mean in experimental group.</td>
</tr>
<tr>
<td>sd.e</td>
<td>Standard deviation in experimental group.</td>
</tr>
<tr>
<td>n.c</td>
<td>Number of observations in control group.</td>
</tr>
<tr>
<td>mean.c</td>
<td>Estimated mean in control group.</td>
</tr>
<tr>
<td>sd.c</td>
<td>Standard deviation in control group.</td>
</tr>
<tr>
<td>studlab</td>
<td>An optional vector with study labels.</td>
</tr>
<tr>
<td>data</td>
<td>An optional data frame containing the study information.</td>
</tr>
<tr>
<td>subset</td>
<td>An optional vector specifying a subset of studies to be used.</td>
</tr>
<tr>
<td>level</td>
<td>The level used to calculate confidence intervals for individual studies.</td>
</tr>
<tr>
<td>level.comb</td>
<td>The level used to calculate confidence intervals for pooled estimates.</td>
</tr>
<tr>
<td>comb.fixed</td>
<td>A logical indicating whether a fixed effect meta-analysis should be conducted.</td>
</tr>
<tr>
<td>comb.random</td>
<td>A logical indicating whether a random effects meta-analysis should be conducted.</td>
</tr>
<tr>
<td>prediction</td>
<td>A logical indicating whether a prediction interval should be printed.</td>
</tr>
<tr>
<td>level.predict</td>
<td>The level used to calculate prediction interval for a new study.</td>
</tr>
<tr>
<td>hakn</td>
<td>A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.</td>
</tr>
<tr>
<td>method.tau</td>
<td>A character string indicating which method is used to estimate the between-study variance $\tau^2$. Either &quot;DL&quot;, &quot;PM&quot;, &quot;REML&quot;, &quot;ML&quot;, &quot;HS&quot;, &quot;SJ&quot;, &quot;HE&quot;, or &quot;EB&quot;, can be abbreviated.</td>
</tr>
<tr>
<td>tau.preset</td>
<td>Prespecified value for the square-root of the between-study variance $\tau^2$.</td>
</tr>
<tr>
<td>TE.tau</td>
<td>Overall treatment effect used to estimate the between-study variance $\tau$-squared.</td>
</tr>
<tr>
<td>tau.common</td>
<td>A logical indicating whether $\tau$-squared should be the same across subgroups.</td>
</tr>
<tr>
<td>method.bias</td>
<td>A character string indicating which test is to be used. Either &quot;rank&quot;, &quot;linreg&quot;, or &quot;mm&quot;, can be abbreviated. See function <code>metabias</code>.</td>
</tr>
<tr>
<td>backtransf</td>
<td>A logical indicating whether results for ratio of means (sm=&quot;ROM&quot;) should be back transformed in printouts and plots. If TRUE (default), results will be presented as ratio of means; otherwise log ratio of means will be shown.</td>
</tr>
<tr>
<td>title</td>
<td>Title of meta-analysis / systematic review.</td>
</tr>
<tr>
<td>complab</td>
<td>Comparison label.</td>
</tr>
<tr>
<td>outclab</td>
<td>Outcome label.</td>
</tr>
<tr>
<td>label.e</td>
<td>Label for experimental group.</td>
</tr>
<tr>
<td>label.c</td>
<td>Label for control group.</td>
</tr>
<tr>
<td>label.left</td>
<td>Graph label on left side of forest plot.</td>
</tr>
<tr>
<td>label.right</td>
<td>Graph label on right side of forest plot.</td>
</tr>
<tr>
<td>sm</td>
<td>A character string indicating which summary measure (&quot;MD&quot;, &quot;SMD&quot;, or &quot;ROM&quot;) is to be used for pooling of studies.</td>
</tr>
</tbody>
</table>
A logical indicating if a pooled variance should be used for the mean difference (\texttt{sm="MD"}).

A character string indicating which method is used to estimate the standardised mean difference (\texttt{sm="SMD"}). Either "Hedges" for Hedges’ g (default), "Cohen" for Cohen’s d, or "Glass" for Glass’ delta, can be abbreviated.

A character string indicating which standard deviation is used in the denominator for Glass’ method to estimate the standardised mean difference. Either "control" using the standard deviation in the control group (\texttt{sd.\textsubscript{c}}) or "experimental" using the standard deviation in the experimental group (\texttt{sd.\textsubscript{e}}), can be abbreviated.

A logical indicating whether exact formulae should be used in estimation of the standardised mean difference and its standard error (see Details).

An optional vector containing grouping information (must be of same length as \texttt{n}\textsubscript{e}).

A character string with a label for the grouping variable.

A logical indicating whether the name of the grouping variable should be printed in front of the group labels.

A character string defining the separator between label and levels of grouping variable.

A logical indicating whether original data (set) should be kept in meta object.

A logical indicating whether warnings should be printed (e.g., if studies are excluded from meta-analysis due to zero standard deviations).

Details

Calculation of fixed and random effects estimates for meta-analyses with continuous outcome data; inverse variance weighting is used for pooling.

Three different types of summary measures are available for continuous outcomes:

- mean difference (argument \texttt{sm="MD"})
- standardised mean difference (\texttt{sm="SMD"})
- ratio of means (\texttt{sm="ROM"})

Meta-analysis of ratio of means – also called response ratios – is described in Hedges et al. (1999) and Friedrich et al. (2008).

For the standardised mean difference three methods are implemented:

- Hedges’ g (default, \texttt{method.\textsubscript{smd}="Hedges"}) - see Hedges (1981)
- Cohen’s d (\texttt{method.\textsubscript{smd}="Cohen"}) - see Cohen (1988)
- Glass’ delta (\texttt{method.\textsubscript{smd}="Glass"}) - see Glass (1976)

Hedges (1981) calculated the exact bias in Cohen’s d which is a ratio of gamma distributions with the degrees of freedom, i.e. total sample size minus two, as argument. By default (argument \texttt{exact.\textsubscript{smd}=FALSE}), an accurate approximation of this bias provided in Hedges (1981) is utilised for Hedges’ g as well as its standard error; these approximations are also used in RevMan 5. Following Borenstein et al. (2009) these approximations are not used in the estimation of Cohen’s d.
White and Thomas (2005) argued that approximations are unnecessary with modern software and accordingly promote to use the exact formulae; this is possible using argument `exact.smd=TRUE`. For Hedges’ g the exact formulae are used to calculate the standardised mean difference as well as the standard error; for Cohen’s d the exact formula is only used to calculate the standard error. In typical applications (with sample sizes above 10), the differences between using the exact formulae and the approximation will be minimal.

For Glass’ delta, by default (argument `sd.glass"control"`), the standard deviation in the control group (sd. c) is used in the denominator of the standard mean difference. The standard deviation in the experimental group (sd. e) can be used by specifying `sd.glass"experimental"`. Calculations are conducted on the log scale for ratio of means (`sm"ROM"`). Accordingly, list elements `TE, TE.fixed, and TE.random` contain the logarithm of ratio of means. In printouts and plots these values are back transformed if argument `backtransf=TRUE`.

For several arguments defaults settings are utilised (assignments using `gs` function). These defaults can be changed using the `settings.meta` function.

Internally, both fixed effect and random effects models are calculated regardless of values choosen for arguments `comb.fixed` and `comb.random`. Accordingly, the estimate for the random effects model can be extracted from component `TE.random` of an object of class "meta" even if argument `comb.random=FALSE`. However, all functions in R package meta will adequately consider the values for `comb.fixed` and `comb.random`. E.g. function `print.meta` will not print results for the random effects model if `comb.random=FALSE`.

The function `metagen` is called internally to calculate individual and overall treatment estimates and standard errors.

A prediction interval for treatment effect of a new study is calculated (Higgins et al., 2009) if arguments `prediction` and `comb.random` are TRUE.

R function `update.meta` can be used to redo the meta-analysis of an existing metacont object by only specifying arguments which should be changed.

For the random effects, the method by Hartung and Knapp (2003) is used to adjust test statistics and confidence intervals if argument `hakn=TRUE`.

The DerSimonian-Laird estimate (1986) is used in the random effects model if `method.tau"DL"`. The iterative Paule-Mandel method (1982) to estimate the between-study variance is used if argument `method.tau="PM"`. Internally, R function `paulemandel` is called which is based on R function `mpaule.default` from R package metRology from S.L.R. Ellison <s.ellison at lgc.co.uk>.

If R package metafor (Viechtbauer 2010) is installed, the following methods to estimate the between-study variance $\tau^2$ (argument `method.tau`) are also available:

- Restricted maximum-likelihood estimator (method.tau="REML")
- Maximum-likelihood estimator (method.tau="ML")
- Hunter-Schmidt estimator (method.tau="HS")
- Sidik-Jonkman estimator (method.tau="SJ")
- Hedges estimator (method.tau="HE")
- Empirical Bayes estimator (method.tau="EB").

For these methods the R function `rma.uni` of R package metafor is called internally. See help page of R function `rma.uni` for more details on these methods to estimate between-study variance.
**Value**

An object of class c("metacont", "meta") with corresponding print, summary, plot function. The object is a list containing the following components:

- `n.e`, `mean.e`, `sd.e`,
- `n.c`, `mean.c`, `sd.c`,
- `studlab`, `sm`, `level`, `level.comb`,
- `comb.fixed`, `comb.random`,
- `pooledvar`, `method.smd`, `sd.glass`,
- `hakn`, `method.tau`, `tau.preset`, `TE.tau`, `method.bias`,
- `tau.common`, `title`, `complab`, `outclab`,
- `label.e`, `label.c`, `label.left`, `label.right`,
- `byvar`, `bylab`, `print.byvar`, `byseparator`, `warn`  
  As defined above.
- `TE`, `seTE`  
  Estimated treatment effect and standard error of individual studies.
- `lower`, `upper`  
  Lower and upper confidence interval limits for individual studies.
- `zval`, `pval`  
  Z-value and p-value for test of treatment effect for individual studies.
- `w.fixed`, `w.random`  
  Weight of individual studies (in fixed and random effects model).
- `TE.fixed`, `seTE.fixed`  
  Estimated overall treatment effect and standard error (fixed effect model).
- `lower.fixed`, `upper.fixed`  
  Lower and upper confidence interval limits (fixed effect model).
- `zval.fixed`, `pval.fixed`  
  Z-value and p-value for test of overall treatment effect (fixed effect model).
- `TE.random`, `seTE.random`  
  Estimated overall treatment effect and standard error (random effects model).
- `lower.random`, `upper.random`  
  Lower and upper confidence interval limits (random effects model).
- `zval.random`, `pval.random`  
  Z-value or t-value and corresponding p-value for test of overall treatment effect (random effects model).
- `prediction`, `level.predict`  
  As defined above.
- `seTE.predict`  
  Standard error utilised for prediction interval.
- `lower.predict`, `upper.predict`  
  Lower and upper limits of prediction interval.
k  Number of studies combined in meta-analysis.
Q  Heterogeneity statistic.
tau Square-root of between-study variance.
se.tau Standard error of square-root of between-study variance.
C  Scaling factor utilised internally to calculate common tau-squared across sub-
groups.
method Pooling method: "Inverse".
df.hakn Degrees of freedom for test of treatment effect for Hartung-Knapp method (only
if hakn=TRUE).
bylevs Levels of grouping variable - if byvar is not missing.
TE.fixed.w, seTE.fixed.w  Estimated treatment effect and standard error in subgroups (fixed effect model)
- if byvar is not missing.
lower.fixed.w, upper.fixed.w  Lower and upper confidence interval limits in subgroups (fixed effect model) -
if byvar is not missing.
zval.fixed.w, pval.fixed.w  z-value and p-value for test of treatment effect in subgroups (fixed effect model)
- if byvar is not missing.
TE.random.w, seTE.random.w  Estimated treatment effect and standard error in subgroups (random effects model)
- if byvar is not missing.
lower.random.w, upper.random.w  Lower and upper confidence interval limits in subgroups (random effects model) -
if byvar is not missing.
zval.random.w, pval.random.w  z-value or t-value and corresponding p-value for test of treatment effect in sub-
groups (random effects model) - if byvar is not missing.
w.fixed.w, w.random.w  Weight of subgroups (in fixed and random effects model) - if byvar is not missing.
df.hakn Degrees of freedom for test of treatment effect for Hartung-Knapp method in
subgroups - if byvar is not missing and hakn=TRUE.
n.harmonic.mean.w  Harmonic mean of number of observations in subgroups (for back transforma-
tion of Freeman-Tukey Double arcsine transformation) - if byvar is not missing.
n.e.w  Number of observations in experimental group in subgroups - if byvar is not missing.
n.c.w  Number of observations in control group in subgroups - if byvar is not missing.
k.w  Number of studies combined within subgroups - if byvar is not missing.
k.all.w  Number of all studies in subgroups - if byvar is not missing.
Q.w  Heterogeneity statistics within subgroups - if byvar is not missing.
Q.w.fixed Overall within subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.
Q.w.random Overall within subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing (only calculated if argument tau.common is TRUE).
df.Q.w Degrees of freedom for test of overall within subgroups heterogeneity - if byvar is not missing.
Q.b.fixed Overall between subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.
Q.b.random Overall between subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing.
df.Q.b Degrees of freedom for test of overall between subgroups heterogeneity - if byvar is not missing.
tau.w Square-root of between-study variance within subgroups - if byvar is not missing.
C.w Scaling factor utilised internally to calculate common tau-squared across subgroups - if byvar is not missing.
H.w Heterogeneity statistic H within subgroups - if byvar is not missing.
lower.H.w, upper.H.w Lower and upper confidence limits for heterogeneity statistic H within subgroups - if byvar is not missing.
I2.w Heterogeneity statistic I2 within subgroups - if byvar is not missing.
lower.I2.w, upper.I2.w Lower and upper confidence limits for heterogeneity statistic I2 within subgroups - if byvar is not missing.
keepdata As defined above.
data Original data (set) used in function call (if keepdata=TRUE).
subset Information on subset of original data used in meta-analysis (if keepdata=TRUE).
call Function call.
version Version of R package meta used to create object.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

References

Borenstein et al. (2009), Introduction to Meta-Analysis, Chichester: Wiley.


White IR, Thomas J (2005), Standardized mean differences in individually-randomized and cluster-randomized trials, with applications to meta-analysis. *Clinical Trials*, 2, 141–51.

See Also

`update.meta, metabin, metagen`

Examples

```r
data(Fleiss93cont)
meta1 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c, data=Fleiss93cont, sm="SMD")
meta1
forest(meta1)

meta2 <- metacont(Fleiss93cont$n.e, Fleiss93cont$mean.e, Fleiss93cont$sd.e, Fleiss93cont$n.c, Fleiss93cont$mean.c, Fleiss93cont$sd.c, sm="SMD")

meta2

data(amlodipine)
meta3 <- metacont(n.amlo, mean.amlo, sqrt(var.amlo), n.plac, mean.plac, sqrt(var.plac), data=amlodipine, studlab=study)
summary(meta3)
```
# Use pooled variance
#
meta4 <- metacont(n.amlo, mean.amlo, sqrt(var.amlo),
  n.plac, mean.plac, sqrt(var.plac),
  data=amlodipine, study=study,
  pooledvar=TRUE)
summary(meta4)

# Use Cohen's d instead of Hedges' g as effect measure
#
meta5 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c, data=Fleiss93cont,
  sm="SMD", method.smd="Cohen")
meta5

# Use Glass' delta instead of Hedges' g as effect measure
#
meta6 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c, data=Fleiss93cont,
  sm="SMD", method.smd="Glass")
meta6

# Use Glass' delta based on the standard deviation in the experimental group
#
meta7 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c, data=Fleiss93cont,
  sm="SMD", method.smd="Glass", sd.glass="experimental")
meta7

# Calculate Hedges' g based on exact formulae
#
update(meta1, exact.smd=TRUE)

# Meta-analysis of response ratios (Hedges et al., 1999)
#
data(woodyplants)
meta8 <- metacont(n.elev, mean.elev, sd.elev,
  n.amb, mean.amb, sd.amb,
  data=woodyplants, sm="ROM")
summary(meta8)
summary(meta8, backtransf=FALSE)

---

**Description**

Calculation of fixed and random effects estimates for meta-analyses with correlations; inverse variance weighting is used for pooling.
Usage

metacor(cor, n, studlab, 
data=NULL, subset=NULL, 
sm=gs("smcor"), 
level=gs("level"), level.comb=gs("level.comb"), 
comb.fixed=gs("comb.fixed"), comb.random=gs("comb.random"), 
hakn=gs("hakn"), 
method.tau=gs("method.tau"), tau.preset=NULL, TE.tau=NULL, 
tau.common=gs("tau.common"), 
prediction=gs("prediction"), level.predict=gs("level.predict"), 
null.effect=0, 
method.bias=gs("method.bias"), 
backtransf=gs("backtransf"), 
title=gs("title"), complab=gs("complab"), outclab="", 
byvar, bylab, print.byvar=gs("print.byvar"), 
byseparator = gs("byseparator"), 
keepdata=gs("keepdata")
)

Arguments

cor  Correlation.
n  Number of observations.
studlab  An optional vector with study labels.
data  An optional data frame containing the study information, i.e., cor and n.
subset  An optional vector specifying a subset of studies to be used.
sm  A character string indicating which summary measure ("ZCOR" or "COR") is to be used for pooling of studies.
level  The level used to calculate confidence intervals for individual studies.
level.comb  The level used to calculate confidence intervals for pooled estimates.
comb.fixed  A logical indicating whether a fixed effect meta-analysis should be conducted.
comb.random  A logical indicating whether a random effects meta-analysis should be conducted.
prediction  A logical indicating whether a prediction interval should be printed.
level.predict  The level used to calculate prediction interval for a new study.
hakn  A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.
method.tau  A character string indicating which method is used to estimate the between-study variance $\tau^2$. Either "DL", "PM", "REML", "ML", "HS", "SJ", "HE", or "EB", can be abbreviated.
tau.preset  Prespecified value for the square-root of the between-study variance $\tau^2$.
TE.tau  Overall treatment effect used to estimate the between-study variance tau-squared.
tau.common  A logical indicating whether tau-squared should be the same across subgroups.
null.effect A numeric value specifying the effect under the null hypothesis.

method.bias A character string indicating which test is to be used. Either "rank", "linreg", or "mm", can be abbreviated. See function metabias

backtransf A logical indicating whether results for Fisher’s z transformed correlations (sm="ZCOR") should be back transformed in printouts and plots. If TRUE (default), results will be presented as correlations; otherwise Fisher’s z transformed correlations will be shown.

title Title of meta-analysis / systematic review.

complab Comparison label.

outclab Outcome label.

byvar An optional vector containing grouping information (must be of same length as event.e).

bylab A character string with a label for the grouping variable.

print.byvar A logical indicating whether the name of the grouping variable should be printed in front of the group labels.

byseparator A character string defining the separator between label and levels of grouping variable.

keepdata A logical indicating whether original data (set) should be kept in meta object.

Details

Fixed effect and random effects meta-analysis of correlations based either on Fisher’s z transformation of correlations (sm="ZCOR") or direct combination of correlations (sm="COR") (see Cooper et al., p264-5 and p273-4).

Only few statisticians would advocate the use of untransformed correlations unless sample sizes are very large (see Cooper et al., p265). The artificial example given below shows that the smallest study gets the largest weight if correlations are combined directly because the correlation is closest to 1.

For several arguments defaults settings are utilised (assignments using gs function). These defaults can be changed using the settings.meta function.

Internally, both fixed effect and random effects models are calculated regardless of values choosen for arguments comb.fixed and comb.random. Accordingly, the estimate for the random effects model can be extracted from component TE.random of an object of class "meta" even if argument comb.random=FALSE. However, all functions in R package meta will adequately consider the values for comb.fixed and comb.random. E.g. function print.meta will not print results for the random effects model if comb.random=FALSE.

