

The use of systematic reviews and meta-analyses in infection control and hospital epidemiology

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Systematic review is a type of research that attempts to identify and summarize all of the evidence related to a specific research question. It can be thought of as a "pause" in the process of conducting research in a particular area, in which the following questions are asked: Based on all of the available evidence, what do we know about this specific question so far, and what future studies should be conducted to clarify areas of uncertainty? The systematic review arose as an alternative to the traditional narrative review—which allows authors to pick and choose the studies they discuss and the depth at which they discuss them—a process prone to bias. By adhering to a prospectively defined protocol that specifies how studies should be identified, evaluated, and statistically combined (the statistical process is a component of systematic review and is called "meta-analysis"), systematic reviews reduce the bias inherent to traditional narrative reviews. Systematic reviews are an increasingly common form of published research, and several of the approximately 1000 such studies that are published annually focus on topics important to infection control professionals. Consequently, it is essential that infection control professionals and hospital epidemiologists be able to understand and evaluate the quality of this useful research design. This article discusses the essential elements of a systematic review, provides a framework for evaluating the quality of such an article, and will help the infection control professional and hospital epidemiologist in determining whether the results of such reviews should change clinical practice. (*Am J Infect Control* 2004;32:246-54.)

The number of systematic reviews and meta-analyses published in the medical literature has increased dramatically in recent years.^{1,2} Only 13 meta-analyses were indexed in Medline in the decade from 1970 to 1980 compared with 416 in just 3 years between 1993 and 1996.³ These articles identify and synthesize the evidence pertaining to a wide variety of topics in every

field of medicine, with infection control well represented among the roughly 1000 such articles now published annually.⁴⁻⁹ Concomitant with this growth, systematic reviews are playing increasing roles in clinical and health care policy decision making.^{10,11}

In traditional narrative reviews, authors pick and choose the studies they discuss and the depth at which they discuss them. Consciously or not, their biases and interests in the field affect how they present the findings of the individual studies.^{12,13} In contrast, systematic reviews adhere to a prospectively defined protocol for identifying and appraising evidence relevant to a focused clinical question (meta-analysis refers to a specific type of systematic review that includes formal quantitative techniques for synthesizing evidence¹⁴⁻¹⁶).

Systematic reviews cannot improve on the quality of the original research being reviewed ("Garbage in, garbage out," as they say). However, with the staggering pace at which clinical research now occurs, there is clearly a need for summarizing the current state of evidence addressing any given clinical question. When multiple studies of a particular practice yield inconclusive or conflicting results, one may choose which studies to believe based on convenience or personal preference (this, of course, is suboptimal). Alternatively, one can apply an explicit and reproducible methodology for characterizing the current state of

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evidence suggested by these studies, which is the purpose of systematic review.

PURPOSE

In this article, we describe the principles of systematic review and meta-analysis to provide readers with a framework for evaluating the quality and usefulness of these published reports. Although other articles also provide an overview of this topic,¹⁷⁻¹⁹ our primary focus is to provide infection control professionals (ICPs) and hospital epidemiologists with the tools to appraise critically systematic reviews. However, we also believe that both ICPs and hospital epidemiologists may find themselves in a position to conduct or collaborate on systematic reviews and thus provide valuable contributions to the literature by highlighting practices with sufficient evidence to warrant widespread implementation.^{4,8,20} For those interested in conducting a systematic review, this article also serves as an introduction to the key steps of this research design, providing a framework that can be supplemented with the provided references.

GUIDELINES

Systematic reviews are research projects that involve structured data collection and analysis, and, as with clinical trials or laboratory investigations, departures from accepted methodologies produce results of varying quality.²¹⁻²⁴ Recently, experts in the area of systematic review and meta-analysis convened a conference and published a report entitled *Quality of Reporting of Meta-Analyses (QUORUM)*,²⁵ which detailed the essential elements of a high-quality meta-analysis when conducted as part of a systematic review. The QUORUM statement resembles the *Consolidated Standards of Reporting Trials (CONSORT)* statement,²⁶ which outlines recommended steps for conducting and reporting randomized controlled trials. Both statements follow an evidence-based methodology and provide empirical evidence (when available) showing why specific steps should be followed.^{25,26} Of note, the QUORUM statement and this review specifically refer to systematic reviews and meta-analyses of randomized controlled trials. Systematic reviews and meta-analyses of observational studies are more complicated and involve steps and assumptions that are beyond the scope of this review but are detailed elsewhere.²⁷

ELEMENTS OF A SYSTEMATIC REVIEW

The goal of this "Current Methodological Concepts" article is to provide the ICP and hospital epidemiologist with an overview of the essential elements of a systematic review to assist in the evaluation of these studies (Table 1). Using examples from the infection control and hospital epidemiology literature, we will

highlight how each element contributes to the overall quality of this research design.

