

# Package ‘metamedian’

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**Type** Package

**Title** Meta-Analysis of Medians

**Version** 0.1.2

**Maintainer** Sean McGrath <sean.mcgrath@mail.mcgill.ca>

**Description** Implements several methods to meta-analyze one-group or two-group studies that report the median of the outcome. In the one-group context, the methods of McGrath et al. (2018a) <doi:10.1002/sim.8013> estimate the pooled median. In the two-group context, the methods of McGrath et al. (2018b) <arXiv:1809.01278> estimate the pooled raw difference of medians across groups.

**Imports** estmeansd, Hmisc, metafor, stats

**License** GPL (>= 3)

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**Author** Sean McGrath [aut, cre] (<<https://orcid.org/0000-0002-7281-3516>>),  
XiaoFei Zhao [aut],  
Russell Steele [aut],  
Andrea Benedetti [aut] (<<https://orcid.org/0000-0002-8314-9497>>)

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get.scenario	<i>Classify scenario based on summary measures</i>
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### Description

The function indicates whether S1, S2, S3, or S4 summary measures are provided. See documentation of [qe](#) for definitions of S1, S2, S3, and S4 summary measures. Note that the sample size is not included in this check.

### Usage

```
get.scenario(min.val, q1.val, med.val, q3.val, max.val, mean.val, sd.val)
```

### Arguments

min.val	numeric value giving the sample minimum.
q1.val	numeric value giving the sample first quartile.
med.val	numeric value giving the sample median.
q3.val	numeric value giving the sample third quartile.
max.val	numeric value giving the sample maximum.
mean.val	numeric value giving the sample mean.
sd.val	numeric value giving the sample standard deviation.

### Value

A character string of one of the following: "S1", "S2", "S3", or "S4".

### Examples

```
scenario <- get.scenario(min.val=1, med.val=5, max.val=20)
```

---

metamedian-deprecated *Deprecated functions in package 'metamedian'*

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### Description

These functions are provided for compatibility with older versions of 'metamedian' only, and will be defunct at the next release.

## Details

The following functions are deprecated and will be made defunct; use the replacement indicated below:

- `qe.fit` calls should now be `qe.fit` (in the ‘estmeansd’ package) calls. That is, this function has been moved to the ‘estmeansd’ package.
- Similarly, `print.qe.fit` calls should now be `print.qe.fit` (in the ‘estmeansd’ package) calls.

---

pool.med

*Meta-Analysis via median of (the difference of) medians method*

---

## Description

This function meta-analyzes the study-specific effect sizes by applying the (weighted) median of medians method (McGrath et al., 2018a) in one-sample contexts and the (weighted) median of the difference of median method (McGrath et al., 2018b) in two-sample contexts.

## Usage

```
pool.med(yi, wi, norm.approx = TRUE)
```

## Arguments

<code>yi</code>	vector of the study-specific effect sizes (e.g., the medians or the difference of medians)
<code>wi</code>	optional vector of positive, study-specific weights (e.g., sample sizes)
<code>norm.approx</code>	optional logical scalar indicating whether normality approximation of the binomial should be used to construct an approximate 95% confidence interval (the default is TRUE).

## Details

For one-group studies, authors may report the sample median or mean. If these measures are supplied for `yi` and weights are not provided for `wi`, the function implements the median of medians (MM) method (McGrath et al., 2018a).

For two-group studies, authors may report the difference of medians or the difference of means across both groups. If these measures are supplied for `yi` and weights are not provided for `wi`, the function implements the median of the difference of medians (MDM) method (McGrath et al., 2018b).

Analogous weighted versions of the MM and MDM methods can be applied when study-specific sample sizes are provided for `wi`.

The confidence interval around the pooled estimate is constructed by inverting the sign test.

**Value**

A list with components

pooled.est	Pooled estimate
ci.lb	Lower bound of confidence interval
ci.ub	Upper bound of confidence interval
cov.level	Theoretical coverage of the confidence interval around the pooled estimate. When norm.approx is set to TRUE, the theoretical coverage is 95%. When norm.approx is set to FALSE, the theoretical coverage is set to the smallest possible value greater than 95%.

**References**

McGrath S., Zhao X., Qin Z.Z., Steele R., and Benedetti A. (2018). One-sample aggregate data meta-analysis of medians. *Statistics in Medicine*. 1–16.