A prediction interval for treatment effect of a new study is calculated (Higgins et al., 2009) if arguments prediction and comb.random are TRUE.

R function update.meta can be used to redo the meta-analysis of an existing metacor object by only specifying arguments which should be changed.

For the random effects, the method by Hartung and Knapp (2003) is used to adjust test statistics and confidence intervals if argument hakn=TRUE.
The DerSimonian-Laird estimate (1986) is used in the random effects model if `method.tau="DL"`. The iterative Paule-Mandel method (1982) to estimate the between-study variance is used if argument `method.tau="PM"`. Internally, R function `paulemandel` is called which is based on R function `mpaule.default` from R package `metRology` from S.L.R. Ellison <s.ellison at lgc.co.uk>.

If R package `metafor` (Viechtbauer 2010) is installed, the following methods to estimate the between-study variance \( \tau^2 \) (argument `method.tau`) are also available:

- Restricted maximum-likelihood estimator (method `tau="REML"`)
- Maximum-likelihood estimator (method `tau="ML"`)
- Hunter-Schmidt estimator (method `tau="HS"`)
- Sidik-Jonkman estimator (method `tau="SJ"`)
- Hedges estimator (method `tau="HE"`)
- Empirical Bayes estimator (method `tau="EB"`).

For these methods the R function `rma.uni` of R package `metafor` is called internally. See help page of R function `rma.uni` for more details on these methods to estimate between-study variance.

**Value**

An object of class `c("metacor", "meta")` with corresponding `print`, `summary`, `plot` function. The object is a list containing the following components:

- `cor`, `n`, `studlab`,
- `sm`, `level`, `level.comb`,
- `comb.fixed`, `comb.random`,
- `hakn`, `method.tau`, `tau.preset`, `TE.tau`, `null.effect`,
- `method.bias`, `tau.common`, `title`, `complab`, `outclab`,
- `byvar`, `bylab`, `print.byvar`, `byseparator`  
  As defined above.
- `TE`, `seTE`  
  Either Fisher’s z transformation of correlations (sm="ZCOR") or correlations (sm="COR") for individual studies.
- `lower`, `upper`  
  Lower and upper confidence interval limits for individual studies.
- `zval`, `pval`  
  z-value and p-value for test of treatment effect for individual studies.
- `w.fixed`, `w.random`  
  Weight of individual studies (in fixed and random effects model).
- `TE.fixed`, `seTE.fixed`  
  Estimated overall effect (Fisher’s z transformation of correlation or correlation) and its standard error (fixed effect model).
- `lower.fixed`, `upper.fixed`  
  Lower and upper confidence interval limits (fixed effect model).
zval.fixed, pval.fixed
    z-value and p-value for test of overall effect (fixed effect model).

TE.random, seTE.random
    Estimated overall effect (Fisher's z transformation of correlation or correlation) and its standard error (random effects model).

lower.random, upper.random
    Lower and upper confidence interval limits (random effects model).

zval.random, pval.random
    z-value or t-value and corresponding p-value for test of overall effect (random effects model).

prediction, level.predict
    As defined above.

seTE.predict
    Standard error utilised for prediction interval.

lower.predict, upper.predict
    Lower and upper limits of prediction interval.

k
    Number of studies combined in meta-analysis.

Q
    Heterogeneity statistic Q.

tau
    Square-root of between-study variance.

se.tau
    Standard error of square-root of between-study variance.

C
    Scaling factor utilised internally to calculate common tau-squared across subgroups.

method
    A character string indicating method used for pooling: "Inverse"

df.hakn
    Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if hakn=TRUE).

bylevs
    Levels of grouping variable - if byvar is not missing.

TE.fixed.w, seTE.fixed.w
    Estimated treatment effect and standard error in subgroups (fixed effect model) - if byvar is not missing.

lower.fixed.w, upper.fixed.w
    Lower and upper confidence interval limits in subgroups (fixed effect model) - if byvar is not missing.

zval.fixed.w, pval.fixed.w
    z-value and p-value for test of treatment effect in subgroups (fixed effect model) - if byvar is not missing.

TE.random.w, seTE.random.w
    Estimated treatment effect and standard error in subgroups (random effects model) - if byvar is not missing.

lower.random.w, upper.random.w
    Lower and upper confidence interval limits in subgroups (random effects model) - if byvar is not missing.

zval.random.w, pval.random.w
    z-value or t-value and corresponding p-value for test of treatment effect in subgroups (random effects model) - if byvar is not missing.
Weight of subgroups (in fixed and random effects model) - if byvar is not missing.

Degrees of freedom for test of treatment effect for Hartung-Knapp method in subgroups - if byvar is not missing and hakn=TRUE.

Harmonic mean of number of observations in subgroups (for back transformation of Freeman-Tukey Double arcsine transformation) - if byvar is not missing.

Number of observations in subgroups - if byvar is not missing.

Number of studies combined within subgroups - if byvar is not missing.

Number of all studies in subgroups - if byvar is not missing.

Heterogeneity statistics within subgroups - if byvar is not missing.

Overall within subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.

Overall within subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing (only calculated if argument tau.common is TRUE).

Degrees of freedom for test of overall within subgroups heterogeneity - if byvar is not missing.

Overall between subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.

Overall between subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing.

Degrees of freedom for test of overall between subgroups heterogeneity - if byvar is not missing.

Square-root of between-study variance within subgroups - if byvar is not missing.

Scaling factor utilised internally to calculate common tau-squared across subgroups - if byvar is not missing.

Heterogeneity statistic H within subgroups - if byvar is not missing.

Lower and upper confidence limits for heterogeneity statistic H within subgroups - if byvar is not missing.

Heterogeneity statistic I2 within subgroups - if byvar is not missing.

Lower and upper confidence limits for heterogeneity statistic I2 within subgroups - if byvar is not missing.

As defined above.

Original data (set) used in function call (if keepdata=TRUE).

Information on subset of original data used in meta-analysis (if keepdata=TRUE).

Function call.

Version of R package meta used to create object.
Author(s)
Guido Schwarzer <sc@imbi.uni-freiburg.de>

References


See Also
`update.nmeta, metacont, metagen, print.meta`

Examples
```r
m1 <- metacor(c(0.85, 0.7, 0.95), c(20, 40, 10))

# # Print correlations (back transformed from Fisher's z transformation)
#
# m1

# # Print Fisher's z transformed correlations
# print(m1, backtransf=FALSE)

# # Forest plot with back transformed correlations
# forest(m1)

# # Forest plot with Fisher's z transformed correlations
# forest(m1, backtransf=FALSE)

m2 <- update(m1, sm="cor")
m2
```
metacr

Meta-analysis of outcome data from Cochrane review

Description

Wrapper function to perform meta-analysis for a single outcome of a Cochrane Intervention review.

Usage

```r
metacr(x, comp.no=1, outcome.no=1, 
method, sm, 
level=gs("level"), level.comb=gs("level.comb"), 
comb.fixed, comb.random, 
hakn=FALSE, 
method.tau="DL", 
tau.common=FALSE, 
prediction=gs("prediction"), level.predict=gs("level.predict"), 
swap.events, logscale, 
backtransf=gs("backtransf"), 
title, complab, outclab, 
keepdata=gs("keepdata"), warn=FALSE)
```

Arguments

- **x**  
  An object of class `rm5` created by R function `read.rm5`.
- **comp.no**  
  Comparison number.
- **outcome.no**  
  Outcome number.
- **method**  
  A character string indicating which method is to be used for pooling of studies. One of "Inverse", "MH", or "Peto", can be abbreviated.
- **sm**  
  A character string indicating which summary measure ("RR", "OR", "RD", "ASD", "HR", "MD", or "SMD", or "ROM") is to be used for pooling of studies.
- **level**  
  The level used to calculate confidence intervals for individual studies.
- **level.comb**  
  The level used to calculate confidence intervals for pooled estimates.
- **comb.fixed**  
  A logical indicating whether a fixed effect meta-analysis should be conducted.
- **comb.random**  
  A logical indicating whether a random effects meta-analysis should be conducted.
- **hakn**  
  A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.
- **method.tau**  
  A character string indicating which method is used to estimate the between-study variance $\tau^2$. Either "DL", "PM", "REML", "ML", "HS", "SJ", "HE", or "EB", can be abbreviated.
### Details

Cochrane Intervention reviews are based on the comparison of two interventions. Each Cochrane Intervention review can have a variable number of comparisons. For each comparison, a variable number of outcomes can be define. For each outcome, a separate meta-analysis is conducted. Review Manager 5 (RevMan 5) is the current software used for preparing and maintaining Cochrane Reviews (http://community.cochrane.org/tools/review-production-tools/revman-5).

This wrapper function can be used to perform meta-analysis for a single outcome of a Cochrane Intervention review. Internally, R functions `metabin`, `metacont`, and `metagen` are called - depending on the definition of the outcome in RevMan 5.

Note, it is recommended to specify the RevMan 5 before executing `metacr`, i.e.,

```r
settings.meta("revman5")
```

### Value

An object of class "meta" and "metabin", "metacont", or "metagen" depending on outcome type utilised in Cochrane Intervention review for selected outcome.

### Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

### References


### See Also

`metabin`, `metacont`, `metagen`, `read.rm5`, `settings.meta`
Examples

```r
# Locate export data file "Fleiss93_CR.csv"
# in sub-directory of package "meta"
#
filename <- system.file("data/Fleiss93_CR.csv.gz", package = "meta")
#
Fleiss93_CR <- read.rm5(filename)
#
# Choose RevMan 5 settings and store old settings
#
oldset <- settings.meta("revman5")
#
# Same result as R command example(Fleiss93):
#
metacr(Fleiss93_CR)
#
# Same result as R command example(Fleiss93cont):
#
metacr(Fleiss93_CR, 1, 2)

forest(metacr(Fleiss93_CR, 1, 2))
#
# Change summary measure to RR
#
ml <- metacr(Fleiss93_CR)
update(ml, sm="RR")
#
# Use old settings
#
settings.meta(oldset)
```

---

**Description**

Performs a cumulative meta-analysis.

**Usage**

`metacum(x, pooled, sortvar)`

**Arguments**

- `x` An object of class `meta`
- `pooled` A character string indicating whether a fixed effect or random effects model is used for pooling. Either missing (see Details), "fixed", or "random", can be abbreviated.
- `sortvar` An optional vector used to sort the individual studies (must be of same length as `x$TE`).
Details

A cumulative meta-analysis is performed. Studies are included sequentially as defined by \texttt{sortvar}. Information from object \texttt{x} is utilised if argument \texttt{pooled} is missing. A fixed effect model is assumed (\texttt{pooled=“fixed”}) if argument \texttt{x$comb.fixed} is \texttt{TRUE}; a random effects model is assumed (\texttt{pooled=“random”}) if argument \texttt{x$comb.random} is \texttt{TRUE} and \texttt{x$comb.fixed} is \texttt{FALSE}.

Value

An object of class \texttt{c(“metacum”, “meta”)} with corresponding \texttt{print, plot} function. The object is a list containing the following components:

\begin{itemize}
\item \texttt{TE, seTE} Estimated treatment effect and standard error of pooled estimate in cumulative meta-analyses.
\item \texttt{lower, upper} Lower and upper confidence interval limits.
\item \texttt{studlab} Study label describing addition of studies.
\item \texttt{p.value} P-value for test of overall effect.
\item \texttt{w} Sum of weights from fixed effect or random effects model.
\item \texttt{I2} Heterogeneity statistic \textit{I}^2.
\item \texttt{Rb} Heterogeneity statistic \textit{R}^2.
\item \texttt{tau} Square-root of between-study variance.
\item \texttt{df.hakn} Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if \texttt{hakn=TRUE}).
\item \texttt{sm} Summary measure.
\item \texttt{method} Method used for pooling.
\item \texttt{k} Number of studies combined in meta-analysis.
\item \texttt{pooled} As defined above.
\item \texttt{comb.fixed} A logical indicating whether analysis is based on fixed effect model.
\item \texttt{comb.random} A logical indicating whether analysis is based on random effects model.
\item \texttt{TE.fixed, seTE.fixed} Value is \texttt{NA}.
\item \texttt{TE.random, seTE.random} Value is \texttt{NA}.
\item \texttt{Q} Value is \texttt{NA}.
\item \texttt{level.comb} The level used to calculate confidence intervals for pooled estimates.
\item \texttt{hakn} A logical indicating whether the method by Hartung and Knapp is used to adjust test statistics and confidence intervals.
\item \texttt{method.tau} A character string indicating which method is used to estimate the between-study variance \( \tau^2 \).
\item \texttt{tau.preset} Prespecified value for the square-root of the between-study variance \( \tau^2 \).
\item \texttt{TE.tau} Overall treatment effect used to estimate the between-study variance \( \tau^2 \).
\item \texttt{n.harmonic.mean} Harmonic mean of number of observations (for back transformation of Freeman-Tukey Double arcsine transformation).
\item \texttt{version} Version of R package \textbf{meta} used to create object.
\end{itemize}
**metagen**

**Description**

Fixed and random effects meta-analysis based on estimates (e.g. log hazard ratios) and their standard errors; inverse variance weighting is used for pooling.

**Author(s)**

Guido Schwarzer <sc@imbi.uni-freiburg.de>

**References**


**See Also**

`metabin`, `metacont`, `print.meta`

**Examples**

```r
data(Fleiss93)
meta1 <- metabin(event.e, n.e, event.c, n.c,
                 data=Fleiss93, studylab=study,
                 sm="RR", method="I")
meta1

metacum(meta1)
metacum(meta1, pooled="random")

forest(metacum(meta1))
forest(metacum(meta1, pooled="random"))

metacum(meta1, sortvar=study)
metacum(meta1, sortvar=7:1)

meta2 <- update(meta1, title="Fleiss93 meta-analysis",
                 backtransf=FALSE)
metacum(meta2)

data(Fleiss93cont)
meta3 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c,
                  data = Fleiss93cont, sm = "SMD")

metacum(meta3)
```
Usage

metagen(TE, seTE, studlab, data=NULL, subset=NULL, sm="", level=gs("level"), level.comb=gs("level.comb"), comb.fixed=gs("comb.fixed"), comb.random=gs("comb.random"), hakn=gs("hakn"), method.tau=gs("method.tau"), tau.preset=NULL, TE.tau=NULL, tau.common=gs("tau.common"), prediction=gs("prediction"), level.predict=gs("level.predict"), null.effect=0, method.bias=gs("method.bias"), n.e=NULL, n.c=NULL, backtransf=gs("backtransf"), pscale=1, irscale = 1, irunit = "person-years", title=gs("title"), complab=gs("complab"), outclab="", label.e=gs("label.e"), label.c=gs("label.c"), label.left=gs("label.left"), label.right=gs("label.right"), byvar, bylab, print.byvar=gs("print.byvar"), byseparator = gs("byseparator"), keepdata=gs("keepdata"), warn=gs("warn")

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE</td>
<td>Estimate of treatment effect.</td>
</tr>
<tr>
<td>seTE</td>
<td>Standard error of treatment estimate.</td>
</tr>
<tr>
<td>studlab</td>
<td>An optional vector with study labels.</td>
</tr>
<tr>
<td>data</td>
<td>An optional data frame containing the study information.</td>
</tr>
<tr>
<td>subset</td>
<td>An optional vector specifying a subset of studies to be used.</td>
</tr>
<tr>
<td>sm</td>
<td>A character string indicating underlying summary measure, e.g., &quot;RD&quot;, &quot;RR&quot;, &quot;OR&quot;, &quot;ASD&quot;, &quot;HR&quot;, &quot;MD&quot;, &quot;SMD&quot;, or &quot;ROM&quot;.</td>
</tr>
<tr>
<td>level</td>
<td>The level used to calculate confidence intervals for individual studies.</td>
</tr>
<tr>
<td>level.comb</td>
<td>The level used to calculate confidence intervals for pooled estimates.</td>
</tr>
<tr>
<td>comb.fixed</td>
<td>A logical indicating whether a fixed effect meta-analysis should be conducted.</td>
</tr>
<tr>
<td>comb.random</td>
<td>A logical indicating whether a random effects meta-analysis should be conducted.</td>
</tr>
<tr>
<td>prediction</td>
<td>A logical indicating whether a prediction interval should be printed.</td>
</tr>
<tr>
<td>level.predict</td>
<td>The level used to calculate prediction interval for a new study.</td>
</tr>
<tr>
<td>null.effect</td>
<td>A numeric value specifying the effect under the null hypothesis.</td>
</tr>
<tr>
<td>n.e</td>
<td>Number of observations in experimental group.</td>
</tr>
<tr>
<td>n.c</td>
<td>Number of observations in control group.</td>
</tr>
<tr>
<td>hakn</td>
<td>A logical indicating whether method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.</td>
</tr>
</tbody>
</table>
method.tau  A character string indicating which method is used to estimate the between-study variance $\tau^2$. Either "DL", "PM", "REML", "ML", "HS", "SJ", "HE", or "EB", can be abbreviated.

tau.preset  Prespecified value for the square-root of the between-study variance $\tau^2$.

TE.tau  Overall treatment effect used to estimate the between-study variance tau-squared.

tau.common  A logical indicating whether tau-squared should be the same across subgroups.

method.bias  A character string indicating which test is to be used. Either "rank", "linreg", or "mm", can be abbreviated. See function metabias

backtransf  A logical indicating whether results should be back transformed in printouts and plots. If backtransf=TRUE (default), results for sm="OR" are printed as odds ratios rather than log odds ratios and results for sm="ZCOR" are printed as correlations rather than Fisher’s z transformed correlations, for example.

pscale  A numeric defining a scaling factor for printing of single event probabilities, i.e. if argument sm is equal to "PLOGIT", "PLN", "PRAW", "PAS", or "PFT". See also metaprop

irscale  A numeric defining a scaling factor for printing of rates, i.e. if argument sm is equal to "IR", "IRLN", "IRS", or "IRFT".

irunit  A character specifying the time unit used to calculate rates, e.g. person-years.

title  Title of meta-analysis / systematic review.

complab  Comparison label.

outclab  Outcome label.

label.e  Label for experimental group.

label.c  Label for control group.

label.left  Graph label on left side of forest plot.

label.right  Graph label on right side of forest plot.

byvar  An optional vector containing grouping information (must be of same length as TE).

bylab  A character string with a label for the grouping variable.

print.byvar  A logical indicating whether the name of the grouping variable should be printed in front of the group labels.

byseparator  A character string defining the separator between label and levels of grouping variable.

keepdata  A logical indicating whether original data (set) should be kept in meta object.

warn  A logical indicating whether warnings should be printed (e.g., if studies are excluded from meta-analysis due to zero standard errors).

Details

Generic method for meta-analysis, only treatment estimates and their standard error are needed. The method is useful, e.g., for pooling of survival data (using log hazard ratio and standard errors as input). The inverse variance method is used for pooling.
For several arguments defaults settings are utilised (assignments using `gs` function). These defaults can be changed using the `settings.meta` function.

Internally, both fixed effect and random effects models are calculated regardless of values choosen for arguments `comb.fixed` and `comb.random`. Accordingly, the estimate for the random effects model can be extracted from component `TE.random` of an object of class "meta" even if argument `comb.random=FALSE`. However, all functions in R package `meta` will adequately consider the values for `comb.fixed` and `comb.random`. E.g. function `print.meta` will not print results for the random effects model if `comb.random=FALSE`.

A prediction interval for treatment effect of a new study is calculated (Higgins et al., 2009) if arguments `prediction` and `comb.random` are `TRUE`.

R function `update.meta` can be used to redo the meta-analysis of an existing `metagen` object by only specifying arguments which should be changed.

