Invited Review Article

Recent Research Trends in Meta-analysis

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SUMMARY

The use of meta-analysis (MA), which is placed on top of the evidence hierarchy, in studies has been increasing exponentially. MA has three effect size families. Using the category of effect size families, this paper introduces the important points in the MA process and highlights the recent research trends in this field, such as network MA, meta-analytic structural equation modeling, and diagnostic test accuracy MA. Several reporting standards were established for primary studies and MA. The critical assessment reviews demonstrated that the current quality of nursing MA reporting was low. The problematic areas of the current nursing MA include study search, study selection, risk of bias, publication bias, and additional analysis based on quality assessment. Directions for future research are also presented in this paper.

Introduction

The use of meta-analysis in studies has been increasing exponentially since the end of the 1970s. The rapid development of meta-analysis (MA) is also related to the increasing use of evidence-based practice approaches. To date, people are overwhelmed by the flood of information available, but these data vary in terms of directionality and quantity. For example, different studies show contradictory and varying effects of vitamin C on human health. Furthermore, most nurses and nursing researchers are not aware of every research finding. Therefore, MA is a valid method of finding evidences so that clinicians and researchers can have a theoretical basis in solving health-related issues.

MA refers to the statistical analysis of the synthesis of the quantitative studies' result. Additionally, MA is different from narrative review, vote counting, and other research review methods because it provides information on the directionality and magnitude of research findings. Effect size is the key concept in MA and an essential part of quantitative research reporting and other quantitative hypothesis testing [1]. Moreover, effect size is a quantitative index of research findings and is considered to be the dependent variable in the MA process, in contrast to the study characteristic, which is the independent variable.

The effect size is composed of three families, namely, d, r, and odds ratio (OR), and is related to research design in the primary studies. In the experimental design, d- and OR families are adequate indices for hypothesis testing and result interpretation, whereas correlation is a good index for the measure of association and relationship between variables. The nursing research MA can be categorized into three groups based on the effect size and research design (intervention, measure-of-association, and diagnostic test accuracy meta-analyses [DTA MA]) and into two groups based on the research characteristics (intervention and measure-of-association meta-analyses). Evans and Pearson explained the challenges encountered in nursing systematic review (SR) and MA [2]. The nursing MA mainly focuses on the effectiveness of intervention. However, appropriateness and feasibility are also important issues in health intervention. Randomized controlled trials (RCTs) only provide a portion of important evidences; therefore, nursing MA should answer other vital questions to gather all valid and relevant evidences together. The aforementioned three categories can be used to adequately examine the research trends in nursing MA. This paper will introduce the recent research trends and important issues on nursing MA based on these categories, as shown in Table 1.

Intervention effect MA: Direct comparison MA vs. network MA

Among the effect size families, intervention effect MA is the most closely related to mean difference and dichotomous outcome effect sizes. Thus, the Cochrane intervention handbook mainly deals with OR, risk ratio, and risk difference of the RCT research designs, in addition to the mean difference, without considering the measure-of-association studies. In 1976, Glass coined the term

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Table 1 *Effect Size Family and Meta-analysis Development Trends.*

Category	Effect size	Study design	Recent development
Intervention meta-analysis	D family	Unmatched groups, post-data only One group, pre–post Unmatched group, pre–post	Indirect comparison, MTC, network meta-analysis (transitivity, consistency)
	OR family	Unmatched groups, prospective Matched groups, prospective Unmatched groups, retrospective	
Measure-of-association meta-analysis	R	Correlation, regression, path analysis, SEM, HLM	Meta-analytic PA, CFA, SEM, HLM
Diagnostic test accuracy meta-analysis	Sensitivity Specificity	Test accuracy research	Bivariate and HSROC approach

MA to refer to the synthesis of the results of psychotherapy studies. The mean difference and OR between the experimental and control groups are the two families of effect size. The standardized mean difference (SMD) is used to represent the continuous variables, whereas the OR is utilized to indicate the dichotomous and categorical research results.