McGrath S., Sohn H., Steele R., and Benedetti A. (2018). Two-sample aggregate data meta-analysis of medians. *ArXiv e-prints*. <https://arxiv.org/abs/1809.01278>.

**Examples**

```
## Storing data (study-specific difference of medians)
yi <- c(5.23, 3.10, 0.50, 0.78, 3.48, 0.59, 2.20, 5.06, 4.00)

## Meta-analysis of the difference of medians
pool.med(yi)
```

---

```
print.qe.fit          Print method for objects of class "qe.fit"
```

---

**Description**

*Note:* As of release 0.1.2, this function is deprecated; `print.qe.fit` (in the ‘estmeansd’ package) should be used instead.

Print method for objects of class "qe.fit".

**Usage**

```
## S3 method for class 'qe.fit'
print(x, ...)
```

**Arguments**

x	object of class "qe.fit".
...	other arguments.

**Value**

No value is returned.

**See Also**

[metamedian-deprecated](#), [qe.fit](#)

**Examples**

```
## Generate S2 summary data
set.seed(1)
n <- 100
x <- stats::rlnorm(n, 2.5, 1)
quants <- stats::quantile(x, probs = c(0.25, 0.5, 0.75))

## Fit distributions
res <- qe.fit(q1.val = quants[1], med.val = quants[2], q3.val = quants[3],
             n = n)
print(res)
```

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 qe

---

*Meta-Analysis via quantile estimation method*


---

**Description**

The function applies the quantile estimation (QE) method (McGrath et al., 2018) to meta-analyze one-group or two-group studies where each study reports one of the following summary measures:

- S1: median, minimum and maximum values, and sample size
- S2: median, first and third quartiles, and sample size
- S3: median, minimum and maximum values, first and third quartiles, and sample size
- S4: mean, standard deviation, and sample size.

For one-group studies, the function estimates the pooled median. For two-group studies, the function estimates the pooled raw difference of medians across groups. The convention used for calculating differences in two-group studies is: value in group 1 minus value in group 2.

**Usage**

```
qe(min.g1, q1.g1, med.g1, q3.g1, max.g1, n.g1, mean.g1, sd.g1, min.g2,
   q1.g2, med.g2, q3.g2, max.g2, n.g2, mean.g2, sd.g2,
   single.family = FALSE, loc.shift = FALSE, ...)
```

**Arguments**

<code>min.g1</code>	vector of study-specific sample minimum values (first group for two-group studies). See 'Details'.
<code>q1.g1</code>	vector of study-specific sample first quartile values (first group for two-group studies). See 'Details'.
<code>med.g1</code>	vector of study-specific sample median values (first group for two-group studies). See 'Details'.
<code>q3.g1</code>	vector of study-specific sample third quartile values (first group for two-group studies). See 'Details'.
<code>max.g1</code>	vector of study-specific sample maximum values (first group for two-group studies). See 'Details'.
<code>n.g1</code>	vector of study-specific sample sizes (first group for two-group studies). See 'Details'.
<code>mean.g1</code>	vector of study-specific sample mean values (first group for two-group studies). See 'Details'.
<code>sd.g1</code>	vector of study-specific sample standard deviation values (first group for two-group studies). See 'Details'.
<code>min.g2</code>	vector of study-specific sample minimum values of the second group for two-group studies. See 'Details'.
<code>q1.g2</code>	vector of study-specific sample first quartile values of the second group for two-group studies. See 'Details'.
<code>med.g2</code>	vector of study-specific sample median values of the second group for two-group studies. See 'Details'.
<code>q3.g2</code>	vector of study-specific sample third quartile values of the second group for two-group studies. See 'Details'.
<code>max.g2</code>	vector of study-specific sample maximum values of the second group for two-group studies. See 'Details'.
<code>n.g2</code>	vector of study-specific sample sizes of the second group for two-group studies. See 'Details'.
<code>mean.g2</code>	vector of study-specific sample mean values of the second group for two-group studies. See 'Details'.
<code>sd.g2</code>	vector of study-specific sample standard deviation values of the second group for two-group studies. See 'Details'.
<code>single.family</code>	logical scalar indicating that for two-group studies, the parametric family of distributions is assumed to be the same across both groups (the default is FALSE). See 'Details' of <a href="#">qe.study.level</a> .
<code>loc.shift</code>	logical scalar indicating that for two-group studies, distributions are assumed to only differ by a location shift (the default is FALSE). See 'Details' of <a href="#">qe.study.level</a> .
<code>...</code>	optional arguments for pooling. See documentation of <a href="#">rma.uni</a> .