For the random effects, the method by Hartung and Knapp (2003) is used to adjust test statistics and confidence intervals if argument `hakn`=`TRUE`.

The DerSimonian-Laird estimate (1986) is used in the random effects model if `method.tau="DL"`. The iterative Paule-Mandel method (1982) to estimate the between-study variance is used if argument `method.tau="PM"`. Internally, R function `paulemandel` is called which is based on R function `mpaulae.default` from R package `metaRology` from S.L.R. Ellison <s.ellison at lgc.co.uk>.

If R package `metafor` (Viechtbauer 2010) is installed, the following methods to estimate the between-study variance $\tau^2$ (argument `method.tau`) are also available:

- Restricted maximum-likelihood estimator (`method.tau="REML"`)
- Maximum-likelihood estimator (`method.tau="ML"`)
- Hunter-Schmidt estimator (`method.tau="HS"`)
- Sidik-Jonkman estimator (`method.tau="SJ"`)
- Hedges estimator (`method.tau="HE"`)
- Empirical Bayes estimator (`method.tau="EB"`).

For these methods the R function `rma.uni` of R package `metafor` is called internally. See help page of R function `rma.uni` for more details on these methods to estimate between-study variance.

Argument `pscale` can be used to rescale proportions, e.g. `pscale=1000` means that proportions are expressed as events per 1000 observations. This is useful in situations with (very) low event probabilities.

Argument `irscale` can be used to rescale rates, e.g. `irscale=1000` means that rates are expressed as events per 1000 time units, e.g. person-years. This is useful in situations with (very) low rates. Argument `irunit` can be used to specify the time unit used in individual studies (default: "person-years"). This information is printed in summaries and forest plots if argument `irscale` is not equal to 1.

**Value**

An object of class `c("metagen", "meta")` with corresponding `print`, `summary`, `plot` function. The object is a list containing the following components:

- `TE, seTE, studlab, n.e, n.c`
metagen

sm, level, level.comb,
comb.fixed, comb.random,
hakn, method.tau, tau.preset, TE.tau, method.bias,
tau.common, title, complab, outlab,
label.e, label.c, label.left, label.right,
byvar, bylab, print.byvar, byseparator, warn
As defined above.
lower, upper Lower and upper confidence interval limits for individual studies.
zval, pval z-value and p-value for test of treatment effect for individual studies.
w.fixed, w.random Weight of individual studies (in fixed and random effects model).
TE.fixed, seTE.fixed Estimated overall treatment effect and standard error (fixed effect model).
lower.fixed, upper.fixed Lower and upper confidence interval limits (fixed effect model).
zval.fixed, pval.fixed z-value and p-value for test of overall treatment effect (fixed effect model).
TE.random, seTE.random Estimated overall treatment effect and standard error (random effects model).
lower.random, upper.random Lower and upper confidence interval limits (random effects model).
zval.random, pval.random z-value or t-value and corresponding p-value for test of overall treatment effect (random effects model).
prediction, level.predict As defined above.
seTE.predict Standard error utilised for prediction interval.
lower.predict, upper.predict Lower and upper limits of prediction interval.
null.effect As defined above.
k Number of studies combined in meta-analysis.
Q Heterogeneity statistic.
df.Q Degrees of freedom for heterogeneity statistic.
tau Square-root of between-study variance.
se.tau Standard error of square-root of between-study variance.
C Scaling factor utilised internally to calculate common tau-squared across subgroups.
method Pooling method: "Inverse".
df.hakn Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if hakn=TRUE).

bylevs Levels of grouping variable - if byvar is not missing.

TE.fixed.w, seTE.fixed.w Estimated treatment effect and standard error in subgroups (fixed effect model) - if byvar is not missing.

lower.fixed.w, upper.fixed.w Lower and upper confidence interval limits in subgroups (fixed effect model) - if byvar is not missing.

zval.fixed.w, pval.fixed.w z-value and p-value for test of treatment effect in subgroups (fixed effect model) - if byvar is not missing.

TE.random.w, seTE.random.w Estimated treatment effect and standard error in subgroups (random effects model) - if byvar is not missing.

lower.random.w, upper.random.w Lower and upper confidence interval limits in subgroups (random effects model) - if byvar is not missing.

zval.random.w, pval.random.w z-value or t-value and corresponding p-value for test of treatment effect in subgroups (random effects model) - if byvar is not missing.

w.fixed.w, w.random.w Weight of subgroups (in fixed and random effects model) - if byvar is not missing.

df.hakn.w Degrees of freedom for test of treatment effect for Hartung-Knapp method in subgroups - if byvar is not missing and hakn=TRUE.

n.harmonic.mean.w Harmonic mean of number of observations in subgroups (for back transformation of Freeman-Tukey Double arcsine transformation) - if byvar is not missing.

n.e.w Number of observations in experimental group in subgroups - if byvar is not missing.

n.c.w Number of observations in control group in subgroups - if byvar is not missing.

k.w Number of studies combined within subgroups - if byvar is not missing.

k.all.w Number of all studies in subgroups - if byvar is not missing.

Q.w Heterogeneity statistics within subgroups - if byvar is not missing.

Q.w.fixed Overall within subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.

Q.w.random Overall within subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing (only calculated if argument tau.common is TRUE).

df.Q.w Degrees of freedom for test of overall within subgroups heterogeneity - if byvar is not missing.

Q.b.fixed Overall between subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.
metagen

Q.b.random Overall between subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing.
df.Q.b Degrees of freedom for test of overall between subgroups heterogeneity - if byvar is not missing.
tau.w Square-root of between-study variance within subgroups - if byvar is not missing.
C.w Scaling factor utilised internally to calculate common tau-squared across subgroups - if byvar is not missing.
H.w Heterogeneity statistic H within subgroups - if byvar is not missing.
lower.H.w, upper.H.w Lower and upper confidence limits for heterogeneity statistic H within subgroups - if byvar is not missing.
I2.w Heterogeneity statistic I2 within subgroups - if byvar is not missing.
lower.I2.w, upper.I2.w Lower and upper confidence limits for heterogeneity statistic I2 within subgroups - if byvar is not missing.
keepdata As defined above.
data Original data (set) used in function call (if keepdata=TRUE).
subset Information on subset of original data used in meta-analysis (if keepdata=TRUE).
call Function call.
version Version of R package meta used to create object.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

References


DerSimonian R & Laird N (1986), Meta-analysis in clinical trials. Controlled Clinical Trials, 7, 177–188.


See Also

update.meta, metabin, metacont, print.meta
Examples

data(fleiss93)
metal <- metabin(event.e, n.e, event.c, n.c, data=Fleiss93, sm="RR", method="I")
metal

# Identical results by using the following commands:
# metaL
metagen(metal$TE, metal$seTE, sm="RR")
forest(metagen(metal$TE, metal$seTE, sm="RR"))

# Meta-analysis with prespecified between-study variance
# summary(metagen(metal$TE, metal$seTE, sm="RR", tau.preset=sqrt(0.1)))

# Meta-analysis of survival data:
# logHR <- log(c(0.95, 1.5))
selogHR <- c(0.25, 0.35)
metagen(logHR, selogHR, sm="HR")

# Paule-Mandel method to estimate between-study variance
# Data from Paule & Mandel (1982)
# average <- c(27.044, 26.022, 26.340, 26.787, 26.796)
variance <- c(0.003, 0.076, 0.464, 0.003, 0.014)
# summary(metagen(average, sqrt(variance), sm="MD", method.tau="PM"))

---

Description

Calculation of fixed effect and random effects estimates (incidence rate ratio or incidence rate difference) for meta-analyses with event counts. Mantel-Haenszel, Cochran, inverse variance method, and generalised linear mixed model (GLMM) are available for pooling. For GLMMs, the rma.glmm function from R package metafor (Viechtbauer 2010) is called internally.
**Usage**

```r
metainc(event.e, time.e, event.c, time.c, studlab,
data=NULL, subset=NULL, method="M-H",
sm=gs("sminc"),
incr=gs("incr"), allincr=gs("allincr"),
addincr=gs("addincr"),
model.glmm = "UM.FS",
level=gs("level"), level.comb=gs("level.comb"),
comb.fixed=gs("comb.fixed"), comb.random=gs("comb.random"),
hakn=gs("hakn"),
method.tau= ifelse(!is.na(charmatch(tolower(method), "glmm", nomatch = NA)),
   "ML", gs("method.tau")),
tau.preset=NULL, TE.tau=NULL,
tau.common=gs("tau.common"),
prediction=gs("prediction"), level.predict=gs("level.predict"),
method.bias=gs("method.bias"),
n.e=NULL, n.c=NULL,
backtransf=gs("backtransf"),
title=gs("title"), complab=gs("complab"), outclab="",
label.e=gs("label.e"), label.c=gs("label.c"),
label.left=gs("label.left"), label.right=gs("label.right"),
byvar, bylab, print.byvar=gs("print.byvar"),
byseparator = gs("byseparator"),
keepdata=gs("keepdata"),
warn=gs("warn"),
...
```

**Arguments**

- `event.e`: Number of events in experimental group.
- `time.e`: Person time at risk in experimental group.
- `event.c`: Number of events in control group.
- `time.c`: Person time at risk in control group.
- `studlab`: An optional vector with study labels.
- `data`: An optional data frame containing the study information, i.e., event.e, time.e, event.c, and time.c.
- `subset`: An optional vector specifying a subset of studies to be used.
- `method`: A character string indicating which method is to be used for pooling of studies. One of "M-H", "Inverse", "Cochran", or "GLMM" can be abbreviated.
- `sm`: A character string indicating which summary measure ("IRR" or "IRD") is to be used for pooling of studies, see Details.
- `incr`: A numerical value which is added to each cell frequency for studies with a zero cell count, see Details.
allincr A logical indicating if incr is added to each cell frequency of all studies if at least one study has a zero cell count. If FALSE (default), incr is added only to each cell frequency of studies with a zero cell count.

addincr A logical indicating if incr is added to each cell frequency of all studies irrespective of zero cell counts.

model.glmm A character string indicating which GLMM should be used. One of "UM.FS", "UM.RS", and "CM.EL", see Details.

level The level used to calculate confidence intervals for individual studies.

level.comb The level used to calculate confidence intervals for pooled estimates.

comb.fixed A logical indicating whether a fixed effect meta-analysis should be conducted.

comb.random A logical indicating whether a random effects meta-analysis should be conducted.

prediction A logical indicating whether a prediction interval should be printed.

level.predict The level used to calculate prediction interval for a new study.

hakn A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.

method.tau A character string indicating which method is used to estimate the between-study variance $\tau^2$. Either "DL", "PM", "REML", "ML", "HS", "SJ", "HE", or "EB", can be abbreviated.

tau.preset Prespecified value for the square-root of the between-study variance $\tau^2$.

TE.tau Overall treatment effect used to estimate the between-study variance $\tau^2$.

tau.common A logical indicating whether tau-squared should be the same across subgroups.

method.bias A character string indicating which test for funnel plot asymmetry is to be used. Either "linreg" or "rank", can be abbreviated. See function metabias

n.e Number of observations in experimental group (optional).

n.c Number of observations in control group (optional).

backtransf A logical indicating whether results for incidence rate ratio (sm="IRR") should be back transformed in printouts and plots. If TRUE (default), results will be presented as incidence rate ratios; otherwise log incidence rate ratios will be shown.

title Title of meta-analysis / systematic review.

complab Comparison label.

outclab Outcome label.

label.e Label for experimental group.

label.c Label for control group.

label.left Graph label on left side of forest plot.

label.right Graph label on right side of forest plot.

byvar An optional vector containing grouping information (must be of same length as event.e).

bylab A character string with a label for the grouping variable.
print.byvar A logical indicating whether the name of the grouping variable should be printed in front of the group labels.

byseparator A character string defining the separator between label and levels of grouping variable.

keepdata A logical indicating whether original data (set) should be kept in meta object.

warn A logical indicating whether warnings should be printed (e.g., if incr is added to studies with zero cell frequencies).

... Additional arguments passed on to rma.glmm function.

Details

Treatment estimates and standard errors are calculated for each study. The following measures of treatment effect are available:

• Incidence Rate Ratio (sm="IRR")
• Incidence Rate Difference (sm="IRD")

For several arguments defaults settings are utilised (assignments using gs function). These defaults can be changed using the settings.meta function.

Internally, both fixed effect and random effects models are calculated regardless of values choosen for arguments comb.fixed and comb.random. Accordingly, the estimate for the random effects model can be extracted from component TE.random of an object of class "meta" even if argument comb.random=FALSE. However, all functions in R package meta will adequately consider the values for comb.fixed and comb.random. E.g. function print.meta will not print results for the random effects model if comb.random=FALSE.

By default, both fixed effect and random effects models are considered (see arguments comb.fixed and comb.random). If method is "MH" (default), the Mantel-Haenszel method is used to calculate the fixed effect estimate (Greenland & Robbins, 1985); if method is "Inverse", inverse variance weighting is used for pooling; if method is "Cochran", the Cochran method is used for pooling (Bayne-Jones, 1964, Chapter 8).

A distinctive and frequently overlooked advantage of incidence rates is that individual patient data (IPD) can be extracted from count data. Accordingly, statistical methods for IPD, i.e., generalised linear mixed models, can be utilised in a meta-analysis of incidence rate ratios (Stijnen et al., 2010). These methods are available (argument method = "GLMM") by calling the rma.glmm function from R package metafor internally. Three different GLMMs are available for meta-analysis of incidence rate ratios using argument model.glmm (which corresponds to argument model in the rma.glmm function):

• Poisson regression model with fixed study effects (default)
  (model.glmm = "UM.FS", i.e., Unconditional Model - Fixed Study effects)
• Mixed-effects Poisson regression model with random study effects
  (model.glmm = "UM.RS", i.e., Unconditional Model - Random Study effects)
• Generalised linear mixed model (conditional Poisson-Normal)
  (model.glmm = "CM.EL", i.e., Conditional Model - Exact Likelihood)
Details on these three GLMMs as well as additional arguments which can be provided using argument `...` in `metainc` are described in `rma.glmm` where you can also find information on the iterative algorithms used for estimation. Note, regardless of which value is used for argument `model.glmm`, results for two different GLMMs are calculated: fixed effect model (with fixed treatment effect) and random effects model (with random treatment effects).

For studies with a zero cell count, by default, 0.5 is added to all cell frequencies of these studies (argument `incr`). This continuity correction is used both to calculate individual study results with confidence limits and to conduct meta-analysis based on the inverse variance method. For Mantel-Haenszel method, Cochran method, and GLMMs, nothing is added to zero cell counts. Accordingly, estimates for these methods are not defined if the number of events is zero in all studies either in the experimental or control group.

Argument `byvar` can be used to conduct subgroup analysis for all methods but GLMMs. Instead use the `metareg` function for GLMMs which can also be used for continuous covariates.

A prediction interval for treatment effect of a new study is calculated (Higgins et al., 2009) if arguments `prediction` and `comb.random` are `TRUE`.

R function `update.meta` can be used to redo the meta-analysis of an existing `metainc` object by only specifying arguments which should be changed.

For the random effects, the method by Hartung and Knapp (2003) is used to adjust test statistics and confidence intervals if argument `hakn` is `TRUE`.

The DerSimonian-Laird estimate (1986) is used in the random effects model if `method.tau="DL"`. The iterative Paule-Mandel method (1982) to estimate the between-study variance is used if argument `method.tau="PM"`. Internally, R function `pau1emandel1` is called which is based on R function `mpaule.default` from R package `metafor` by S.L.R. Ellison <s.ellison at lgc.co.uk>.

If R package `metafor` (Viechtbauer 2010) is installed, the following methods to estimate the between-study variance $\tau^2$ (argument `method.tau`) are also available:

- Restricted maximum-likelihood estimator (`method.tau="REML"`)
- Maximum-likelihood estimator (`method.tau="ML"`)
- Hunter-Schmidt estimator (`method.tau="HS"`)
- Sidik-Jonkman estimator (`method.tau="SJ"`)
- Hedges estimator (`method.tau="HE"`)
- Empirical Bayes estimator (`method.tau="EB"`).

For these methods the R function `rma.uni` of R package `metafor` is called internally. See help page of R function `rma.uni` for more details on these methods to estimate between-study variance.

Value

An object of class `c(“metainc”, “meta”)` with corresponding `print`, `summary`, `plot` function. The object is a list containing the following components:

- `event.e`, `time.e`, `event.c`, `time.c`, `studlab`,
- `sm`, `method`, `incr`, `allincr`, `addincr`, `model.glmm`, `warn`,
level, level.comb, comb.fixed, comb.random,
hakn, method.tau, tau.preset, TE.tau, method.bias,
tau.common, title, complab, outclab,
label.e, label.c, label.left, label.right,
byvar, bylab, print.byvar, byseparator
   As defined above.
TE, seTE       Estimated treatment effect and standard error of individual studies.
lower, upper   Lower and upper confidence interval limits for individual studies.
zval, pval     z-value and p-value for test of treatment effect for individual studies.
w.fixed, w.random
   Weight of individual studies (in fixed and random effects model).
TE.fixed, seTE.fixed
   Estimated overall treatment effect and standard error (fixed effect model).
lower.fixed, upper.fixed
   Lower and upper confidence interval limits (fixed effect model).
zval.fixed, pval.fixed
   z-value and p-value for test of overall treatment effect (fixed effect model).
TE.random, seTE.random
   Estimated overall treatment effect and standard error (random effects model).
lower.random, upper.random
   Lower and upper confidence interval limits (random effects model).
zval.random, pval.random
   z-value or t-value and corresponding p-value for test of overall treatment effect
   (random effects model).
prediction, level.predict
   As defined above.
seTE.predict   Standard error utilised for prediction interval.
lower.predict, upper.predict
   Lower and upper limits of prediction interval.
k            Number of studies combined in meta-analysis.
Q            Heterogeneity statistic Q.
df.Q         Degrees of freedom for heterogeneity statistic.
tau          Square-root of between-study variance.
se.tau       Standard error of square-root of between-study variance.
C            Scaling factor utilised internally to calculate common tau-squared across sub-groups.
sparse       Logical flag indicating if any study included in meta-analysis has any zero cell frequencies.
incre.event  Increment added to number of events.
Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if \texttt{hakn=TRUE}).

\texttt{df.hakn}

Number of studies combined in meta-analysis using Mantel-Haenszel method.

\texttt{k.MH}

Levels of grouping variable - if \texttt{byvar} is not missing.

\texttt{bylevs}

Estimated treatment effect and standard error in subgroups (fixed effect model) - if \texttt{byvar} is not missing.

\texttt{TE.fixed.w, seTE.fixed.w}

Lower and upper confidence interval limits in subgroups (fixed effect model) - if \texttt{byvar} is not missing.

\texttt{lower.fixed.w, upper.fixed.w}

Levels of grouping variable - if \texttt{byvar} is not missing.

\texttt{bylevs}

Estimated treatment effect and standard error in subgroups (random effects model) - if \texttt{byvar} is not missing.

\texttt{TE.random.w, seTE.random.w}

Estimated treatment effect and standard error in subgroups (random effects model) - if \texttt{byvar} is not missing.

\texttt{TE.random.w, seTE.random.w}

Lower and upper confidence interval limits in subgroups (random effects model) - if \texttt{byvar} is not missing.

\texttt{lower.random.w, upper.random.w}

Levels of grouping variable - if \texttt{byvar} is not missing.

\texttt{bylevs}

z-value and p-value for test of treatment effect in subgroups (fixed effect model) - if \texttt{byvar} is not missing.

\texttt{zval.fixed.w, pval.fixed.w}

z-value or t-value and corresponding p-value for test of treatment effect in subgroups (random effects model) - if \texttt{byvar} is not missing.