The research designs in experimental studies can be categorized into three groups based on the mean difference: unmatched-group post-data-only, unmatched-group pre–post data (standardized mean change difference effect size), and one-group pre–post data and matched-group designs. The unmatched-group post-data-only design is similar to the independent t-test. On the contrary, the one-group pre–post data design is closely related to the dependent t-test, whereas the unmatched-group pre–post data design is associated with the mean change difference effect size [3]. If a researcher uses the mean difference effect size, then one effect size as a main measure of MA should be chosen because synthesizing different research designs into one MA has its own pros and cons.

Researchers can choose one of the study designs for the problem formulation stages or inclusion criteria. Borenstein et al. suggest that the synthesis of different research designs has no technical barriers [4]. Therefore, three different research designs can be synthesized together in nursing research MA [5]. Furthermore, no technical barriers might be in the synthesis of dependent and independent t-test results together, but some arguments in the educational settings might be present. Hedges' g is applicable only in the correction of small sample bias, and a meta-analyst can use Hedges' g, instead of Cohen's d, in the three mean difference study designs.

Some information could be missing, such as correlation, in the one-group pre–post data and unmatched-group pre–post data effect size calculation. The problem is that almost every study will not report the correlation between pretest and posttest measures, because it is not considered to be a reporting value in regular studies. However, meta-analysts cannot calculate effect size without this information, which has to be imputed in some way [6].

The OR families are the most widely used study designs in the medical research areas. For dichotomous outcome, researchers can choose one of the OR, risk ratio, and risk difference based on the index stability and substantive meaning. OR and risk difference are the most frequently used and substantive indexes, respectively, in medical research. Similar to the mean difference, the OR families are composed of three research designs: unmatched group, prospective (controlled trials, cohort studies); matched groups, prospective (crossover trials, pre–post data designs); and unmatched group, retrospective (case–control studies). Researchers can choose one study design for the inclusion criteria or three studies simultaneously to analyze three research designs together. Generally, RCTs and non-RCTs are usually analyzed separately in medical research. However, researchers can synthesize these studies together to determine side effects or answer other important research questions. Medical researchers are increasingly paying

attention to network MA because the use of direct comparison has several limitations, such as insufficient availability of direct comparison research and discrepancies in the comparison of more than three interventions together. Nowadays, MA and network MA are on top of the evidence hierarchy [7]. Network MA requires special assumption and analysis methods, such as heterogeneity, transitivity, and consistencies. Furthermore, it is also applicable to social science research fields [8]. Additionally, network MA can be used to provide valuable information to patients, practitioners, and decision makers.

Measure-of-association MA: Correlation MA vs. meta-analytic structural equation modeling (SEM) approach

Measures of association are utilized in the studies of psychological issue and relationship between health clinicians and patients. The correlation in the measure-of-association analysis is highly similar to SMD in the intervention effect MA. Additionally, covariance has similar concepts to unstandardized mean difference. A correlation is considered to be a standardized covariance, and is defined as a direct measure of relationship between two variables. Furthermore, correlation can also be extended to simple and multiple regression, path and confirmatory factor analyses, and structural equation and hierarchical linear modeling. Therefore, primary studies using these methods are directly related to measure-of-association meta-analyses. Fisher's z-transformation is used, instead of correlation, when conducting measure-of-association MA. This method is very similar to log OR in dichotomous outcomes because of the data distributional assumption. The signs of the correlation coefficients are another factor that should be considered by researchers when synthesizing correlations between two constructs. Some researchers synthesize positive and negative relationships separately, whereas others synthesize these relationships together through careful consideration of the direction of relationships between variables [9,10]. Additionally, researchers should also consider the unidimensionality of the main outcome variable when conducting measure-of-association MA. For example, if a researcher wants to analyze the relationship between depression and other psychological variables as the main outcome variable, then only depression should be used as the main dependent variable, and depression and anxiety should not be synthesized as dependent variables together because of the presence of variabilities between them. If a researcher uses these two constructs simultaneously, then we cannot explicitly distinguish the relationship between depression and the other variable. The most important factor to consider when performing measure-of-association MA is the theoretical model. The measure-of-association MA is different from RCT and intervention effect studies. Researchers want to explain the relationship of variables based on theoretical or research model. Without a theoretical model, categorizing related variables and explaining the result of relationship adequately would be very difficult, similar to