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## A new trend in research: Meta-Analysis

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### Abstract

Meta-analysis is a collection of systematic technique for resolving apparent contradictions in research findings. It translates results from different studies to a common metric and statistically explores relations between study characteristics and findings. A systematic review answers a defined research question by collecting all empirical evidences that fits to pre specified eligibility criteria. Meta-analysis is also called conducting research about previous research. It has the capacity to contrast results from different studies besides providing an estimate of unknown common truth. There is a common truth behind all studies having same concept, but which has been measured with a certain error within individual studies. The aim is to use approaches from statistics to derive an estimate closest to that common truth which is yet unknown based on how this error is perceived. All existing methods yield a weighted average from the results of the individual studies. Only difference exists in the manner of allocation of weight age and computation of uncertainty. Meta-analysis identifies patterns among study results, sources of disagreement among those results or other interesting relationships that may come to light in the context of multiple studies. Meta-analysis can only proceed if we are able to identify a common statistical measure that is shared among studies also termed as Effect size which has a standard error so that we can proceed with computing a weighted average of that common measure. Such weighting usually takes into consideration the sample sizes of the individual studies although it can also include other factors such as quality of the study. The main benefit of Meta-analysis is the aggregation of information that further leads to higher statistical power and stronger estimate that is not possible by any individual study. But while performing Meta-analysis, an investigator must make choices that can affect its results including review of related literature, making objectives, delimitation of the study, analysis and interpretation of data etc. Meta-analysis is often an important component of systematic review of related literature, but not always.

**Keywords:** Meta-analysis, Effect size, Weighted Average, Statistics, Variable, Significance

### Introduction

Educational research often produces contradictory results. Difference among studies, settings, measuring instruments and research methods make research findings difficult to compare. Meta-analysis is a collection of systematic technique for resolving apparent contradictions in research findings. It translates results from different studies to a common metric and statistically explores relations between study characteristics and findings. A systematic review answers a defined research question by collecting all empirical evidences that fits to pre specified eligibility criteria. Meta-analysis is also called conducting research about previous research. It has the capacity to contrast results from different studies besides providing an estimate of unknown common truth. There is a common truth behind all studies having same concept, but which has been measured with a certain error within individual studies. The aim is to use approaches from statistics to derive an estimate closest to that common truth which is yet unknown based on how this error is perceived. All existing methods yield a weighted average from the results of the individual studies. Only difference exists in the manner of allocation of weightage and computation of uncertainty. Meta-analysis identifies patterns among study results, sources of disagreement among those results

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or other interesting relationships that may come to light in the context of multiple studies. Meta-analysis can only proceed if we are able to identify a common statistical measure that is shared among studies also termed as Effect size which has a standard error so that we can proceed with computing a weighted average of that common measure. Such weighting usually takes into consideration the sample sizes of the individual studies although it can also include other factors such as quality of the study. The main benefit of Meta-analysis is the aggregation of information that further leads to higher statistical power and stronger estimate that is not possible by any individual study. But while performing Meta-analysis, an investigator must make choices that can affect its results including review of related literature, making objectives, delimitation of the study, analysis and interpretation of data etc. Meta-analysis is often an important component of systematic review of related literature, but not always.

### Historical Background of Meta-Analysis

The historical roots of meta-analysis can be found in 17th century studies of astronomy while one statistician Karl Pearson published a paper in the British Medical Journal in 1904 in which collected data from several studies of typhoid inoculation is seen for the first time. In the 1970s, more sophisticated analytical techniques were introduced in educational research starting with the work of Gene V. Glass, Frank L. Schmidt and John E. Hunter. He coined this word "Meat analysis". Meta-analysis refers to the analysis of analyses.