\texttt{zval.random.w, pval.random.w}

Weight of subgroups (in fixed and random effects model) - if \texttt{byvar} is not missing.

\texttt{w.fixed.w, w.random.w}

Degrees of freedom for test of treatment effect for Hartung-Knapp method in subgroups - if \texttt{byvar} is not missing and \texttt{hakn=TRUE}.

\texttt{df.hakn.w}

Harmonic mean of number of observations in subgroups (for back transformation of Freeman-Tukey Double arcsine transformation) - if \texttt{byvar} is not missing.

\texttt{n.harmonic.mean.w}

Number of events in experimental group in subgroups - if \texttt{byvar} is not missing.

\texttt{event.e.w}

Total person time in experimental group (experimental group) - if \texttt{byvar} is not missing.

\texttt{time.e.w}

Number of observations in experimental group in subgroups - if \texttt{byvar} is not missing.

\texttt{n.e.w}

Number of events in control group in subgroups - if \texttt{byvar} is not missing.

\texttt{event.c.w}

Total person time in subgroups (control group) - if \texttt{byvar} is not missing.

\texttt{time.c.w}

Number of observations in control group in subgroups - if \texttt{byvar} is not missing.

\texttt{n.c.w}

Number of studies combined within subgroups - if \texttt{byvar} is not missing.

\texttt{k.w}

Number of all studies in subgroups - if \texttt{byvar} is not missing.

\texttt{k.all.w}

Heterogeneity statistics within subgroups - if \texttt{byvar} is not missing.

\texttt{Q.w}

Overall within subgroups heterogeneity statistic \(Q\) (based on fixed effect model) - if \texttt{byvar} is not missing.

\texttt{Q.w.fixed}
metainc

Q.w.random Overall within subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing (only calculated if argument tau.common is TRUE).
df.Q.w Degrees of freedom for test of overall within subgroups heterogeneity - if byvar is not missing.
Q.b.fixed Overall between subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.
Q.b.random Overall between subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing.
df.Q.b Degrees of freedom for test of overall between subgroups heterogeneity - if byvar is not missing.
tau.w Square-root of between-study variance within subgroups - if byvar is not missing.
C.w Scaling factor utilised internally to calculate common tau-squared across subgroups - if byvar is not missing.
H.w Heterogeneity statistic H within subgroups - if byvar is not missing.
lower.H.w, upper.H.w Lower and upper confidence limit for heterogeneity statistic H within subgroups - if byvar is not missing.
I2.w Heterogeneity statistic I2 within subgroups - if byvar is not missing.
lower.I2.w, upper.I2.w Lower and upper confidence limit for heterogeneity statistic I2 within subgroups - if byvar is not missing.
keepdata As defined above.
data Original data (set) used in function call (if keepdata=TRUE).
subset Information on subset of original data used in meta-analysis (if keepdata=TRUE).
.glmm.fixed GLMM object generated by call of rma.glmm function (fixed effect model).
.glmm.random GLMM object generated by call of rma.glmm function (random effects model).
call Function call.
version Version of R package meta used to create object.
version.metafor Version of R package metafor used for GLMMs.

Author(s)
Guido Schwarzer <sc@imbi.uni-freiburg.de>

References
DerSimonian R & Laird N (1986), Meta-analysis in clinical trials. *Controlled Clinical Trials, 7*, 177–188.


See Also

`metabin, update.meta, print.meta`

Examples

```r
data(smoking)

m1 <- metainc(d.smokers, py.smokers,
    d.nonsmokers, py.nonsmokers,
    data=smoking, studlab=study)
print(m1, digits=2)

m2 <- metainc(d.smokers, py.smokers,
    d.nonsmokers, py.nonsmokers,
    data=smoking, studlab=study,
    method="Cochran")
print(m2, digits=2)

data(lungcancer)

m3 <- metainc(d.smokers, py.smokers,
    d.nonsmokers, py.nonsmokers,
    data=lungcancer, studlab=study)
print(m3, digits=2)

# Redo Cochran meta-analysis with inflated standard errors
#
# All cause mortality
#```
TEa <- log((smoking$d.smokers/smoking$py.smokers) /
(smoking$d.nonsmokers/smoking$py.nonsmokers))
seTEa <- sqrt(1/smoking$d.smokers +
1/smoking$d.nonsmokers + 2.5/smoking$d.nonsmokers)
# metagen(TEA, seTEa, sm="IRR", studlab=smoking$study)

# Lung cancer mortality
#
TEl <- log((lungcancer$d.smokers/lungcancer$py.smokers) /
(lungcancer$d.nonsmokers/lungcancer$py.nonsmokers))
seTEl <- sqrt(1/lungcancer$d.smokers +
1/lungcancer$d.nonsmokers + 2.25/lungcancer$d.nonsmokers)
# metagen(TEL, seTEl, sm="IRR", studlab=lungcancer$study)

## Not run:
# Meta-analysis using generalised linear mixed models
# (only if R packages 'metafor' and 'lme4' are available)
#
#
# Poisson regression model (fixed study effects)
# m4 <- metainc(d.smokers, py.smokers, d.nonsmokers, py.nonsmokers,
# data = smoking, studlab = study, method = "GLMM")
m4
#
# Mixed-effects Poisson regression model (random study effects)
# update(m4, model.glmm = "UM.RS", nAGQ = 1)
#
# Generalised linear mixed model (conditional Poisson-Normal)
# update(m4, model.glmm = "CM.EL")

## End(Not run)

### metainf

| Influence analysis in meta-analysis using leave-one-out method |

**Description**

Performs an influence analysis. Pooled estimates are calculated omitting one study at a time.
Usage

`metainf(x, pooled, sortvar)`

Arguments

- `x`  
  An object of class `meta`.
- `pooled`  
  A character string indicating whether a fixed effect or random effects model is used for pooling. Either missing (see Details), "fixed" or "random", can be abbreviated.
- `sortvar`  
  An optional vector used to sort the individual studies (must be of same length as `x$TE`).

Details

Performs a influence analysis; pooled estimates are calculated omitting one study at a time. Studies are sorted according to `sortvar`.

Information from object `x` is utilised if argument `pooled` is missing. A fixed effect model is assumed (`pooled="fixed"`) if argument `x$comb.fixed` is TRUE; a random effects model is assumed (`pooled="random"`) if argument `x$comb.random` is TRUE and `x$comb.fixed` is FALSE.

Value

An object of class `c("metainf", "meta")` with corresponding `print`, `plot` function. The object is a list containing the following components:

- `TE, seTE`  
  Estimated treatment effect and standard error of pooled estimate in influence analysis.
- `lower, upper`  
  Lower and upper confidence interval limits.
- `studlab`  
  Study label describing omission of studies.
- `p.value`  
  P-value for test of overall effect.
- `w`  
  Sum of weights from fixed effect or random effects model.
- `I2`  
  Heterogeneity statistic I2.
- `Rb`  
  Heterogeneity statistic Rb.
- `tau`  
  Square-root of between-study variance.
- `df.hakn`  
  Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if `hakn=TRUE`).
- `sm`  
  Summary measure.
- `method`  
  Method used for pooling.
- `k`  
  Number of studies combined in meta-analysis.
- `pooled`  
  As defined above.
- `comb.fixed`  
  A logical indicating whether analysis is based on fixed effect model.
- `comb.random`  
  A logical indicating whether analysis is based on random effects model.

### Value

An object of class `c("metainf", "meta")` with corresponding `print`, `plot` function. The object is a list containing the following components:

- `TE, seTE`  
  Estimated treatment effect and standard error of pooled estimate in influence analysis.
- `lower, upper`  
  Lower and upper confidence interval limits.
- `studlab`  
  Study label describing omission of studies.
- `p.value`  
  P-value for test of overall effect.
- `w`  
  Sum of weights from fixed effect or random effects model.
- `I2`  
  Heterogeneity statistic I2.
- `Rb`  
  Heterogeneity statistic Rb.
- `tau`  
  Square-root of between-study variance.
- `df.hakn`  
  Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if `hakn=TRUE`).
- `sm`  
  Summary measure.
- `method`  
  Method used for pooling.
- `k`  
  Number of studies combined in meta-analysis.
- `pooled`  
  As defined above.
- `comb.fixed`  
  A logical indicating whether analysis is based on fixed effect model.
- `comb.random`  
  A logical indicating whether analysis is based on random effects model.

### Value

An object of class `c("metainf", "meta")` with corresponding `print`, `plot` function. The object is a list containing the following components:

- `TE, seTE`  
  Estimated treatment effect and standard error of pooled estimate in influence analysis.
- `lower, upper`  
  Lower and upper confidence interval limits.
- `studlab`  
  Study label describing omission of studies.
- `p.value`  
  P-value for test of overall effect.
- `w`  
  Sum of weights from fixed effect or random effects model.
- `I2`  
  Heterogeneity statistic I2.
- `Rb`  
  Heterogeneity statistic Rb.
- `tau`  
  Square-root of between-study variance.
- `df.hakn`  
  Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if `hakn=TRUE`).
- `sm`  
  Summary measure.
- `method`  
  Method used for pooling.
- `k`  
  Number of studies combined in meta-analysis.
- `pooled`  
  As defined above.
- `comb.fixed`  
  A logical indicating whether analysis is based on fixed effect model.
- `comb.random`  
  A logical indicating whether analysis is based on random effects model.

### Value

An object of class `c("metainf", "meta")` with corresponding `print`, `plot` function. The object is a list containing the following components:

- `TE, seTE`  
  Estimated treatment effect and standard error of pooled estimate in influence analysis.
- `lower, upper`  
  Lower and upper confidence interval limits.
- `studlab`  
  Study label describing omission of studies.
- `p.value`  
  P-value for test of overall effect.
- `w`  
  Sum of weights from fixed effect or random effects model.
- `I2`  
  Heterogeneity statistic I2.
- `Rb`  
  Heterogeneity statistic Rb.
- `tau`  
  Square-root of between-study variance.
- `df.hakn`  
  Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if `hakn=TRUE`).
- `sm`  
  Summary measure.
- `method`  
  Method used for pooling.
- `k`  
  Number of studies combined in meta-analysis.
- `pooled`  
  As defined above.
- `comb.fixed`  
  A logical indicating whether analysis is based on fixed effect model.
- `comb.random`  
  A logical indicating whether analysis is based on random effects model.

### Value

An object of class `c("metainf", "meta")` with corresponding `print`, `plot` function. The object is a list containing the following components:

- `TE, seTE`  
  Estimated treatment effect and standard error of pooled estimate in influence analysis.
- `lower, upper`  
  Lower and upper confidence interval limits.
- `studlab`  
  Study label describing omission of studies.
- `p.value`  
  P-value for test of overall effect.
- `w`  
  Sum of weights from fixed effect or random effects model.
- `I2`  
  Heterogeneity statistic I2.
- `Rb`  
  Heterogeneity statistic Rb.
- `tau`  
  Square-root of between-study variance.
- `df.hakn`  
  Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if `hakn=TRUE`).
- `sm`  
  Summary measure.
- `method`  
  Method used for pooling.
- `k`  
  Number of studies combined in meta-analysis.
- `pooled`  
  As defined above.
- `comb.fixed`  
  A logical indicating whether analysis is based on fixed effect model.
- `comb.random`  
  A logical indicating whether analysis is based on random effects model.

### Value

An object of class `c("metainf", "meta")` with corresponding `print`, `plot` function. The object is a list containing the following components:

- `TE, seTE`  
  Estimated treatment effect and standard error of pooled estimate in influence analysis.
- `lower, upper`  
  Lower and upper confidence interval limits.
- `studlab`  
  Study label describing omission of studies.
- `p.value`  
  P-value for test of overall effect.
- `w`  
  Sum of weights from fixed effect or random effects model.
- `I2`  
  Heterogeneity statistic I2.
- `Rb`  
  Heterogeneity statistic Rb.
- `tau`  
  Square-root of between-study variance.
- `df.hakn`  
  Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if `hakn=TRUE`).
- `sm`  
  Summary measure.
- `method`  
  Method used for pooling.
- `k`  
  Number of studies combined in meta-analysis.
- `pooled`  
  As defined above.
- `comb.fixed`  
  A logical indicating whether analysis is based on fixed effect model.
- `comb.random`  
  A logical indicating whether analysis is based on random effects model.
TE.random, seTE.random
  Value is NA.
Q
  Value is NA.
level.comb
  The level used to calculate confidence intervals for pooled estimates.
hakn
  A logical indicating whether the method by Hartung and Knapp is used to adjust test statistics and confidence intervals.
method.tau
  A character string indicating which method is used to estimate the between-study variance $\tau^2$.
tau.preset
  Prespecified value for the square-root of the between-study variance $\tau^2$.
TE.tau
  Overall treatment effect used to estimate the between-study variance $\tau^2$.
n.harmonic.mean
  Harmonic mean of number of observations (for back transformation of Freeman-Tukey Double arcsine transformation).
version
  Version of R package meta used to create object.

Author(s)
Guido Schwarzer <sc@imbi.uni-freiburg.de>

References

See Also
metabin, metacont, print.meta

Examples
data(Fleiss93)
meta1 <- metabin(event.e, n.e, event.c, n.c,
  data=Fleiss93, studlab=study,
  sm="RR", method="I")
meta1
metainf(meta1)
metainf(meta1, pooled="random")
forest(metainf(meta1))
forest(metainf(meta1), layout="revman5")
forest(metainf(meta1, pooled="random"))
metainf(meta1, sortvar=study)
metainf(meta1, sortvar=7:1)
meta2 <- update(meta1, title="Fleiss93 meta-analysis",
  backtransf=FALSE)
metainf(meta2)
Meta-analysis of single proportions

Description

Calculation of an overall proportion from studies reporting a single proportion. Inverse variance method and generalised linear mixed model (GLMM) are available for pooling. For GLMMs, the \texttt{rma.glmm} function from R package \texttt{metafor} (Viechtbauer 2010) is called internally.

Usage

\begin{verbatim}
metaprop(event, n, studlab, 
data=NULL, subset=NULL, method = "Inverse", 
sm=gs("smprop"), 
incr=gs("incr"), allincr=gs("allincr"), 
addincr=gs("addincr"), 
method.ci=gs("method.ci"), 
level=gs("level"), level.comb=gs("level.comb"), 
comb.fixed=gs("comb.fixed"), comb.random=gs("comb.random"), 
hakn=gs("hakn"), 
method.tau= ifelse(!is.na(charmatch(tolower(method), "gllmm", nomatch = NA)), 
 "ML", gs("method.tau")), 
tau.preset=NULL, TE.tau=NULL, 
tau.common=gs("tau.common"), 
prediction=gs("prediction"), level.predict=gs("level.predict"), 
null.effect=NA, 
method.bias=gs("method.bias"), 
backtransf=gs("backtransf"), 
pscale=1, 
title=gs("title"), complab=gs("complab"), outclab="", 
byvar, bylab, print.byvar=gs("print.byvar"), 
byseparator = gs("byseparator"), 
keepdata=gs("keepdata"), 
warn=gs("warn"),
...)
\end{verbatim}

Arguments

\begin{itemize}
  \item \texttt{event} Number of events.
\end{itemize}
Number of observations.

An optional vector with study labels.

An optional data frame containing the study information, i.e., event and n.

An optional vector specifying a subset of studies to be used.

A character string indicating which method is to be used for pooling of studies. One of "Inverse" and "GLMM", can be abbreviated.

A character string indicating which summary measure ("PFT", "PAS", "PRAW", "PLN", or "PLOGIT") is to be used for pooling of studies, see Details.

A numeric which is added to event number and sample size of studies with zero or all events, i.e., studies with an event probability of either 0 or 1.

A logical indicating if incr is considered for all studies if at least one study has either zero or all events. If FALSE (default), incr is considered only in studies with zero or all events.

A logical indicating if incr is used for all studies irrespective of number of events.

A character string indicating which method is used to calculate confidence intervals for individual studies, see Details.

The level used to calculate confidence intervals for individual studies.

The level used to calculate confidence intervals for pooled estimates.

A logical indicating whether a fixed effect meta-analysis should be conducted.

A logical indicating whether a random effects meta-analysis should be conducted.

A logical indicating whether a prediction interval should be printed.

The level used to calculate prediction interval for a new study.

A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.

A character string indicating which method is used to estimate the between-study variance \( \tau^2 \), see Details.

Prespecified value for the square-root of the between-study variance \( \tau^2 \).

Overall treatment effect used to estimate the between-study variance tau-squared.

A logical indicating whether tau-squared should be the same across subgroups.

A numeric value specifying the effect under the null hypothesis.

A character string indicating which test is to be used. Either "rank", "linreg", or "mm", can be abbreviated. See function metabias.

A logical indicating whether results for transformed proportions (argument sm!="PRAW") should be back transformed in printouts and plots. If TRUE (default), results will be presented as proportions; otherwise transformed proportions will be shown. See Details for presentation of confidence intervals.

A numeric defining a scaling factor for printing of single event probabilities.

Title of meta-analysis / systematic review.
complab  Comparison label.
outclab  Outcome label.
byvar    An optional vector containing grouping information (must be of same length as event).
bylab    A character string with a label for the grouping variable.
print.byvar    A logical indicating whether the name of the grouping variable should be printed in front of the group labels.
byseparator    A character string defining the separator between label and levels of grouping variable.
keepdata    A logical indicating whether original data (set) should be kept in meta object.
warn    A logical indicating whether the addition of incr to studies with zero or all events should result in a warning.
...    Additional arguments passed on to rma.glmm function.

details
Fixed effect and random effects meta-analysis of single proportions to calculate an overall proportion. The following transformations of proportions are implemented to calculate an overall proportion:

- Logit transformation (sm="PL0GIT", default)
- Log transformation (sm="PLN")
- Freeman-Tukey Double arcsine transformation (sm="PFT")
- Arcsine transformation (sm="PAS")
- Raw, i.e. untransformed, proportions (sm="PRaw")

Note, you should use R function metabin to compare proportions of pairwise comparisons instead of using metaprop for each treatment arm separately which will break randomisation in randomised controlled trials.

Various methods are available to calculate confidence intervals for individual study results (see Agresti & Coull 1998; Newcombe 1988):

- Clopper-Pearson interval also called 'exact' binomial interval (method.ci="CP", default)
- Wilson Score interval (method.ci="WS")
- Wilson Score interval with continuity correction (method.ci="WSCC")
- Agresti-Coull interval (method.ci="AC")
- Simple approximation interval (method.ci="SA")
- Simple approximation interval with continuity correction (method.ci="SACC")
- Normal approximation interval based on summary measure, i.e. defined by argument sm (method.ci="NAsm")
Note, with exception of the normal approximation based on the summary measure, i.e. method.ci="NAsm", the same confidence interval is calculated for any summary measure (argument sm) as only number of events and observations are used in the calculation disregarding the chosen summary measure. Results will be presented for transformed proportions if argument backtransf=FALSE in the print.meta, print.summary.meta, or forest.meta function. In this case, argument method.ci="NAsm" is used, i.e. confidence intervals based on the normal approximation based on the summary measure.

Argument pscale can be used to rescale proportions, e.g. pscale=1000 means that proportions are expressed as events per 1000 observations. This is useful in situations with (very) low event probabilities.

For several arguments defaults settings are utilised (assignments using gs function). These defaults can be changed using the settings.meta function.

Internally, both fixed effect and random effects models are calculated regardless of values choosen for arguments comb.fixed and comb.random. Accordingly, the estimate for the random effects model can be extracted from component TE.random of an object of class "meta" even if argument comb.random=FALSE. However, all functions in R package meta will adequately consider the values for comb.fixed and comb.random. E.g. function print.meta will not print results for the random effects model if comb.random=FALSE.

A distinctive and frequently overlooked advantage of binary data is that individual patient data (IPD) can be extracted. Accordingly, a random intercept logistic regression model can be utilised for the meta-analysis of proportions (Stijnen et al., 2010). This method is available (argument method = "GLMM") by calling the rma.glmm function from R package metafor internally.

If the summary measure is equal to "PRAW", "PLN", or "PLOGIT", a continuity correction is applied if any study has either zero or all events, i.e., an event probability of either 0 or 1. By default, 0.5 is used as continuity correction (argument incr). This continuity correction is used both to calculate individual study results with confidence limits and to conduct meta-analysis based on the inverse variance method. For GLMMs no continuity correction is used.

Argument byvar can be used to conduct subgroup analysis for all methods but GLMMs. Instead use the metareg function for GLMMs which can also be used for continuous covariates.

A prediction interval for treatment effect of a new study is calculated (Higgins et al., 2009) if arguments prediction and comb.random are TRUE.

R function update.meta can be used to redo the meta-analysis of an existing metaprop object by only specifying arguments which should be changed.

For the random effects, the method by Hartung and Knapp (2003) is used to adjust test statistics and confidence intervals if argument hakn=TRUE.

The DerSimonian-Laird estimate (1986) is used in the random effects model if method.tau="DL". The iterative Paule-Mandel method (1982) to estimate the between-study variance is used if argument method.tau="PM". Internally, R function paulemandel1 is called which is based on R function mpaule.default from R package metRology from S.L.R. Ellison <s.ellison at lgc.co.uk>.

If R package metafor (Viechtbauer 2010) is installed, the following methods to estimate the between-study variance $\tau^2$ (argument method.tau) are also available:

- Restricted maximum-likelihood estimator (method.tau="REML")
- Maximum-likelihood estimator (method.tau="ML")
- Hunter-Schmidt estimator (method.tau="HS")
- Sidik-Jonkman estimator (method.tau="SJ")
- Hedges estimator (method.tau="HE")
- Empirical Bayes estimator (method.tau="EB").

For these methods the R function rma.uni of R package metafor is called internally. See help page of R function rma.uni for more details on these methods to estimate between-study variance.

Value

An object of class c("metaprop", "meta") with corresponding print, summary, plot function.
The object is a list containing the following components:
event, n, studlab,
sm, incr, allincr, addincr, method.ci,
level, level.comb,
    As defined above.
comb.fixed, comb.random,
hakn, method.tau, tau.preset, TE.tau, null.hypothesis,
method.bias, tau.common, title, complab, outlab,
byvar, bylab, print.byvar, byseparator, warn

TE, seTE       Estimated (un)transformed proportion and its standard error for individual studies.
lower, upper   Lower and upper confidence interval limits for individual studies.
zval, pval     z-value and p-value for test of treatment effect for individual studies.

w.fixed, w.random
Weight of individual studies (in fixed and random effects model).

TE.fixed, seTE.fixed
Estimated overall (un)transformed proportion and standard error (fixed effect model).
lower.fixed, upper.fixed
Lower and upper confidence interval limits (fixed effect model).

zval.fixed, pval.fixed
z-value and p-value for test of overall effect (fixed effect model).

TE.random, seTE.random
Estimated overall (un)transformed proportion and standard error (random effects model).
lower.random, upper.random
Lower and upper confidence interval limits (random effects model).

zval.random, pval.random
z-value or t-value and corresponding p-value for test of overall effect (random effects model).
prediction, level.predict
   As defined above.
seTE.predict  Standard error utilised for prediction interval.
lower.predict, upper.predict
   Lower and upper limits of prediction interval.
k  Number of studies combined in meta-analysis.
Q  Heterogeneity statistic Q.
tau  Square-root of between-study variance.
se.tau  Standard error of square-root of between-study variance.
C  Scaling factor utilised internally to calculate common tau-squared across sub-
groups.
method  A character string indicating method used for pooling: "Inverse"
df.hakn  Degrees of freedom for test of treatment effect for Hartung-Knapp method (only
if hakn=TRUE).
bylevs  Levels of grouping variable - if byvar is not missing.
TE.fixed.w, seTE.fixed.w
   Estimated treatment effect and standard error in subgroups (fixed effect model)
   - if byvar is not missing.
lower.fixed.w, upper.fixed.w
   Lower and upper confidence interval limits in subgroups (fixed effect model) -
   if byvar is not missing.
zval.fixed.w, pval.fixed.w
   z-value and p-value for test of treatment effect in subgroups (fixed effect model)
   - if byvar is not missing.
TE.random.w, seTE.random.w
   Estimated treatment effect and standard error in subgroups (random effects model)
   - if byvar is not missing.
lower.random.w, upper.random.w
   Lower and upper confidence interval limits in subgroups (random effects model)
   - if byvar is not missing.
zval.random.w, pval.random.w
   z-value or t-value and corresponding p-value for test of treatment effect in sub-
groups (random effects model) - if byvar is not missing.
w.fixed.w, w.random.w
   Weight of subgroups (in fixed and random effects model) - if byvar is not miss-
ing.
df.hakn  Degrees of freedom for test of treatment effect for Hartung-Knapp method in
subgroups - if byvar is not missing and hakn=TRUE.
n.harmonic.mean.w
   Harmonic mean of number of observations in subgroups (for back transforma-
tion of Freeman-Tukey Double arcsine transformation) - if byvar is not missing.
event.w  Number of events in subgroups - if byvar is not missing.
n.w  Number of observations in subgroups - if byvar is not missing.
k.w  Number of studies combined within subgroups - if byvar is not missing.

k.all.w  Number of all studies in subgroups - if byvar is not missing.

Q.w  Heterogeneity statistics within subgroups - if byvar is not missing.

Q.w.fixed  Overall within subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.

Q.w.random  Overall within subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing (only calculated if argument tau.common is TRUE).

df.Q.w  Degrees of freedom for test of overall within subgroups heterogeneity - if byvar is not missing.

Q.b.fixed  Overall between subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.

Q.b.random  Overall between subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing.

df.Q.b  Degrees of freedom for test of overall between subgroups heterogeneity - if byvar is not missing.

tau.w  Square-root of between-study variance within subgroups - if byvar is not missing.

C.w  Scaling factor utilised internally to calculate common tau-squared across subgroups - if byvar is not missing.

H.w  Heterogeneity statistic H within subgroups - if byvar is not missing.

lower.H.w, upper.H.w  Lower and upper confidence limits for heterogeneity statistic H within subgroups - if byvar is not missing.

I2.w  Heterogeneity statistic I2 within subgroups - if byvar is not missing.

lower.I2.w, upper.I2.w  Lower and upper confidence limits for heterogeneity statistic I2 within subgroups - if byvar is not missing.

incr.event  Increment added to number of events.

keepdata  As defined above.

data  Original data (set) used in function call (if keepdata=TRUE).

subset  Information on subset of original data used in meta-analysis (if keepdata=TRUE).

.glmm.fixed  GLMM object generated by call of rma.glmm function (fixed effect model).

.glmm.random  GLMM object generated by call of rma.glmm function (random effects model).

call  Function call.

version  Version of R package meta used to create object.

version.metafor  Version of R package metafor used for GLMMs.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>
References


See Also

`update.meta, metacont, metagen, print.meta`

Examples