## Details

Letting  $k$  denote the number of studies, provide study-specific summary data as vectors of length  $k$ . If a study does not report a given summary measure (e.g., the minimum value), give a value of NA for the position in the relevant vector. If no studies report a given summary measure, a vector of only NA values need not be provided. See 'Examples' for appropriate use.

The sampling variance of the effect size for each study is estimated via the QE method. The default starting values and box constraints of the parameters in the minimization algorithm (`qe.fit`) are used. After estimating the sampling variances for all studies, studies are meta-analyzed using the `rma.uni` function.

## Value

An object of class "rma.uni". See documentation of `rma.uni`.

## References

McGrath S., Sohn H., Steele R., and Benedetti A. (2018). Two-sample aggregate data meta-analysis of medians. *ArXiv e-prints*. <https://arxiv.org/abs/1809.01278>.

## Examples

```
## Example 1: Meta-analysis of one-group studies

## Storing data
## Note: All 6 studies report S2
med.vals <- c(6.1, 5.2, 3.1, 2.8, 4.5)
q1.vals <- c(2.0, 1.6, 2.6, 0.9, 3.2)
q3.vals <- c(10.2, 13.0, 8.3, 8.2, 9.9)
n.vals <- c(100, 92, 221, 81, 42)

## Meta-analyze studies via QE method
qe(q1.g1 = q1.vals, med.g1 = med.vals, q3.g1 = q3.vals, n.g1 = n.vals)

## Example 2: Meta-analysis of one-group studies

## Storing data
## Note: Studies 1, 2, 3, and 4 report S1, S2, S3, and S4, respectively
min.vals <- c(0.7, NA, 1.1, NA)
q1.vals <- c(NA, 5.2, 5.3, NA)
med.vals <- c(8.7, 10.7, 11.0, NA)
q3.vals <- c(NA, 5.2, 5.3, NA)
max.vals <- c(22.2, NA, 24.7, NA)
n.vals <- c(52, 34, 57, 90)
sd.vals <- c(NA, NA, NA, 4.2)
mean.vals <- c(NA, NA, NA, 12.2)

## Meta-analyze studies via QE method
qe(min.g1 = min.vals, q1.g1 = q1.vals, med.g1 = med.vals, q3.g1 = q3.vals,
   max.g1 = max.vals, n.g1 = n.vals, mean.g1 = mean.vals, sd.g1 = sd.vals)
```

```
## Example 3: Meta-analysis of two-group studies

## Storing data
## Note: All 4 studies report S3
min.g1 <- c(2.3, 3.2, 1.9, 1.7)
q1.g1 <- c(6.0, 7.1, 3.5, 3.8)
med.g1 <- c(8.7, 9.5, 5.9, 6.0)
q3.g1 <- c(11.3, 13.1, 10.8, 11.0)
max.g1 <- c(20.6, 25.3, 17.0, 18.6)
n.g1 <- c(53, 49, 66, 75)
min.g2 <- c(0.4, 0.9, 0.5, 0.3)
q1.g2 <- c(2.5, 3.1, 2.7, 2.3)
med.g2 <- c(5.1, 6.2, 4.9, 4.7)
q3.g2 <- c(9.6, 10.1, 8.8, 9.2)
max.g2 <- c(20.2, 21.4, 18.8, 19.2)
n.g2 <- c(50, 45, 60, 73)

## Meta-analyze studies via QE method
qe(min.g1 = min.g1, q1.g1 = q1.g1, med.g1 = med.g1, q3.g1 = q3.g1,
  max.g1 = max.g1, n.g1 = n.g1, min.g2 = min.g2, q1.g2 = q1.g2,
  med.g2 = med.g2, q3.g2 = q3.g2, max.g2 = max.g2, n.g2 = n.g2)
```

---

qe.fit

*Quantile estimation fitting*

---

## Description

*Note:* As of release 0.1.2, this function is deprecated; `qe.fit` (in the ‘estmeansd’ package) should be used instead.

