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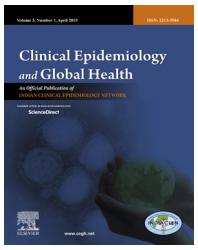

Original Article

Pooling of effect estimates obtained from various study designs in systematic reviews of public health interventions: A Bayesian approach to meta-analysis

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ABSTRACT

Background: Randomised controlled trials (RCTs) are gold standard in assessing the effectiveness of a clinical intervention because of their high internal validity. However, the same does not hold true for interventions conducted at the population level like public health interventions. Well-designed RCTs are not easy to conduct at population level. Similarly, well planned, high-quality non-RCTs or observational studies can complement RCTs. Because of this, several systematic reviews of public health interventions are assessed with other study designs, namely non-RCTs and observational studies. In such situations, studies of similar study design are pooled together to obtain an overall effect estimate. This is inevitable, because the principle of meta-analysis does not offer an opportunity for combining effect estimates coming from various study designs. If the meta-analysis performed for each study design provides contrasting results, then this introduces a quandary for the decision makers and public health policy makers to call for a decision.

Objective: The present study aims to integrate the results coming from a variety of study designs in order to obtain a single estimate of effect of intervention.

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Methodology: Bayesian approach to meta-analysis was used by formulating prior distribution from observational studies or non-RCTs and likelihood function from RCTs. Five systematic reviews of public health intervention were used to demonstrate the methodology.
Results/conclusions: By formulating prior distribution from observational studies, the posterior estimates were found to be different than that from the results of RCTs or other study designs. The posterior pooled-estimate was found to be precise and the width of the credible interval narrowed. Inclusion of the relevant observational studies (or non-RCTs) in the systematic review is a potential advantage for evaluating the effectiveness of public health intervention.

1. Introduction

Interventions, programmes and policies that aim at promoting health and preventing disease to a large number of individuals are defined as public health interventions.[1] These interventions are complex, context dependant and are assessed with a variety of study designs, ranging from observational studies to randomised controlled trials (RCTs). There has been increasing interest in the use of observational studies and non-randomised controlled trials (non-RCTs) in assessing the effectiveness of public health interventions.[2–4] The strength of observational studies in relation to RCTs has been an ongoing debate in the evaluation methodology of public health among experts.[5]

Observational studies along with RCTs are included in many of the public health systematic reviews of interventions and programmes.[6–10] For example, a systematic review that examined the effect of interventions that administered in the alcohol server setting for preventing injuries, included five before and after controlled studies, eight RCTs and ten non-randomised controlled trials (Non-RCTs).[9] Similarly, a systematic review that evaluated the effectiveness of interventions to promote smoke alarms at resident included 17 RCTs and nine non-RCTs.[10] In such situations, most of the systematic review authors have performed meta-analysis separately for each study design. This is true because the principle of meta-analysis does not offer an opportunity for combining effect estimates coming from various study designs.[11] Moreover, this results in several pooled effect estimates. What if the meta-analysis performed for each study design provides contrasting results? This introduces a quandary for the decision makers and public health policy makers to call for a decision.

Contrarily, there are a number of public health systematic reviews that have included only RCTs rather than observational studies (or Non-RCTs).[12–15] This provides only partial evidence in concluding the effectiveness of public health programmes and interventions. It is, therefore, very useful to think of how best we can make use of a wide range of evidences available for answering the public health interventions. In this paper, we propose a method based on Bayesian approach to get a single summary estimate by incorporating effect measures coming from a variety of study designs. The idea is to build a prior distribution using evidence from observational studies or non-RCTs and likelihood function from RCTs.

Several studies have appeared in the recent years documenting the use of Bayesian meta-analysis in the systematic reviews of clinical or drug trials.[16,17] But, to our knowledge, only one systematic review of clinical intervention was found, where prior distribution was formulated from observational studies,[18] and no study was ever found, where this methodology been applied in evidence consolidation of public health intervention. Because of the inclusion of several study designs in public health interventions, we felt the methodology to be of great importance for evidence consolidation.

2. Methodology

2.1. *Introduction to Bayesian meta-analysis*

The Bayesian meta-analysis assumes that both the parameters and the data are random variables that follow a distribution. This is the main difference between Bayesian meta-analysis and traditional meta-analysis. The prior distribution and likelihood function are essential to perform Bayesian meta-analysis. The likelihood function is defined as the likelihood of the data given the parameters, that is, the effect estimates obtained from different studies will form the likelihood function.[19] The prior belief that is built external to the observed data is considered to be the prior distribution. There are several ways of building a prior distribution, namely vague, sceptical, reference or subjective priors.[19] The posterior distribution is obtained, by multiplying the likelihood function and prior distribution.[20] The resulting posterior distribution is summarised by means of computing posterior estimates and credible intervals. For example, a 95% credible interval (CrI) for relative risk is that region in which we believe that the relative risk lies with probability 0.95. The results of Bayesian meta-analysis will be similar to that of results of traditional meta-analysis, when vague prior distributions are placed on the parameters. Bayesian met-analysis can be performed either by using Gaussian or exact binomial model. The analysis by Gaussian model can be performed for any outcome measure, as long as the effect size and its associated standard error are available from each study. Whereas, an analysis by the exact binomial model can be performed only when odds ratios are available from each study.[19] In the present study, we used