```r
# Apply various meta-analysis methods to estimate proportions
m1 <- metaprop(4:1, c(10, 20, 30, 40))
m2 <- update(m1, sm="PAS")
m3 <- update(m1, sm="PRAW")
m4 <- update(m1, sm="PLN")
m5 <- update(m1, sm="PFT")
```

```r
m5
#
forest(m1)
# forest(m2)
# forest(m3)
# forest(m3, pscale=100)
# forest(m4)
# forest(m5)
#
# Do not back transform results, e.g. print logit transformed
# proportions if sm="PLOGIT" and store old settings
#
oldset <- settings.meta(backtransf=FALSE)
#
## Examples with zero events
# m1 <- metaprop(c(0, 0, 10, 10), rep(100, 4))
m2 <- metaprop(c(0, 0, 10, 10), rep(100, 4), incr=0.1)
#
## Example from Miller (1978):
# death <- c(3, 6, 10, 1)
# animals <- c(11, 17, 21, 6)
```
```r
m3 <- metaprop(death, animals, sm="PFT")
forest(m3)

# # Data examples from Newcombe (1998)
# - apply various methods to estimate confidence intervals for
#   individual studies
# event <- c(81, 15, 0, 1)
n <- c(263, 148, 20, 29)

# m1 <- metaprop(event, n, sm="PLOGIT", method.ci="SA")
m2 <- update(m1, method.ci="SACC")
m3 <- update(m1, method.ci="WS")
m4 <- update(m1, method.ci="WSCC")
m5 <- update(m1, method.ci="CP")

lower <- round(rbind(NA, m1$lower, m2$lower, NA, m3$lower, m4$lower, NA, m5$lower), 4)
upper <- round(rbind(NA, m1$upper, m2$upper, NA, m3$upper, m4$upper, NA, m5$upper), 4)

# tab1 <- data.frame(
#   scen1=meta:::p.ci(lower[,1], upper[,1]),
#   scen2=meta:::p.ci(lower[,2], upper[,2]),
#   scen3=meta:::p.ci(lower[,3], upper[,3]),
#   scen4=meta:::p.ci(lower[,4], upper[,4]),
#   stringsAsFactors=FALSE)

names(tab1) <- c("r=81, n=263", "r=15, n=148", "r=0, n=20", "r=1, n=29")
row.names(tab1) <- c("Simple", "- SA", "- SACC", "Score", "- WS", "- WSCC", "Binomial", "- CP")
tab1[is.na(tab1)] <- ""

# # Newcombe (1998), Table I, methods 1-5:
#
tab1

# # Same confidence interval, i.e. unaffected by choice of summary measure
#
print(metaprop(event, n, sm="PLOGIT", method.ci="WS"), ma=FALSE)
print(metaprop(event, n, sm="PLN", method.ci="WS"), ma=FALSE)
print(metaprop(event, n, sm="PFT", method.ci="WS"), ma=FALSE)
print(metaprop(event, n, sm="PAS", method.ci="WS"), ma=FALSE)
print(metaprop(event, n, sm="PRAW", method.ci="WS"), ma=FALSE)

# # Different confidence intervals as argument sm="NAsm"
#
print(metaprop(event, n, sm="PLOGIT", method.ci="NAsm"), ma=FALSE)
print(metaprop(event, n, sm="PLN", method.ci="NAsm"), ma=FALSE)
print(metaprop(event, n, sm="PFT", method.ci="NAsm"), ma=FALSE)
print(metaprop(event, n, sm="PAS", method.ci="NAsm"), ma=FALSE)
print(metaprop(event, n, sm="PRAW", method.ci="NAsm"), ma=FALSE)
```

metarate

## Description

Calculation of an overall incidence rate from studies reporting a single incidence rate. Inverse variance method and generalised linear mixed model (GLMM) are available for pooling. For GLMMs, the \texttt{rma.glmm} function from R package \texttt{metafor} (Viechtbauer 2010) is called internally.

## Usage

\begin{verbatim}
metarate(event, time, studlab, 
data=NULL, subset=NULL, method = "Inverse", 
sm=gs("smrate"), 
incr=gs("incr"), allincr=gs("allincr"), 
addincr=gs("addincr"), 
level=gs("level"), level.comb=gs("level.comb"),
\end{verbatim}
Arguments

- **event**: Number of events.
- **time**: Person time at risk.
- **studlab**: An optional vector with study labels.
- **data**: An optional data frame containing the study information, i.e., event and time.
- **subset**: An optional vector specifying a subset of studies to be used.
- **method**: A character string indicating which method is to be used for pooling of studies. One of "Inverse" and "GLMM", can be abbreviated.
- **sm**: A character string indicating which summary measure ("IR", "IRLN", "IRS", or "IRFT") is to be used for pooling of studies, see Details.
- **incr**: A numeric which is added to the event number of studies with zero events, i.e., studies with an incidence rate of 0.
- **allincr**: A logical indicating if incr is considered for all studies if at least one study has zero events. If FALSE (default), incr is considered only in studies with zero events.
- **addincr**: A logical indicating if incr is used for all studies irrespective of number of events.
- **level**: The level used to calculate confidence intervals for individual studies.
- **level.comb**: The level used to calculate confidence intervals for pooled estimates.
- **comb.fixed**: A logical indicating whether a fixed effect meta-analysis should be conducted.
- **comb.random**: A logical indicating whether a random effects meta-analysis should be conducted.
- **prediction**: A logical indicating whether a prediction interval should be printed.
- **level.predict**: The level used to calculate prediction interval for a new study.
A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.

A character string indicating which method is used to estimate the between-study variance \( \tau^2 \), see Details.

Prespecified value for the square-root of the between-study variance \( \tau^2 \).

Overall treatment effect used to estimate the between-study variance tau-squared.

A logical indicating whether tau-squared should be the same across subgroups.

A numeric value specifying the effect under the null hypothesis.

A character string indicating which test is to be used. Either "rank", "linreg", or "mm", can be abbreviated. See function `metabias`.

A logical indicating whether results for transformed rates (argument `sm`="IR") should be back transformed in printouts and plots. If TRUE (default), results will be presented as incidence rates; otherwise transformed rates will be shown.

A numeric defining a scaling factor for printing of rates.

A character specifying the time unit used to calculate rates, e.g. person-years.

Title of meta-analysis / systematic review.

Comparison label.

Outcome label.

An optional vector containing grouping information (must be of same length as event).

A character string with a label for the grouping variable.

A logical indicating whether the name of the grouping variable should be printed in front of the group labels.

A character string defining the separator between label and levels of grouping variable.

A logical indicating whether original data (set) should be kept in meta object.

A logical indicating whether the addition of `incr` to studies with zero events should result in a warning.

Additional arguments passed on to `rma.glmm` function.

---

**Details**

Fixed effect and random effects meta-analysis of single incidence rates to calculate an overall rate. The following transformations of incidence rates are implemented to calculate an overall rate:

- Log transformation (`sm="IRLN"`, default)
- Square root transformation (`sm="IRS"`)  
- Freeman-Tukey Double arcsine transformation (`sm="IRFT"`)  
- No transformation (`sm="IR"`)
Note, you should use R function `metainc` to compare incidence rates of pairwise comparisons instead of using `metarate` for each treatment arm separately which will break randomisation in randomised controlled trials.

Argument `irscale` can be used to rescale rates, e.g. `irscale=1000` means that rates are expressed as events per 1000 time units, e.g. person-years. This is useful in situations with (very) low rates. Argument `irunit` can be used to specify the time unit used in individual studies (default: "person-years"). This information is printed in summaries and forest plots if argument `irscale` is not equal to 1.

For several arguments defaults settings are utilised (assignments using `gs` function). These defaults can be changed using the `settings.meta` function.

Internally, both fixed effect and random effects models are calculated regardless of values choosen for arguments `comb.fixed` and `comb.random`. Accordingly, the estimate for the random effects model can be extracted from component `TE.random` of an object of class "meta" even if argument `comb.random`=FALSE. However, all functions in R package `meta` will adequately consider the values for `comb.fixed` and `comb.random`. E.g. function `print.meta` will not print results for the random effects model if `comb.random`=FALSE.

A random intercept Poisson regression model can be utilised for the meta-analysis of incidence rates (Stijnen et al., 2010). This method is available (argument `method = "GLMM"`) by calling the `rma.glmm` function from R package `metafor` internally.

If the summary measure is equal to "IR" or "IRLN", a continuity correction is applied if any study has zero events, i.e., an incidence rate of 0. By default, 0.5 is used as continuity correction (argument `incr`). This continuity correction is used both to calculate individual study results with confidence limits and to conduct meta-analysis based on the inverse variance method. For Freeman-Tukey and square root transformation and GLMMs no continuity correction is used.

Argument `byvar` can be used to conduct subgroup analysis for all methods but GLMMs. Instead use the `metareg` function for GLMMs which can also be used for continuous covariates.

A prediction interval for treatment effect of a new study is calculated (Higgins et al., 2009) if arguments `prediction` and `comb.random` are true.

R function `update.meta` can be used to redo the meta-analysis of an existing metarate object by only specifying arguments which should be changed.

For the random effects, the method by Hartung and Knapp (2003) is used to adjust test statistics and confidence intervals if argument `hakn`=TRUE.

The DerSimonian-Laird estimate (1986) is used in the random effects model if `method.tau="DL"`. The iterative Paule-Mandel method (1982) to estimate the between-study variance is used if argument `method.tau="PM"`. Internally, R function `paulemandel` is called which is based on R function `mpaule.default` from R package `metRology` from S.L.R. Ellison <s.ellison at lgc.co.uk>.

If R package `metafor` (Viechtbauer 2010) is installed, the following methods to estimate the between-study variance \( \tau^2 \) (argument `method.tau`) are also available:

- Restricted maximum-likelihood estimator (`method.tau="REML"`)
- Maximum-likelihood estimator (`method.tau="ML"`)
- Hunter-Schmidt estimator (`method.tau="HS"`)
- Sidik-Jonkman estimator (`method.tau="SJ"`)
- Hedges estimator (`method.tau="HE"`)
• Empirical Bayes estimator (method.tau="EB").

For these methods the R function rma.uni of R package metafor is called internally. See help page of R function rma.uni for more details on these methods to estimate between-study variance.

Value

An object of class c("metarate", "meta") with corresponding print, summary, plot function. The object is a list containing the following components:

- event, n, studlab,
- sm, incr, allincr, addincr, method.ci,
- level, level.comb,
- comb.fixed, comb.random,
- hakn, method.tau, tau.preset, TE.tau, null.effect,
- method.bias, tau.common, title, complab, outlab,
- byvar, bylab, print.byvar, byseparator, warn

TE, seTE Estimated (un)transformed incidence rate and its standard error for individual studies.
lower, upper Lower and upper confidence interval limits for individual studies.
zval, pval z-value and p-value for test of treatment effect for individual studies.
w.fixed, w.random Weight of individual studies (in fixed and random effects model).
TE.fixed, seTE.fixed Estimated overall (un)transformed incidence rate and standard error (fixed effect model).
lower.fixed, upper.fixed Lower and upper confidence interval limits (fixed effect model).
zval.fixed, pval.fixed z-value and p-value for test of overall effect (fixed effect model).
TE.random, seTE.random Estimated overall (un)transformed incidence rate and standard error (random effects model).
lower.random, upper.random Lower and upper confidence interval limits (random effects model).
zval.random, pval.random z-value or t-value and corresponding p-value for test of overall effect (random effects model).
prediction, level.predict As defined above.
setE.predict  Standard error utilised for prediction interval.
lower.predict,  upper.predict  Lower and upper limits of prediction interval.
k  Number of studies combined in meta-analysis.
Q  Heterogeneity statistic Q.
tau  Square-root of between-study variance.
se.tau  Standard error of square-root of between-study variance.
C  Scaling factor utilised internally to calculate common tau-squared across sub-
groups.
method  A character string indicating method used for pooling: "Inverse"
df.hakn  Degrees of freedom for test of treatment effect for Hartung-Knapp method (only
         if hakn=TRUE).
bylevs  Levels of grouping variable - if byvar is not missing.
TE.fixed.w, seTE.fixed.w  Estimated treatment effect and standard error in subgroups (fixed effect model)
         - if byvar is not missing.
lower.fixed.w, upper.fixed.w  Lower and upper confidence interval limits in subgroups (fixed effect model) -
         if byvar is not missing.
zval.fixed.w, pval.fixed.w  z-value and p-value for test of treatment effect in subgroups (fixed effect model)
         - if byvar is not missing.
TE.random.w, seTE.random.w  Estimated treatment effect and standard error in subgroups (random effects model)
         - if byvar is not missing.
lower.random.w, upper.random.w  Lower and upper confidence interval limits in subgroups (random effects model) -
         if byvar is not missing.
zval.random.w, pval.random.w  z-value or t-value and corresponding p-value for test of treatment effect in sub-
groups (random effects model) - if byvar is not missing.
w.fixed.w, w.random.w  Weight of subgroups (in fixed and random effects model) - if byvar is not miss-
ing.
df.hakn.w  Degrees of freedom for test of treatment effect for Hartung-Knapp method in
         subgroups - if byvar is not missing and hakn=TRUE.
n.harmonic.mean.w  Harmonic mean of number of observations in subgroups (for back transforma-
tion of Freeman-Tukey Double arcsine transformation) - if byvar is not missing.
event.w  Number of events in subgroups - if byvar is not missing.
n.w  Number of observations in subgroups - if byvar is not missing.
k.w  Number of studies combined within subgroups - if byvar is not missing.
k.all.w  Number of all studies in subgroups - if byvar is not missing.
Heterogeneity statistics within subgroups - if byvar is not missing.

Overall within subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.

Overall within subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing (only calculated if argument tau.common is TRUE).

Degrees of freedom for test of overall within subgroups heterogeneity - if byvar is not missing.

Overall between subgroups heterogeneity statistic Q (based on fixed effect model) - if byvar is not missing.

Overall between subgroups heterogeneity statistic Q (based on random effects model) - if byvar is not missing.

Degrees of freedom for test of overall between subgroups heterogeneity - if byvar is not missing.

Square-root of between-study variance within subgroups - if byvar is not missing.

Scaling factor utilised internally to calculate common tau-squared across subgroups - if byvar is not missing.

Heterogeneity statistic H within subgroups - if byvar is not missing.

Lower and upper confidence limits for heterogeneity statistic H within subgroups - if byvar is not missing.

Heterogeneity statistic I2 within subgroups - if byvar is not missing.

Lower and upper confidence limits for heterogeneity statistic I2 within subgroups - if byvar is not missing.

Increment added to number of events.

As defined above.

Original data (set) used in function call (if keepdata=TRUE).

Information on subset of original data used in meta-analysis (if keepdata=TRUE).

GLMM object generated by call of rma.glmm function (fixed effect model).

GLMM object generated by call of rma.glmm function (random effects model).

Function call.

Version of R package meta used to create object.

Version of R package metafor used for GLMMs.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>
References


See Also

`updateNmeta, metacont, metagen, print.meta`

Examples