This function fits several parametric families of distributions from summary data in the following forms:

- S1: median, minimum and maximum values, and sample size
- S2: median, first and third quartiles, and sample size
- S3: median, minimum and maximum values, first and third quartiles, and sample size

## Usage

```
qe.fit(min.val, q1.val, med.val, q3.val, max.val, n,
  qe.fit.control = list())
```

## Arguments

min.val	numeric value giving the sample minimum.
q1.val	numeric value giving the sample first quartile.
med.val	numeric value giving the sample median.



q3.val	numeric value giving the sample third quartile.
max.val	numeric value giving the sample maximum.
n	numeric value giving the sample size.
qe.fit.control	optional list of control parameters for the minimization algorithm. Default values are defined in the function.
norm.mu.start	numeric value giving the starting value for the $\mu$ parameter of the normal distribution.
norm.sigma.start	numeric value giving the starting value for the $\sigma$ parameter of the normal distribution.
lnorm.mu.start	numeric value giving the starting value for the $\mu$ parameter of the log-normal distribution.
lnorm.sigma.start	numeric value giving the starting value for the $\sigma$ parameter of the log-normal distribution.
gamma.shape.start	numeric value giving the starting value for the shape parameter of the gamma distribution.
gamma.rate.start	numeric value giving the starting value for the rate parameter of the gamma distribution.
weibull.shape.start	numeric value giving the starting value for the shape parameter of the Weibull distribution.
weibull.scale.start	numeric value giving the starting value for the scale parameter of the Weibull distribution.
norm.mu.bounds	vector giving the bounds on the $\mu$ parameter of the normal distribution.
norm.sigma.bounds	vector giving the bounds on the $\sigma$ parameter of the normal distribution.
lnorm.mu.bounds	vector giving the bounds on the $\mu$ parameter of the the log-normal distribution.
lnorm.sigma.bounds	vector giving the bounds on the $\sigma$ parameter of the log-normal distribution.
gamma.shape.bounds	vector giving the bounds on the shape parameter of the gamma distribution.
gamma.rate.bounds	vector giving the bounds on the rate parameter of the gamma distribution.
weibull.shape.bounds	vector giving the bounds on the shape parameter of the Weibull distribution.
weibull.scale.bounds	vector giving the bounds on the scale parameter of the Weibull distribution.

## Details

Distributions are fit by minimizing the distance between observed and distribution quantiles in the L2-norm. If data are positive, the normal, log-normal, gamma, and Weibull distributions are fit. Otherwise, only the normal distribution is fit. The limited-memory Broyden-Fletcher-Goldfarb-Shanno (L-BFGS-M) algorithm implemented in the `optim` function is used for minimization. Default box constraints are described in McGrath et al. (2018).

## Value

A object of class `qe.fit`. The object is a list with the following components:

norm.par	Estimated parameters of the normal distribution.
lnorm.par	Estimated parameters of the log-normal distribution.
gamma.par	Estimated parameters of the gamma distribution.
weibull.par	Estimated parameters of Weibull distribution.
values	Values of the objective functions evaluated at the estimated paramters of each candidate distribution.

The results are printed with the `print.qe.fit` function.

## References

McGrath S., Sohn H., Steele R., and Benedetti A. (2018). Two-sample aggregate data meta-analysis of medians. *ArXiv e-prints*. <https://arxiv.org/abs/1809.01278>.

**See Also**

[metamedian-deprecated](#)

**Examples**

```
## Generate S2 summary data
set.seed(1)
n <- 100
x <- stats::rlnorm(n, 2.5, 1)
quants <- stats::quantile(x, probs = c(0.25, 0.5, 0.75))

## Fit distributions
qe.fit(q1.val = quants[1], med.val = quants[2], q3.val = quants[3], n = n)
```

---

qe.study.level

*Study-Level application of quantile estimation method*

---

**Description**

This function estimates the asymptotic sampling variance of either the (estimated) median or the (estimated) difference of medians for a primary study that reports one of the following summary measures:

- S1: median, minimum and maximum values, and sample size
- S2: median, first and third quartiles, and sample size
- S3: median, minimum and maximum values, first and third quartiles, and sample size
- S4: mean, standard deviation, and sample size.