### Steps in Meta-Analysis

Meta-analysis typically follows the same steps as primary research:

1. A Meta analyst defines the review's purpose, Organizes frameworks that can be theoretical or practical questions of varying scope but clear enough to guide study selection and data collection.
2. Sample selection adopts specified procedure for locating studies. Typically meta analyses are comprehensive reviews of the full population of relevant studies.
3. Data are collected from studies by following two ways.
4. Study features are coded according to the objectives of the review and used as check on threats to validity.
5. Study outcomes are transformed to a common metric so that they can be compared. A common metric in educational research is the effect size, the standardized difference between treatment and control group means.
6. Finally, statistical procedures are used to investigate relations among study characteristics and findings.

### Approaches Used In Meta-Analysis

#### 1. Vote counting

Reviews generally categorize its findings as significantly positive, significantly negative or non-significant. The category which has most entries is considered as best representative of that particular research. But this approach is not exact or appropriate in all cases. This approach generally confuses treatment effect and sample size as statistical significance is a function of both. Conclusions from vote counting are generally misleading.

#### 2. Classic or Glassian Meta-analysis

Early Meta-analysis set the pattern conventionally such as Define questions to be examined, collect study features and outcomes. These types of Meta analyses share three distinguishing features:

- a. 'Classic' Meta-analysis applies liberal inclusion criteria. Glass argued that one should not disregard studies on the basis of study quality; a Meta-analysis itself can determine if study quality is related to variance in reported treatment effect.
- b. The unit of analysis is study finding. A single study can report many comparisons between groups and sub groups on different criteria. Effect sizes are calculated for each comparison.
- c. Meta analyst may average effects from different dependent variables, even when these measure different constructs.

This approach has proven robust when submitted to critical re-analysis. This is accessible to most educational researches. However, using study findings as unit of analysis produces non independent data and gives great weight to studies with comparisons. Averaging across construct including studies with obvious methodical flaws can confuse the reliability of findings.

#### 3. Study effect meta-analysis

This approach alters the Glassian form in two ways:

- a. Inclusion rules are more selective. Studies with serious methodical flaws are excluded.
- b. The study is the unit of analysis. One effect size is computed for each study which preserves the independence of data and gives equal weight to all included studies. But unfortunately it also reduces the number of data points analyzed in the review and reviewer's biases may operate in decisions to exclude studies.

#### 4. Tests of homogeneity

Homogeneity tests were developed to determine the likelihood that variance among effect sizes is due to sampling error only. If homogeneity statistic is significant for a group of studies, a procedure analogous to analysis of variance can be used. Studies are repeatedly divided into subgroups according to study features until within group variation is non-significant. Many factors can cause variation in effect sizes i.e. effect sizes, measurement unreliability, range restrictions, reporting errors, within study statistical adjustments, unreported factors etc. homogeneity tests are likely to indicate heterogeneity among effect sizes even when the variation is of no theoretical importance.

#### 5. Psychometric meta-analysis

Hunter and Schmidt's approach combines some of the best features of other approaches.

- a. All studies related to given topic are gathered regardless of quality.
- b. The distribution of effect sizes is corrected for sampling error, range restriction etc.
- c. If remaining variance is still large, effect sizes are grouped into subsets according to pre-selected study features and each sub set is Meta analyzed separately.

Unfortunately this technique requires substantial information from individual studies for accurate correction

of effect sizes which is not always available in research reports.

### Merits

A meta-analysis is a statistical overview of the results from one or more systematic review. Basically, it produces a weighted average of the included study results. It is a statistical approach to combine the results from multiple studies in an effort to increase power, improves estimates of size of the effect and to resolve uncertainty when reports seem disagree. Results of Meta-analysis can be generalized to a larger population. Besides this, it has several advantages:

- The precision and accuracy of estimates can be improved as more data is used. This, in turn, may increase the statistical power to detect an effect.
- Inconsistency of results across studies can be quantified and analyzed. Whether inconsistency arises from sampling error or from partial results or influenced by heterogeneity.
- Hypothesis testing can be applied on summary estimates.
- Moderators can be included to explain variation between studies.
- The presence of publication bias can be investigated.

### Demerits

Demerits of Meta-analysis is divided in to two categories:

1. It obscures important qualitative information by averaging simple numerical representations across studies.
2. Research is best reviewed by reflective expert who can shift insight from the confusing argumentation of a field.

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