```r
#
# Apply various meta-analysis methods to estimate incidence rates
#
ml <- metarate(4:1, c(10, 20, 30, 40))
m2 <- update(ml, sm="IR")
m3 <- update(ml, sm="IRS")
m4 <- update(ml, sm="IRFT")
#
ml
m2
m3
m4
#
forest(ml)
forest(ml, irscale=100)
f森林(ml, irscale=100, irunit="person-days")
f森林(ml, backtransf = FALSE)
# forest(m2)
# forest(m3)
# forest(m4)
#
m5 <- metarate(40:37, c(100, 200, 300, 400), sm="IRFT")
m5
```
metareg

Meta-regression

Description

Meta-regression for objects of class meta. This is a wrapper function for the R function \texttt{rma.uni} in the R package \texttt{metafor} (Viechtbauer 2010).

Usage

\texttt{metareg(x, formula, method.tau = x$method.tau, hakn = x$hakn, level.comb = x$level.comb, intercept = TRUE, ...)}

Arguments

- \texttt{x} An object of class meta.
- \texttt{formula} Either a character string or a formula object.
- \texttt{method.tau} A character string indicating which method is used to estimate the between-study variance tau-squared. Either \texttt{"FE"}, \texttt{"DL"}, \texttt{"REML"}, \texttt{"ML"}, \texttt{"HS"}, \texttt{"SJ"}, \texttt{"HE"}, or \texttt{"EB"}, can be abbreviated.
- \texttt{hakn} A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.
- \texttt{level.comb} The level used to calculate confidence intervals for parameter estimates in the meta-regression model.
- \texttt{intercept} A logical indicating whether an intercept should be included in the meta-regression model.
- \texttt{...} Additional arguments passed to R function \texttt{rma.uni}.

Details

This R function is a wrapper function for R function \texttt{rma.uni} in the R package \texttt{metafor} (Viechtbauer 2010), i.e., function \texttt{metareg} can only be used if R package \texttt{metafor} is installed. Argument \texttt{...} can be used to pass additional arguments to R function \texttt{rma.uni}. For example, argument control to provide a list of control values for the iterative estimation algorithm. See help page of R function \texttt{rma.uni} for more details.

Value

An object of class \texttt{c("metareg", "rma.uni","rma")}. Please look at the help page of R function \texttt{rma.uni} for more details on the output from this function.

In addition, a list \texttt{.meta} is added to the output containing the following components:

- \texttt{x, formula, method.tau, hakn, level.comb, intercept} As defined above.
- \texttt{dots} Information provided in argument \texttt{...}. 

---

\texttt{metareg}

\texttt{Meta-regression}

**Description**

Meta-regression for objects of class \texttt{meta}. This is a wrapper function for the R function \texttt{rma.uni} in the R package \texttt{metafor} (Viechtbauer 2010).

**Usage**

\texttt{metareg(x, formula, method.tau = x$method.tau, hakn = x$hakn, level.comb = x$level.comb, intercept = TRUE,...)}

**Arguments**

\begin{itemize}
  \item \texttt{x} An object of class \texttt{meta}.
  \item \texttt{formula} Either a character string or a formula object.
  \item \texttt{method.tau} A character string indicating which method is used to estimate the between-study variance \texttt{tau-squared}. Either \texttt{"FE"}, \texttt{"DL"}, \texttt{"REML"}, \texttt{"ML"}, \texttt{"HS"}, \texttt{"SJ"}, \texttt{"HE"}, or \texttt{"EB"}, can be abbreviated.
  \item \texttt{hakn} A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.
  \item \texttt{level.comb} The level used to calculate confidence intervals for parameter estimates in the meta-regression model.
  \item \texttt{intercept} A logical indicating whether an intercept should be included in the meta-regression model.
  \item \texttt{...} Additional arguments passed to R function \texttt{rma.uni}.
\end{itemize}

**Details**

This R function is a wrapper function for R function \texttt{rma.uni} in the R package \texttt{metafor} (Viechtbauer 2010), i.e., function \texttt{metareg} can only be used if R package \texttt{metafor} is installed. Argument \texttt{...} can be used to pass additional arguments to R function \texttt{rma.uni}. For example, argument control to provide a list of control values for the iterative estimation algorithm. See help page of R function \texttt{rma.uni} for more details.

**Value**

An object of class \texttt{c("metareg", "rma.uni","rma")}. Please look at the help page of R function \texttt{rma.uni} for more details on the output from this function.

In addition, a list \texttt{.meta} is added to the output containing the following components:

- \texttt{x, formula, method.tau, hakn, level.comb, intercept} As defined above.
- \texttt{dots} Information provided in argument \texttt{...}. 

---
Function call.

Version of R package **meta** used to create object.

Version of R package **metafor** used to create object.

**Author(s)**

Guido Schwarzer <sc@imbi.uni-freiburg.de>

**References**


**See Also**

**bubble, summary.meta, metagen**

**Examples**

data(fleissYScont)

# Add some (fictitious) grouping variables:
Fleiss93cont$age <- c(55, 65, 55, 65, 55)
Fleiss93cont$region <- c("Europe", "Europe", "Asia", "Asia", "Europe")

meta1 <- metacont(n.e, mean.e, sd.e,
                   n.c, mean.c, sd.c,
                   data = Fleiss93cont, sm = "MD")

mu1 <- update(meta1, byvar = region)

mu2 <- update(meta1, byvar = region,
               tau.common = TRUE, comb.fixed = FALSE)

### Not run:
# Warnings due to wrong ordering of arguments (order has changed with
# version 3.0-0 of R package meta)
#
metareg(~ region, meta1)
metareg(~ region, data = meta1)

# Warning as no information on covariate is available
#
metareg(meta1)

### End(Not run)

# Do meta-regression for covariate region
# (see R code to create object mu2)
# metareg(mu2)

# Same result for
# - tau-squared
# - test of heterogeneity
# - test for subgroup differences
# (as argument 'tau.common' was used to create mu2)
#
mu2
metareg(mu2, intercept = FALSE)
metareg(metal, region)
#
# Different result for
# - tau-squared
# - test of heterogeneity
# - test for subgroup differences
# (as argument 'tau.common' is - by default - FALSE)
#
mul

# Generate bubble plot
#
bubble(metareg(mu2))

# Do meta-regression with two covariates
#
mul, region + age

# Do same meta-regressions using 'official' formula notation
#
metareg(metal, ~ region)
mul, ~ region + age

# Do meta-regression using REML method and print intermediate results
# for iterative estimation algorithm; furthermore print results with
# three digits.
#
mul, region, method.tau = "REML",
control = list(verbos = TRUE), digits = 3)

# Use Hartung-Knapp method
#
mu3 <- update(mu2, hakn = TRUE)
u
metareg(mul, intercept = FALSE)
**Description**

Meta-analysis on Thrombolytic Therapy after Acute Myocardial Infarction

**Usage**

data(olkin95)

**Format**

A data frame with the following columns:

- **author**  First author
- **year**  Year of publication
- **event.e**  Number of events in experimental group
- **n.e**  Number of observations in experimental group
- **event.c**  Number of events in control group
- **n.c**  Number of observations in control group

**Source**


**Examples**

data(olkin95)
supply(olkin95)
supply(olkin95)$event.e

**print.meta**

Print and summary method for objects of class `meta`

**Description**

Print and summary method for objects of class `meta`.

**Usage**

```r
## S3 method for class 'meta'
print(x, sortvar, 
comb.fixed=x$comb.fixed, 
comb.random=x$comb.random, 
prediction=x$prediction, 
details=FALSE, ma=TRUE, backtransf=x$backtransf, 
pscale=x$pscale, irscale = x$irscale, irunit = x$irunit, 
digits = gs("digits"), digits.se = gs("digits.se"), 
digits.zval = gs("digits.zval"), 
```
digits.pval = max(gs("digits.pval"), 2),
digits.pval.Q = max(gs("digits.pval.Q"), 2),
digits.Q = gs("digits.Q"),
digits.tau2 = gs("digits.tau2"),
digits.H = gs("digits.H"),
digits.I2 = gs("digits.I2"),
digits.prop = gs("digits.prop"),
digits.weight = gs("digits.weight"),
scientific.pval = gs("scientific.pval"),
warn.backtransf = FALSE,
...)

## S3 method for class 'metabias'
print(x, ...)

## S3 method for class 'meta'
summary(object,
  comb.fixed=object$comb.fixed, comb.random=object$comb.random,
  prediction=object$prediction,
  backtransf=object$backtransf,
  pscale=object$pscale, irscale = object$irscale, irunit = object$irunit,
  bylab=object$bylab, print.byvar=object$print.byvar,
  byseparator=object$byseparator, bystud=FALSE,
  print.CMH=object$print.CMH, warn=object$warn, ...)

## S3 method for class 'summary.meta'
print(x, digits = gs("digits"),
  comb.fixed=x$comb.fixed, comb.random=x$comb.random,
  prediction=x$prediction,
  print.byvar=x$print.byvar, byseparator=x$byseparator,
  print.CMH=x$print.CMH,
  header=TRUE, backtransf=x$backtransf,
  pscale=x$pscale, irscale = x$irscale, irunit = x$irunit,
  bylab.nchar=35,
  digits.zval = gs("digits.zval"),
digits.pval = max(gs("digits.pval"), 2),
digits.pval.Q = max(gs("digits.pval.Q"), 2),
digits.Q = gs("digits.Q"),
digits.tau2 = gs("digits.tau2"),
digits.H = gs("digits.H"),
digits.I2 = gs("digits.I2"),
scientific.pval = gs("scientific.pval"),
  print.Rb = gs("print.Rb"),
  text.tau2 = gs("text.tau2"), text.I2 = gs("text.I2"),
  text.Rb = gs("text.Rb"),
  warn.backtransf = FALSE,
  ...)

cilayout(bracket="[", separator="; ")

Arguments

x An object of class meta, metabias, or summary.meta.
object
sortvar
comb.fixed
comb.random
prediction
bylab
print.byvar
byseparator
header
details
ma
backtransf
pscale
irscale
irunit
bylab.nchar
bystud
print.CMH
digits
warn
warn.backtransf
bracket
separator

An object of class `meta`.
An optional vector used to sort the individual studies (must be of same length as x$TE).
A logical indicating whether a fixed effect meta-analysis should be conducted.
A logical indicating whether a random effects meta-analysis should be conducted.
A logical indicating whether a prediction interval should be printed.
A character string with a label for the grouping variable.
A logical indicating whether the name of the grouping variable should be printed in front of the group labels.
A character string defining the separator between label and levels of grouping variable.
A logical indicating whether information on title of meta-analysis, comparison and outcome should be printed at the beginning of the printout.
A logical indicating whether further details of individual studies should be printed.
A logical indicating whether the summary results of the meta-analysis should be printed.
A logical indicating whether printed results should be back transformed. If backtransf=TRUE, results for sm="OR" are printed as odds ratios rather than log odds ratios and results for sm="ZCOR" are printed as correlations rather than Fisher's z transformed correlations, for example.
A numeric giving scaling factor for printing of single event probabilities, i.e. if argument sm is equal to "PLOGIT", "PLN", "PRAW", "PAS", or "PFT".
A numeric defining a scaling factor for printing of rates, i.e. if argument sm is equal to "IR", "IRLN", "IRS", or "IRFT".
A character specifying the time unit used to calculate rates, e.g. person-years.
A numeric specifying the number of characters to print from label for the grouping variable.
A logical indicating whether results of individual studies should be printed by grouping variable.
A logical indicating whether result of the Cochran-Mantel-Haenszel test for overall effect should be printed.
Minimal number of significant digits, see print.default.
A logical indicating whether the use of summary.meta in connection with metacum or metainf should result in a warning.
A logical indicating whether a warning should be printed if backtransformed proportions and rates are below 0 and backtransformed proportions are above 1.
A character with bracket symbol to print lower confidence interval: "[", "(". "{". ".".
A character string with information on separator between lower and upper confidence interval.
digits.se Minimal number of significant digits for standard deviations and standard errors, see print.default.
digits.zval Minimal number of significant digits for z- or t-value, see print.default.
digits.pval Minimal number of significant digits for p-value of overall treatment effect, see print.default.
digits.pval.Q Minimal number of significant digits for p-value of heterogeneity test, see print.default.
digits.Q Minimal number of significant digits for heterogeneity statistic Q, see print.default.
digits.tau2 Minimal number of significant digits for between-study variance, see print.default.
digits.H Minimal number of significant digits for H statistic, see print.default.
digits.I2 Minimal number of significant digits for I-squared and Rb statistic, see print.default.
digits.prop Minimal number of significant digits for proportions, see print.default.
digits.weight Minimal number of significant digits for weights, see print.default.
scientific.pval A logical specifying whether p-values should be printed in scientific notation, e.g., 1.2345e-01 instead of 0.12345.
print.I2 A logical specifying whether heterogeneity statistic I^2 should be printed.
print.H A logical specifying whether heterogeneity statistic H should be printed.
print.Rb A logical specifying whether heterogeneity statistic Rb should be printed.
text.tau2 Text printed to identify between-study variance tau^2.
text.I2 Text printed to identify heterogeneity statistic I^2.
text.Rb Text printed to identify heterogeneity statistic Rb.
... Additional arguments.

Details

Note, in R package meta, version 3.0-0 some arguments have been removed from R functions summary.meta (arguments: byvar, level, level.comb, level.prediction) and print.summary.meta (arguments: level, level.comb, level.prediction). This functionality is now provided by R function update.meta (or directly in meta-analysis functions, e.g., metabin, metacont, metagen, metacor, and metaprop).

Review Manager 5 (RevMan 5) is the current software used for preparing and maintaining Cochrane Reviews (http://community.cochrane.org/tools/review-production-tools/revman-5). In RevMan 5, subgroup analyses can be defined and data from a Cochrane review can be imported to R using the function read.rm5. If a meta-analysis is then conducted using function meta r, information on subgroups is available in R (components byvar, bylab, and print.byvar, byvar in an object of class "meta"). Accordingly, by using function meta r there is no need to define subgroups in order to redo the statistical analysis conducted in the Cochrane review.

Note, for an object of type metaprop, starting with version 3.7-0 of meta, list elements TE, lower and upper in element study correspond to transformed proportions and confidence limits (regardless whether exact confidence limits are calculated; argument ciexact=TRUE in metaprop function). Accordingly, the following results are based on the same transformation defined by argument sm: list elements TE, lower and upper in elements study, fixed, random, within.fixed and within.random.
R function cilayout can be utilised to change the layout to print confidence intervals (both in printout from print.meta and print.summary.meta function as well as in forest plots). The default layout is "[lower; upper]". Another popular layout is "(lower - upper)" which is used throughout an R session by using R command cilayout("","-").

Argument pscale can be used to rescale proportions, e.g. pscale=1000 means that proportions are expressed as events per 1000 observations. This is useful in situations with (very) low event probabilities.

Value

A list is returned by the function summary.meta with the following elements:

- study: Results for individual studies (a list with elements TE, seTE, lower, upper, z, p, level, df).
- fixed: Results for fixed effect model (a list with elements TE, seTE, lower, upper, z, p, level, df).
- random: Results for random effects model (a list with elements TE, seTE, lower, upper, z, p, level, df).
- k: Number of studies combined in meta-analysis.
- Q: Heterogeneity statistic Q.
- tau: Square-root of between-study variance.
- se.tau: Standard error of square-root of between-study variance.
- C: Scaling factor utilised internally to calculate common tau-squared across subgroups.
- H: Heterogeneity statistic H (a list with elements TE, lower, upper).
- I2: Heterogeneity statistic I2 (a list with elements TE, lower, upper), see Higgins & Thompson (2002).
- Rb: Heterogeneity statistic Rb (a list with elements TE, lower, upper), see Crippa et al. (2016).
- k.all: Total number of studies.
- Q.CMH: Cochran-Mantel-Haenszel test statistic for overall effect.
- sm: A character string indicating underlying summary measure.
- method: A character string with the pooling method.
- call: Function call.
- ci.lab: Label for confidence interval.
- hakn: A logical indicating whether method by Hartung and Knapp was used.
- method.tau: A character string indicating which method is used to estimate the between-study variance tau-squared.
- tau.common: A logical indicating whether tau-squared is assumed to be the same across subgroups.
- within.fixed: Result for fixed effect model within groups (a list with elements TE, seTE, lower, upper, z, p, level, df, harmonic.mean) - if byvar is not missing.
Result for random effects model within groups (a list with elements TE, seTE, lower, upper, z, p, level, df, harmonic.mean) - if byvar is not missing.

Number of studies combined within groups - if byvar is not missing.

Heterogeneity statistic Q within groups - if byvar is not missing.

Heterogeneity statistic Q between groups (based on fixed effect model) - if byvar is not missing.

Heterogeneity statistic Q between groups (based on random effects model) - if byvar is not missing.

Square-root of between-study variance within subgroups - if byvar is not missing.

Scaling factor utilised internally to calculate common tau-squared across subgroups.

Heterogeneity statistic H within subgroups (a list with elements TE, lower, upper) - if byvar is not missing.

Heterogeneity statistic I2 within subgroups (a list with elements TE, lower, upper) - if byvar is not missing.

Heterogeneity statistic Rb within subgroups (a list with elements TE, lower, upper) - if byvar is not missing.

Levels of grouping variable - if byvar is not missing.

Title of meta-analysis / systematic review.

Comparison label.

Outcome label.

Original data (set) used to create meta object.

Information on subset of original data used in meta-analysis.

As defined above.

Version of R package meta used to create object.

Guido Schwarzer <sc@imbi.uni-freiburg.de>


### print.rm5

Print and summary methods for objects of class `rm5`.

#### Description
Print and summary methods for objects of class `rm5`.

#### Usage

```r
## S3 method for class 'rm5'
print(x, ...)  