**Usage**

```
qe.study.level(min.g1, q1.g1, med.g1, q3.g1, max.g1, n.g1, mean.g1, sd.g1,
  min.g2, q1.g2, med.g2, q3.g2, max.g2, n.g2, mean.g2, sd.g2,
  single.family = FALSE, loc.shift = FALSE,
  qe.fit.control.g1 = list(), qe.fit.control.g2 = list())
```

**Arguments**

min.g1	numeric value giving the sample minimum (first group for two-group studies).
q1.g1	numeric value giving the first quartile (first group for two-group studies).
med.g1	numeric value giving the sample median (first group for two-group studies).
q3.g1	numeric value giving the sample third quartile (first group for two-group studies).

max.g1	numeric value giving the sample maximum (first group for two-group studies).
n.g1	numeric value giving the sample size (first group for two-group studies).
mean.g1	numeric value giving the sample mean (first group for two-group studies).
sd.g1	numeric value giving the sample standard deviation (first group for two-group studies).
min.g2	numeric value giving the sample minimum of the second group for two-group studies.
q1.g2	numeric value giving the sample first quartile of the second group for two-group studies.
med.g2	numeric value giving the sample median of the second group for two-group studies.
q3.g2	numeric value giving the sample third quartile of the second group for two-group studies.
max.g2	numeric value giving the sample maximum of the second group for two-group studies.
n.g2	numeric value giving the sample size of the second group for two-group studies.
mean.g2	numeric value giving the sample mean of the second group for two-group studies.
sd.g2	numeric value giving the sample standard deviation of the second group for two-group studies.
single.family	logical scalar indicating that for two-group studies, the parametric family of distributions is assumed to be the same across both groups (the default is FALSE). See 'Details'.
loc.shift	logical scalar indicating that for two-group studies, distributions are assumed to only differ by a location shift (the default is FALSE). See 'Details'.
qe.fit.control.g1	optional list of control parameters for <a href="#">qe.fit</a> (first group for two-group studies).
qe.fit.control.g2	optional list of control parameters for <a href="#">qe.fit</a> of the second group for two-group studies.

## Details

In order to estimate the asymptotic sampling variance of the median, one must have an estimate of the probability density function of the outcome evaluated at the population median. When a study provides summary measures of S1, S2, or S3, the [qe.fit](#) function is applied to estimate the outcome distribution. When a study provides S4 summary measures, the outcome distribution is assumed to be normal and the parameters are fit by maximum likelihood estimation.

For two-group studies studies, one may assume that the outcome in both groups follows the same parametric family of distributions. In this case, distribution selection for the QE method is applied as follows. The [qe.fit](#) function is applied to fit the candidate distributions of each group separately. However, for each candidate distribution, the objective function evaluated at the fitting parameters are summed over the two groups. The parametric family of distributions with the smallest sum is used as the underlying distribution of the both groups. If `single.family` is TRUE, then

selected.dist is a character string indicating the selected parametric family. If single.family is FALSE, then selected.dist is a vector of length 2 where elements 1 and 2 are character strings of the selected parametric families in groups 1 and 2, respectively.

One may also assume for two-group studies that the outcome distributions in the two groups only differ by a location shift. In this case, a weighted mean (weighted by sample size) of the estimated probability density functions evaluated at the population medians is used to estimate the asymptotic sampling variance of the difference of medians. See McGrath et al. (2018) for further details.

### Value

A list with the following components:

var	Estimated sampling variance of the effect size.
effect.size	Effect size of study.
selected.dist	Selected outcome distribution(s). See 'Details'.
study.type	Character string specifying whether one-group or two-group summary data was provided.

### References

McGrath S., Sohn H., Steele R., and Benedetti A. (2018). Two-sample aggregate data meta-analysis of medians. *ArXiv e-prints*. <https://arxiv.org/abs/1809.01278>.

### Examples

```
## Generate S2 summary data
set.seed(1)
n <- 100
x <- stats::rlnorm(n, 2.5, 1)
quants <- stats::quantile(x, probs = c(0.25, 0.5, 0.75))

## Estimate sampling variance of the median
qe.study.level(q1.g1 = quants[1], med.g1 = quants[2], q3.g1 = quants[3],
              n.g1 = n)
```

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