## S3 method for class 'summary.rm5'
print(x, ...)  

## S3 method for class 'rm5'
summary(object, comp.no, outcome.no, ...)  

## S3 method for class 'rm5'
m metabias(x, comp.no, outcome.no,  
method.bias="linreg",  
method.bias.binary=method.bias,  
method.bias.or="score",  
k.min=10, ...)```

#### Examples

```r
data(Fleiss93cont)
meta1 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c,  
data=Fleiss93cont, sm="SMD",  
studlab=paste(study, year))
summary(meta1)
summary(update(meta1, byvar=c(1,2,1,1,2), bylab="group"))
forest(update(meta1, byvar=c(1,2,1,1,2), bylab="group"))

## Not run:
# Use unicode characters to print tau^2 and I^2
# print(summary(meta1), text.tau2 = "\u03c4\u00b2", text.I2 = "\"1\u00b0\")

## End(Not run)
```
Arguments

x
An object of class rm5.

object
An object of class rm5.

comp.no
Comparison number.

outcome.no
Outcome number.

method.bias
A character string indicating which test for small-study effects is to be used for all outcomes. Either "rank", "linreg", or "mm", can be abbreviated. See function metabias

method.bias.binary
A character string indicating which test is to be used for binary outcomes. Either "rank", "linreg", "mm", "count", "score", or "peters", can be abbreviated. See function metabias

method.bias.or
A character string indicating which test is to be used for binary outcomes with odds ratio as summary measure. Either "rank", "linreg", "mm", "count", "score", or "peters", can be abbreviated. See function metabias

k.min
Minimum number of studies to perform test for small-study effects.

...
Additional arguments (ignored at the moment)

Details

Review Manager 5 (RevMan 5) is the current software used for preparing and maintaining Cochrane Reviews (http://community.cochrane.org/tools/review-production-tools/revman-5). In RevMan 5, subgroup analyses can be defined and data from a Cochrane review can be imported to R using the function read.rm5.

The R function summary.rm5 can be used to redo all meta-analyses of the imported Cochrane Review.

The R function metabias.rm5 can be used to conduct a test for funnel plot asymmetry for all meta-analyses of the imported Cochrane Review.

The R function metacr is called internally.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

References


See Also

metabias.meta, summary.meta, read.rm5
Examples

# Locate export data file "Fleiss93.CR.csv"
# in sub-directory of package "meta"
#
filename <- system.file("data/Fleiss93.CR.csv.gz", package = "meta")
#
Fleiss93.CR <- read.rm5(filename)

#
# Print summary results for all meta-analysis:
#
summary(Fleiss93.CR)

#
# Print results for tests of small-study effects:
#
metabias(Fleiss93.CR, k.min=5)

---

read.mtv

Import RevMan 4 data files (.mtv)

Description

Reads a file created with RevMan 4 and creates a data frame from it.

Usage

read.mtv(file)

Arguments

file The name of a file to read data values from.

Details

Reads a file created with RevMan 4 (Menu: "File" - "Export" - "Analysis data file...") and creates a data frame from it.

Value

A data frame containing the following components:

- **comp.no**  Comparison number.
- **outcome.no**  Outcome number.
- **group.no**  Group number.
- **studlab**  Study label.
- **year**  Year of publication.
event.e Number of events in experimental group.
n.e Number of observations in experimental group.
event.c Number of events in control group.
n.c Number of observations in control group.
mean.e Estimated mean in experimental group.
sd.e Standard deviation in experimental group.
mean.c Estimated mean in control group.
sd.c Standard deviation in control group.
o.e Observed minus expected (IPD analysis).
V Variance of o.e (IPD analysis).
order Ordering of studies.
conceal Concealment of treatment allocation.
grplab Group label.
type Type of outcome. D = dichotomous, C = continuous, P = IPD.
outclab Outcome label.
graph.exp Graph label for experimental group.
graph.cont Graph label for control group.
label.exp Label for experimental group.
label.cont Label for control group.
complab Comparison label.

Author(s)
Guido Schwarzer <sc@imbi.uni-freiburg.de>

References

See Also
metabin, metacont, metagen

Examples
# Locate MTV-data file "FLEISS93.MTV" in sub-directory of package "meta"
#
filename <- system.file("extdata/Fleiss93.MTV", package = "meta")
#
fleiss93.cc <- read.mtv(filename)

# Same result as R Command example(Fleiss93):
#
import event.e, n.e, event.c, n.c,
data=fleiss93.cc, subset=type="D",
studlab=paste(studlab, year))

# Same result: example(Fleiss93cont)
#
metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c,
data=fleiss93.cc, subset=type="C",
studlab=paste(studlab, year))

---

**read.rm5**

**Import RevMan 5 data files (.csv)**

**Description**

Reads data file from Cochrane Intervention review created with RevMan 5 and creates a data frame from it.

**Usage**

```
read.rm5(file, sep = ",", quote = "\", title, numbers.in.labels = TRUE)
```

**Arguments**

- **file**: The name of a file to read data values from.
- **sep**: The field separator character. Values on each line of the file are separated by this character. The comma is the default field separator character in RevMan 5.
- **quote**: The set of quoting characters. In RevMan 5 a "\"" is the default quoting character.
- **title**: Title of Cochrane review.
- **numbers.in.labels**: A logical indicating whether comparison number and outcome number should be printed at the beginning of the comparison (argument complab) and outcome label (argument outclab); this is the default in RevMan 5.

**Details**

RevMan 5 includes the ability to write Systematic reviews of interventions, Diagnostic test accuracy reviews, Methodology reviews and Overviews of reviews.

This function provides the ability to read a data file from a Cochrane Intervention review created with RevMan 5: a data frame is created from it. Cochrane Intervention reviews are based on the comparison of two interventions.

In order to generate a data analysis file in RevMan 5 use the following Menu points: "File" - "Export" - "Data and analyses". It is mandatory to include the following fields in the
exported data file by selecting them with the mouse cursor in the Export Analysis Data Wizard: (i) Comparison Number, (ii) Outcome Number, (iii) Subgroup Number. When these fields are not selected a corresponding error message will be printed in R. It is recommended to include all fields in the exported data file except for the last field "Risk of bias tables". For example, in order to redo the meta-analysis in R for the RevMan 5 data type "0-E and Variance" the fields "0-E" and "Variance" have to be selected in the Export Analysis Data Wizard. If the last field "Risk of bias tables" is selected the import in R fails with an error message "line X did not have Y elements".

By default in RevMan 5, the name of the exported data file is the title of the Cochrane Review. Accordingly, information on the title is extracted from the name of the exported data file (argument: file) if argument title is missing (default).

Each respective meta-analysis for arguments event.e.pooled – df.pooled is defined by values for "comp.no" and "outcome.no", and "grp.no".

Value

A data frame containing the following components:

- **comp.no**: Comparison number.
- **outcome.no**: Outcome number.
- **group.no**: Group number.
- **studlab**: Study label.
- **year**: Year of publication.
- **event.e**: Number of events in experimental group.
- **n.e**: Number of observations in experimental group.
- **event.c**: Number of events in control group.
- **n.c**: Number of observations in control group.
- **mean.e**: Estimated mean in experimental group.
- **sd.e**: Standard deviation in experimental group.
- **mean.c**: Estimated mean in control group.
- **sd.c**: Standard deviation in control group.
- **O.E**: Observed minus expected (IPD analysis).
- **V**: Variance of 0.E (IPD analysis).
- **TE, seTE**: Estimated treatment effect and standard error of individual studies.
- **lower, upper**: Lower and upper limit of 95% confidence interval for treatment effect in individual studies.
- **weight**: Weight of individual studies (according to meta-analytical method used in respective meta-analysis - see below for details).
- **order**: Ordering of studies.
- **grplab**: Group label.
- **type**: Type of outcome. D = dichotomous, C = continuous, P = IPD.
- **method**: A character string indicating which method has been used for pooling of studies. One of "Inverse", "MH", or "Peto".
sm  A character string indicating which summary measure has been used for pooling of studies.
model A character string indicating which meta-analytical model has been used (either "Fixed" or "Random").
comb.fixed A logical indicating whether fixed effect meta-analysis has been used in respective meta-analysis (see below for details).
comb.random A logical indicating whether random effects meta-analysis has been used in respective meta-analysis (see below for details).
outclab Outcome label.
k Total number of studies combined in respective meta-analysis).
event.e.pooled Number of events in experimental group in respective meta-analysis (see below for details).
n.e.pooled Number of observations in experimental group in respective meta-analysis (see below for details).
event.c.pooled Number of events in control group in respective meta-analysis (see below for details).
n.c.pooled Number of observations in control group in respective meta-analysis (see below for details).
TE.pooled Estimated treatment effect in respective meta-analysis (see below for details).
lower, upper Lower and upper limit of 95% confidence interval for treatment effect in respective meta-analysis (see below for details).
weight.pooled Total weight in respective meta-analysis (see below for details).
Z.pooled Z-score for test of overall treatment effect in respective meta-analysis (see below for details).
pval.pooled P-value for test of overall treatment effect in respective meta-analysis (see below for details).
Q Heterogeneity statistic Q in respective meta-analysis (see below for details).
pval.Q P-value of heterogeneity statistic Q in respective meta-analysis (see below for details).
I2 Heterogeneity statistic I2 in respective meta-analysis (see below for details).
tau2 Between-study variance (moment estimator of DerSimonian-Laird) in respective meta-analysis.
Q.w Heterogeneity statistic Q within groups in respective meta-analysis (see below for details).
pval.Q.w P-value of heterogeneity statistic Q within groups in respective meta-analysis (see below for details).
I2.w Heterogeneity statistic I2 within groups in respective meta-analysis (see below for details).
label.e Label for experimental group.
label.c Label for control group.
label.left Graph label on left side of forest plot.
label.right  Graph label on right side of forest plot.

RR.cochrane  A logical indicating if \(2\times\text{incr}\) instead of \(1\times\text{incr}\) is to be added to \(n.e\) and \(n.c\) in the calculation of the risk ratio (i.e., \text{sm}="RR") for studies with a zero cell. This is used in RevMan 5.

complab  Comparison label.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

References


See Also

metabin, metacont, metagen, metacr

Examples

```r
# Locate export data file "Fleiss93_CR.csv"
# in sub-directory of package "meta"
#
# filename <- system.file("data/Fleiss93_CR.csv.gz", package = "meta")
# Fleiss93_CR <- read.rm5(filename)

# Same result as R command example(Fleiss93):
#
# metacr(Fleiss93_CR)

# Same result as R command example(Fleiss93cont):
#
# metacr(Fleiss93_CR, 1, 2)
```

---

**settings.meta**  
*Print and change default settings to conduct and print or plot meta-analyses in R package meta.*

Description

Print and change default settings to conduct and print or plot meta-analyses in R package *meta*. The following general settings are available: *Review Manager 5, Journal of the American Medical Association*.

Usage

```r
settings.meta(…)
```
Arguments

... Arguments to change default settings.

Details

This function can be used to define defaults for several arguments (i.e., assignments using gs) of the following R functions: `metabin`, `metacont`, `metacor`, `metacr`, `metagen`, `metainc`, `metaprop`, `metarate`

Furthermore, some of these settings are considered to print meta-analysis results using `print.meta` and `print.summary.meta`, and to produce forest plots using `forest.meta`.

The function can be used to either change individual settings (see Examples) or use one of the following general settings:

- `settings.meta("revman5")`
- `settings.meta("jama")`

The first command can be used to reproduce meta-analyses from Cochrane reviews conducted with Review Manager 5 (RevMan 5, [http://community.cochrane.org/tools/review-production-tools/revman-5](http://community.cochrane.org/tools/review-production-tools/revman-5)) and specifies to use a RevMan 5 layout in forest plots. The second command can be used to generate forest plots following instructions for authors of the Journal of the American Medical Association ([http://jamanetwork.com/journals/jama/pages/instructions-for-authors](http://jamanetwork.com/journals/jama/pages/instructions-for-authors)).

RevMan 5 settings, in detail:

<table>
<thead>
<tr>
<th>Argument</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>hakn</td>
<td>FALSE</td>
<td>method not available in RevMan 5</td>
</tr>
<tr>
<td>method.tau</td>
<td>&quot;DL&quot;</td>
<td>only available method in RevMan 5</td>
</tr>
<tr>
<td>tau.common</td>
<td>FALSE</td>
<td>common between-study variance in subgroups</td>
</tr>
<tr>
<td>MH.exact</td>
<td>FALSE</td>
<td>exact Mantel-Haenszel method</td>
</tr>
<tr>
<td>RR.cochrane</td>
<td>TRUE</td>
<td>calculation of risk ratios</td>
</tr>
<tr>
<td>layout</td>
<td>&quot;RevMan5&quot;</td>
<td>layout for forest plots</td>
</tr>
<tr>
<td>test.overall</td>
<td>TRUE</td>
<td>print information on test of overall effect</td>
</tr>
<tr>
<td>digits.I2</td>
<td>0</td>
<td>number of digits for I-squared measure</td>
</tr>
<tr>
<td>digits.tau2</td>
<td>0</td>
<td>number of digits for tau-squared</td>
</tr>
<tr>
<td>CIBracket, CIseparator</td>
<td>&quot;[&quot;</td>
<td>print confidence intervals as &quot;[., .]&quot;</td>
</tr>
</tbody>
</table>

JAMA settings:

<table>
<thead>
<tr>
<th>Argument</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>layout</td>
<td>&quot;JAMA&quot;</td>
<td>layout for forest plots</td>
</tr>
<tr>
<td>test.overall</td>
<td>TRUE</td>
<td>print information on test of overall effect</td>
</tr>
<tr>
<td>digits.I2</td>
<td>0</td>
<td>number of digits for I-squared measure</td>
</tr>
<tr>
<td>CIBracket, CIseparator</td>
<td>&quot;(&quot;</td>
<td>print confidence intervals as &quot;(.-.)&quot;</td>
</tr>
</tbody>
</table>

A list of all arguments with current settings is printed using the command `settings.meta("print")`. In order to reset all settings of R package `meta` the command `settings.meta("reset")` can be
used.

Author(s)
Guido Schwarzer <sc@imbi.uni-freiburg.de>

See Also

gs, forest.meta

Examples

#
# Get listing of current settings
#
settings.meta("print")

#
# Meta-analyses using default settings
#
metabin(10, 20, 15, 20)
metaprop(4, 20)
metabin(10, 20, 15, 20, sm="RD")
metaprop(4, 20, sm="PLN")
#
# Change summary measure for R functions metabin and metaprop
# and store old settings
#
oldset <- settings.meta(smbin="RD", smprop="PLN")
#
metabin(10, 20, 15, 20)
metaprop(4, 20)
#
# Use old settings
#
settings.meta(oldset)

#
# Change level used to calculate confidence intervals
# (99%-CI for studies, 99.9%-CI for pooled effects)
#
metagen(1:3, (2:4)/10, sm="MD")
settings.meta(level=0.99, level.comb=0.999)
metagen(1:3, (2:4)/10, sm="MD")

#
# Always print a prediction interval
#
settings.meta(prediction=TRUE)
metagen(1:3, (2:4)/10, sm="MD")
metagen(4:6, (4:2)/10, sm="MD")

#
# Try to set unknown argument results in a warning
# settings.meta(unknownarg=TRUE)
#
# # Reset to default settings of R package meta
# settings.meta("reset")
metabin(10, 20, 15, 20)
metaprop(4, 20)
metagen(1:3, (2:4)/10, sm="MD")
#
# # Do not back transform results (e.g. print log odds ratios instead of
# odds ratios, print transformed correlations/proportions instead of
# correlations/proportions)
# settings.meta(backtransf=FALSE)
metabin(10, 20, 15, 20)
metaprop(4, 20)
metacor(c(0.85, 0.7, 0.95), c(20, 40, 10))
#
# # Forest plot using RevMan 5 style
# settings.meta("revman5")
forest(metagen(1:3, (2:4)/10, sm="MD", comb.fixed=FALSE),
      label.left="Favours A", label.right="Favours B",
      colgap.studlab = grid::unit(2, "cm"),
      colgap.forest.left = grid::unit(0.2, "cm"))
#
# # Forest plot using JAMA style
# settings.meta("jama")
forest(metagen(1:3, (2:4)/10, sm="MD", comb.fixed=FALSE),
      label.left="Favours A", label.right="Favours B",
      colgap.studlab = grid::unit(2, "cm"),
      colgap.forest.left = grid::unit(0.2, "cm"))
#
# # Use slightly different layout for confidence intervals
# (especially useful if upper confidence limit can be negative)
# settings.meta(CIseparator=" - ")
forest(metagen(-(-1:3), (2:4)/10, sm="MD", comb.fixed=FALSE),
      label.left="Favours A", label.right="Favours B",
      colgap.studlab = grid::unit(2, "cm"),
      colgap.forest.left = grid::unit(0.2, "cm"))

# Use old settings
#
settings.meta(oldset)
Description

Meta-analyses on the effect of smoking on mortality risk.

Data have been reconstructed based on the famous Smoking and Health Report to the Surgeon General (Bayne-Jones S et al., 1964). Data sets can be used to evaluate the risk of smoking on overall mortality and lung-cancer deaths, respectively. The person time is attributed such that the rate ratios are equal to the reported mortality ratios implicitly assuming that the data have arisen from a homogeneous age group; more detailed information by age is not available from the report. Note, the group of "non-smokers" actually consists of all participants except those who are smokers of cigarettes only. Information on real non-smokers is not available from the published Smoking and Health Report.

Usage

data(smoking)

data(lungcancer)

Format

A data frame with the following columns:

- **study**: Study label
- **participants**: Total number of participants
- **d.smokers**: Number of deaths in smokers’ group
- **py.smokers**: Person years at risk in smokers’ group
- **d.nonsmokers**: Number of deaths in non-smokers’ group
- **py.nonsmokers**: Person years at risk in non-smokers’ group

Source


See Also

- **metainc**
Examples

data(smoking)

m1 <- metaInc(d.smokers, py.smokers,
    d.nonsmokers, py.nonsmokers,
    data=smoking, studlab=study)
print(m1, digits=2)

data(lungcancer)

m2 <- metaInc(d.smokers, py.smokers,
    d.nonsmokers, py.nonsmokers,
    data=lungcancer, studlab=study)
print(m2, digits=2)

---

trimfill.meta

**Trim-and-fill method to adjust for bias in meta-analysis**

Description

Trim-and-fill method for estimating and adjusting for the number and outcomes of missing studies in a meta-analysis.

Usage

trimfill(x, ...)

## Default S3 method:
trimfill(x, seTE, left=NULL, ma.fixed=TRUE, type="L", n.iter.max=50,
    sm=NULL, studlab=NULL, level=0.95, level.comb=level,
    comb.fixed=FALSE, comb.random=TRUE,
    hakn=FALSE, method.tau="DL",
    prediction=FALSE, level.predict=level,
    backtransf=TRUE, pscale=1,
    irscale = 1, irunit = "person-years",
    silent=TRUE, ...)

## S3 method for class 'meta'
trimfill(x, left=NULL, ma.fixed=TRUE, type="L", n.iter.max=50,
    level=x$level, level.comb=x$level.comb,
    comb.fixed=FALSE, comb.random=TRUE,
    hakn=x$hakn, method.tau=x$method.tau,
    prediction=x$prediction, level.predict=x$level.predict,
    backtransf=x$backtransf, pscale=x$pscale,
    irscale = x$irscale, irunit = x$irunit,
    silent=TRUE, ...)

Arguments

- **x**: An object of class `meta`, or estimated treatment effect in individual studies.
- **seTE**: Standard error of estimated treatment effect.
- **left**: A logical indicating whether studies are supposed to be missing on the left or right side of the funnel plot. If NULL, the linear regression test for funnel plot symmetry (i.e., function `metabias(..., method="linreg")`) is used to determine whether studies are missing on the left or right side.
- **ma.fixed**: A logical indicating whether a fixed effect or random effects model is used to estimate the number of missing studies.
- **type**: A character indicating which method is used to estimate the number of missing studies. Either "L" or "R".
- **n.iter.max**: Maximum number of iterations to estimate number of missing studies.
- **sm**: An optional character string indicating underlying summary measure, e.g., "RD", "RR", "OR", "ASD", "HR", "MD", "SMD", or "ROM"; ignored if x is of class `meta`.
- **studlab**: An optional vector with study labels; ignored if x is of class `meta`.
- **level**: The level used to calculate confidence intervals for individual studies. If existing, x$level is used as value for level; otherwise 0.95 is used.
- **level.comb**: The level used to calculate confidence interval for the pooled estimate. If existing, x$level.comb is used as value for level.comb; otherwise 0.95 is used.
- **comb.fixed**: A logical indicating whether a fixed effect meta-analysis should be conducted.
- **comb.random**: A logical indicating whether a random effects meta-analysis should be conducted.
- **hakn**: A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.
- **method.tau**: A character string indicating which method is used to estimate the between-study variance \( \tau^2 \). Either "DL", "PM", "REML", "ML", "HS", "SJ", "HE", or "EB", can be abbreviated.
- **prediction**: A logical indicating whether a prediction interval should be printed.
- **level.predict**: The level used to calculate prediction interval for a new study.
- **backtransf**: A logical indicating whether results should be back transformed in printouts and plots. If backtransf=TRUE, results for sm="OR" are printed as odds ratios rather than log odds ratios and results for sm="ZCOR" are printed as correlations rather than Fisher’s z transformed correlations, for example.
- **pscale**: A numeric giving scaling factor for printing of single event probabilities, i.e. if argument sm is equal to "PLOGIT", "PLN", "PRAW", "PAS", or "PFT".
- **irscale**: A numeric defining a scaling factor for printing of rates, i.e. if argument sm is equal to "IR", "IRLN", "IRS", or "IRFT".
- **irunit**: A character specifying the time unit used to calculate rates, e.g. person-years.
- **silent**: A logical specifying the time unit used to calculate rates, e.g. person-years.
- **...**: other arguments
Details

The trim-and-fill method (Duval, Tweedie 2000a, 2000b) can be used for estimating and adjusting for the number and outcomes of missing studies in a meta-analysis. The method relies on scrutiny of one side of a funnel plot for asymmetry assumed due to publication bias.

Three different methods have been proposed originally to estimate the number of missing studies. Two of these methods (L- and R-estimator) have been shown to perform better in simulations, and are available in this R function (argument type).

A fixed effect or random effects model can be used to estimate the number of missing studies (argument ma.fixed). Furthermore, a fixed effect and/or random effects model can be used to summaries study results (arguments comb.fixed and comb.random). Simulation results (Peters et al. 2007) indicate that the fixed-random model, i.e. using a fixed effect model to estimate the number of missing studies and a random effects model to summaries results, (i) performs better than the fixed-fixed model, and (ii) performs no worse than and marginally better in certain situations than the random-random model. Accordingly, the fixed-random model is the default.

An empirical comparison of the trim-and-fill method and the Copas selection model (Schwarzer et al. 2010) indicates that the trim-and-fill method leads to excessively conservative inference in practice. The Copas selection model is available in R package metasens.

The function metagen is called internally.

Value

An object of class c("metagen", "meta", "trimfill"). The object is a list containing the following components:

- studlab, sm, left, ma.fixed, type,
- n.iter.max, level, level.comb, level.predict,
  As defined above.
- comb.fixed, comb.random, prediction, hakn, method.tau
- TE, seTE Estimated treatment effect and standard error of individual studies.
- lower, upper Lower and upper confidence interval limits for individual studies.
- zval, pval z-value and p-value for test of treatment effect for individual studies.
- w.fixed, w.random Weight of individual studies (in fixed and random effects model).
- TE.fixed, seTE.fixed Estimated overall treatment effect and standard error (fixed effect model).
- TE.random, seTE.random Estimated overall treatment effect and standard error (random effects model).
- seTE.predict Standard error utilised for prediction interval.
- lower.predict, upper.predict Lower and upper limits of prediction interval.
- k Number of studies combined in meta-analysis.
- Q Heterogeneity statistic Q.
tau

method

call

n.iter

trimfill

df.hakn

title

complab

outclab

label.e

label.c

label.left

label.right

k0

n.e

n.c

event.e

event.c

mean.e

sd.e

mean.c

sd.c

n

event

cor

class.x

version

Square-root of between-study variance.

Pooling method: "Inverse".

Function call.

Actual number of iterations to estimate number of missing studies.

A logical vector indicating studies that have been added by trim-and-fill method.

Degrees of freedom for test of treatment effect for Hartung-Knapp method (only if hakn=TRUE).

Title of meta-analysis / systematic review.

Comparison label.

Outcome label.

Label for experimental group.

Label for control group.

Graph label on left side of forest plot.

Graph label on right side of forest plot.

Number of studies added by trim-and-fill.

Number of observations in experimental group (only for object x of class metabin or metacont).

Number of observations in control group (only for object x of class metabin or metacont).

Number of events in experimental group (only for object x of class metabin).

Number of events in control group (only for object x of class metabin).

Estimated mean in experimental group (only for object x of class metacont).

Standard deviation in experimental group (only for object x of class metacont).

Estimated mean in control group (only for object x of class metacont).

Standard deviation in control group (only for object x of class metacont).

Number of observations (only for object x of class metaprop).

Number of events (only for object x of class metaprop).

Corelation (only for object x of class metacor).

Main class of object x (e.g. 'metabin' or 'metacont').

Version of R package meta used to create object.

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>
References


See Also

*metagen*, *metabias*, *funnel*

Examples

```r
data(Fleiss93)
meta1 <- metabin(event.e, n.e, event.c, n.c,
data=Fleiss93, sm="OR")
 tf1 <- trimfill(meta1)
 summary(tf1)
 funnel(tf1)
 funnel(tf1, pch=ifelse(tf1$trimfill, 1, 16),
       level=0.9, comb.random=FALSE)

# # Use log odds ratios on x-axis
# funnel(tf1, backtransf=FALSE)
funnel(tf1, pch=ifelse(tf1$trimfill, 1, 16),
       level=0.9, comb.random=FALSE, backtransf=FALSE)
trimfill(meta1$TE, meta1$seTE, sm=meta1$sm)
```

update.meta

*Update a meta-analysis object*

Description

Update an existing meta-analysis object.
Usage

## S3 method for class 'meta'
update(object,
data = object$data, subset = object$subset,
studlab = object$data$.studlab,
method = object$method, sm = object$sm,
inr = object$allincr, addincr = object$addincr, alllstudies = object$allstudies,
MH.exact = object$MH.exact, RR.cochrane = object$RR.cochrane,
model.glmm = object$model.glmm,
level = object$level, level.comb = object$level.comb,
comb.fixed = object$comb.fixed, comb.random = object$comb.random,
hakn = object$hakn, method.tau = object$method.tau,
tau.preset = object$tau.preset,
TE.tau = object$TE.tau, tau.common = object$tau.common,
prediction = object$prediction, level.predict = object$level.predict,
null.effect = object$null.effect,
method.bias = object$method.bias, backtransf = object$backtransf,
pscale = object$pscale,
irscale = object$irscale, irunit = object$irunit,
title = object$title, complab = object$complab, outclab = object$outclab,
label.e = object$label.e, label.c = object$label.c,
label.left = object$label.left, label.right = object$label.right,
n.e = object$n.e, n.c = object$n.c,
pooledvar = object$pooledvar, method.smd = object$method.smd,
sd.glass = object$sd.glass, exact.smd = object$exact.smd,
method.ci = object$method.ci,
byvar = object$byvar, bylab = object$bylab, print.byvar = object$print.byvar,
byseparator = object$byseparator,
print.CMH = object$print.CMH, keepdata = TRUE,
left = object$left, ma.fixed = object$ma.fixed,
type = object$type, n.iter.max = object$n.iter.max,
warn = object$warn, ...)  

Arguments

object  
An object of class meta.

data  
Dataset.

subset  
Subset.

studlab  
Study label.

method  
A character string indicating which method is to be used for pooling of studies; see `metabin` and `metainc` function for admissible values.

sm  
A character string indicating which summary measure is used for pooling.

incr  
Either a numerical value or vector which can be added to each cell frequency for studies with a zero cell count or the character string “TA” which stands for treatment arm continuity correction.
**update.meta**

- **allincr**: A logical indicating if `incr` is added to each cell frequency of all studies if at least one study has a zero cell count. If FALSE (default), `incr` is added only to each cell frequency of studies with a zero cell count.

- **addincr**: A logical indicating if `incr` is added to each cell frequency of all studies irrespective of zero cell counts.

- **allstudies**: A logical indicating if studies with zero or all events in both groups are to be included in the meta-analysis (applies only if `sm` is equal to "RR" or "OR").

- **MH.exact**: A logical indicating if `incr` is not to be added to all cell frequencies for studies with a zero cell count to calculate the pooled estimate based on the Mantel-Haenszel method.

- **RR.cochrane**: A logical indicating if $2 \times incr$ instead of $1 \times incr$ is to be added to $n_e$ and $n_c$ in the calculation of the risk ratio (i.e., if $sm="RR"$) for studies with a zero cell. This is used in RevMan 5, the Cochrane Collaboration’s program for preparing and maintaining Cochrane reviews.

- **model.glmm**: A character string indicating which GLMM model should be used.

- **level**: The level used to calculate confidence intervals for individual studies.

- **level.comb**: The level used to calculate confidence intervals for pooled estimates.

- **comb.fixed**: A logical indicating whether a fixed effect meta-analysis should be conducted.

- **comb.random**: A logical indicating whether a random effects meta-analysis should be conducted.

- **hakn**: A logical indicating whether the method by Hartung and Knapp should be used to adjust test statistics and confidence intervals.

- **method.tau**: A character string indicating which method is used to estimate the between-study variance $\tau^2$. Either "DL", "PM", "REML", "ML", "HS", "SJ", "HE", or "EB", can be abbreviated. See function `metagen`.

- **tau.preset**: Prespecified value for the square-root of the between-study variance $\tau^2$.

- **TE.tau**: Overall treatment effect used to estimate the between-study variance $\tau^2$.

- **tau.common**: A logical indicating whether tau-squared should be the same across subgroups.

- **prediction**: A logical indicating whether a prediction interval should be printed.

- **level.predict**: The level used to calculate prediction interval for a new study.

- **null.effect**: A numeric value specifying the effect under the null hypothesis.

- **method.bias**: A character string indicating which test for funnel plot asymmetry is to be used. Either "rank", "linreg", "mm", "count", "score", or "peters", can be abbreviated. See function `metabias`.

- **backtransf**: A logical indicating whether results should be back transformed in printouts and plots. If `backtransf=TRUE`, results for `sm="OR"` are printed as odds ratios rather than log odds ratios and results for `sm="ZCOR"` are printed as correlations rather than Fisher’s z transformed correlations, for example.

- **pscale**: A numeric giving scaling factor for printing of single event probabilities, i.e. if argument `sm` is equal to "PILOGIT", "PLN", "PRAW", "PAS", or "PFT".

- **irscale**: A numeric defining a scaling factor for printing of rates, i.e. if argument `sm` is equal to "IR", "IRLN", "IRS", or "IRFT".
**update.meta**

- **irunit**: A character specifying the time unit used to calculate rates, e.g. person-years.
- **title**: Title of meta-analysis / systematic review.
- **complab**: Comparison label.
- **outclab**: Outcome label.
- **label.e**: Label for experimental group.
- **label.c**: Label for control group.
- **label.left**: Graph label on left side of forest plot.
- **label.right**: Graph label on right side of forest plot.
- **n.e**: Number of observations in experimental group. (only for `metagen` object)
- **n.c**: Number of observations in control group. (only for `metagen` object)
- **pooledvar**: A logical indicating if a pooled variance should be used for the mean difference (only for `metacont` object with `sm="MD"`).
- **method.smd**: A character string indicating which method is used to estimate the standardised mean difference (only for `metacont` object with `sm="SMD"`). Either "Hedges" for Hedges’ g (default), "Cohen" for Cohen’s d, or "Glass" for Glass’ delta, can be abbreviated.
- **sd.glass**: A character string indicating which standard deviation is used in the denominator for Glass’ method to estimate the standardised mean difference (only for `metacont` object with `sm="SMD"`). Either "control" using the standard deviation in the control group (`sd.c`) or "experimental" using the standard deviation in the experimental group (`sd.e`), can be abbreviated.
- **exact.smd**: A logical indicating whether exact formulae should be used in estimation of the standardised mean difference and its standard error.
- **method.ci**: A character string indicating which method is used to calculate confidence intervals for individual studies. Either "CP", "WS", "WSCC", "AC", "SA", "SACC", or "NAsm", can be abbreviated. See function `metaprop`.
- **byvar**: An optional vector containing grouping information (must be of same length as `event.e`).
- **bylab**: A character string with a label for the grouping variable.
- **print.byvar**: A logical indicating whether the name of the grouping variable should be printed in front of the group labels.
- **byseparator**: A character string defining the separator between label and levels of grouping variable.
- **print.CMH**: A logical indicating whether result of the Cochran-Mantel-Haenszel test for overall effect should be printed.
- **keepdata**: A logical indicating whether original data (set) should be kept in meta object.
- **left**: A logical indicating whether studies are supposed to be missing on the left or right side of the funnel plot. If NULL, the linear regression test for funnel plot symmetry (i.e., function `metabias(..., method="linreg")`) is used to determine whether studies are missing on the left or right side.
- **ma.fixed**: A logical indicating whether a fixed effect or random effects model is used to estimate the number of missing studies.
update.meta

<table>
<thead>
<tr>
<th>type</th>
<th>A character indicating which method is used to estimate the number of missing studies. Either &quot;L&quot; or &quot;R&quot;.</th>
</tr>
</thead>
<tbody>
<tr>
<td>n.iter.max</td>
<td>Maximum number of iterations to estimate number of missing studies.</td>
</tr>
<tr>
<td>warn</td>
<td>A logical indicating whether warnings should be printed (e.g., if incr is added to studies with zero cell frequencies).</td>
</tr>
<tr>
<td>...</td>
<td>Additional arguments (ignored at the moment).</td>
</tr>
</tbody>
</table>

Details

Wrapper function to update an existing meta-analysis object which was created with R function `metabin`, `metacont`, `metagen`, `metacor`, `metainc`, or `metaprop`.

This function can also be used for objects of class 'trimfill', 'metacum', and 'metainf'.

More details on function arguments are available in help files of respective R functions, i.e. `metabin`, `metacont`, ...

Value

An object of class "meta" and "metabin", "metacont", "metagen", "metaprop", or "metacor".

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

See Also

`metabin`, `metacont`, `metagen`, `metaprop`, `metacor`

Examples

```r
data(Fleiss93cont)
meta1 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c,
                   data=Fleiss93cont, sm="SMD", studlab=study)

# Change summary measure (from 'SMD' to 'MD')
# update(meta1, sm="MD")

# Restrict analysis to subset of studies
# update(meta1, subset=1:2)

# Use different levels for confidence intervals
# meta2 <- update(meta1, level=0.66, level.comb=0.99)
print(meta2, digits=2)
forest(meta2)
```
weights.meta

Calculate absolute and percentage weights for meta-analysis

Description

The weights.meta method returns a data frame containing information on absolute and percentage weights of individual studies contributing to fixed effect and random effects meta-analysis.

Usage

```r
## S3 method for class 'meta'
weights(object, comb.fixed = object$comb.fixed,
        comb.random = object$comb.random, ...)
```

Arguments

- `object`: An object of class `meta`.
- `comb.fixed`: A logical indicating whether absolute and percentage weights from the fixed effect model should be calculated.
- `comb.random`: A logical indicating whether absolute and percentage weights from the random effects model should be calculated.
- `...`: Additional arguments (ignored at the moment).

Value

A data frame with the following variables is returned:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>w.fixed</code></td>
<td>absolute weights in fixed effect model</td>
<td>(if <code>comb.fixed</code> = TRUE)</td>
</tr>
<tr>
<td><code>p.fixed</code></td>
<td>percentage weights in fixed effect model</td>
<td>(if <code>comb.fixed</code> = TRUE)</td>
</tr>
<tr>
<td><code>w.random</code></td>
<td>absolute weights in random effects model</td>
<td>(if <code>comb.random</code> = TRUE)</td>
</tr>
<tr>
<td><code>p.random</code></td>
<td>percentage weights in random effects model</td>
<td>(if <code>comb.random</code> = TRUE)</td>
</tr>
</tbody>
</table>

Author(s)

Guido Schwarzer <sc@imbi.uni-freiburg.de>

See Also

`metabin`, `metacont`, `metagen`

Examples

```r
data(Fleiss93cont)
#
# Do meta-analysis (fixed effect and random effects model)```
woodyplants

# meta1 <- metacont(n.e, mean.e, sd.e, n.c, mean.c, sd.c, study, 
data=Fleiss93cont, sm="SMD")
#
# Print weights for fixed effect and random effects meta-analysis
# weights(meta1)
#
# Do meta-analysis (only random effects model)
# meta2 <- update(meta1, comb.fixed = FALSE)
# # Print weights for random effects meta-analysis
# weights(meta2)
#
# Print weights for fixed effect and random effects meta-analysis
# weights(meta2, comb.fixed = TRUE)

woodyplants  Elevated CO_2 and total biomass of woody plants

Description

Meta-analysis on effects of elevated CO_2 on total biomass of woody plants

Usage

data(woodyplants)

Format

A data frame with the following columns:

- **obsno**  Observation number
- **papno**  Database paper number
- **treat**  Treatment code
- **level**  Treatment level
- **n.elev** Number of observations in experimental group (elevated CO_2-level)
- **mean.elev** Estimated mean in experimental group
- **sd.elev** Standard deviation in experimental group
- **n.amb**  Number of observations in control group (ambient CO_2-level)
- **mean.amb** Estimated mean in control group
- **sd.amb** Standard deviation in control group
Details
This dataset has been used as an example in Hedges et al. (1999) to describe methods for the meta-analysis of response ratios. The complete dataset with 102 observations and 26 variables is available online as a supplement. Here only a subset of 10 variables is provided and used in the examples.

Source
Website http://www.esapubs.org/archive/ecol/E080/008/

References

Examples
```r
data(woodyplants)

# Meta-analysis of response ratios (Hedges et al., 1999)
#
meta8 <- metaccont(n.elev, mean.elev, sd.elev,
    n.amb, mean.amb, sd.amb,
    data=woodyplants, sm="ROM",
    studlab=paste(obsno, papno, sep = " / "))
summary(meta8, prediction=TRUE)

# Meta-analysis for plants grown with low soil fertility treatment
#
meta9 <- update(meta8, subset=(treat=="fert"&level=="low"))
summary(meta9, prediction=TRUE)

# Meta-analysis for plants grown under low light conditions
#
meta10 <- update(meta8, subset=(treat=="light"&level=="low"))
summary(meta10, prediction=TRUE)
```
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