Step 1: Research question

As with all scientific research, a systematic review begins with a clearly defined and focused research question. Questions that are too broad in scope may not be feasible, and questions that are too narrow may not be clinically relevant. For example, a meta-analysis of "the best way to prevent nosocomial infection" would involve too many different treatments, diseases, and outcomes to permit performance of a systematic review within an acceptable timeframe (By the time such a tome was produced, its findings would almost certainly be years out of date!). A question more conducive to systemic review would be the following: "Which interventions have been shown to prevent catheter-related bloodstream infections?"²⁸ Another, more focused, question would be "Do antiseptic catheters prevent catheter-related bloodstream infections?"⁸ Regardless of the breadth of the question, some authorities suggest that every research question should meet the "FINER" criteria: Feasible, Interesting, Novel, Ethical, and Relevant.²⁹ Usually the best systematic reviews and meta-analyses are conducted by teams that include investigators with both methodologic and content expertise.

Step 2: Protocol

Prospective development of and adherence to an explicit protocol in a systematic review limits bias by preventing investigators from changing aspects of the research to produce a desired or anticipated result. For example, an investigator may find that more recent studies report positive results, whereas larger, older studies have mixed results. The investigator may then decide to restrict the review to more recent studies, because of a preexisting belief that the intervention is effective. Decisions about study inclusion and exclusion criteria should reflect intrinsic methodologic considerations, not the results of the studies themselves. For instance, excluding older studies requires justification on the grounds that the technology in question (or other relevant aspects of medical care) have changed so dramatically that the results of such studies are no longer relevant regardless of their results.

Step 3: Search

The ultimate goal of a systematic review is to evaluate all prior evidence that relates to the research question, as specified in the protocol. If important studies are missed, the summary estimate may be inaccurate. For example, limiting the search to English language articles has been shown to affect the results of systematic reviews.³⁰ Similarly, not including unpublished studies

Table 1. Eight steps in conducting a systematic review and meta-analysis

Step	Goal	Pitfalls
1. Research question	Clearly define and focus the research question, eg, what is the effectiveness of intervention X in reducing complication Y?	Questions that are too broad may not be feasible or may include studies that are heterogeneous.
2. Protocol	Prospectively develop and adhere to a comprehensive review methodology	Developing or modifying the protocol after detailed review of the studies may introduce bias depending on reviewers' prior beliefs about the evidence.
3. Search	Combine comprehensive searching of bibliographic databases, with scanning reference lists in identified articles and contact with experts in the field	Negative studies are more likely to be missed (because of publication bias). Non-English language studies may be more difficult to find.
4. Study selection (inclusion/exclusion)	Include only high-quality studies that specifically address the research question	Most systematic reviews include all randomized controlled trials that address a topic and evaluate study quality at later stages in the process.
5. Quality assessment	Determine the quality of the included studies, which may allow a sensitivity analysis that excludes lower quality studies	Although quality rating makes intuitive sense, there is no consensus on the best scale; use of different scales may actually affect the overall results of any given meta-analysis.
6. Data abstraction	Multiple reviewers abstract essential data to ensure accuracy; one reviewer may be blinded to authors, date, journal, and title to limit bias in abstraction	A truly "blind" abstraction process, when one reviewer is blinded to the results while abstracting the methods, is cumbersome and has not been shown to affect results of systematic reviews.
7. Analysis	Statistically combine the point estimates of individual studies, giving more weight to studies with low variance	"Garbage in, garbage out"—a combination of low-quality studies may not be valid. Combinations of studies may reveal heterogeneity, suggesting some major difference in the methods, populations, or measures in the included studies. Publication bias should be assessed, and relevant sensitivity analyses should be presented.
8. Interpretation	Put the systematic review into context of clinical practice	The summary estimate should not be overemphasized. Limitations in the data should be explored. What future studies are indicated?

can lead to an overestimation of the effect of an intervention in that studies with positive findings (positive studies) are published more often than studies with negative findings (negative studies; see section on publication bias below).^{31,32}

A complete search generally includes all of the items listed in Table 2. Most searches begin with a computerized search of several electronic databases, such as MEDLINE, EMBASE, CINAHL, Current Contents, and Pre-Medline. Other databases are available and are often more relevant to certain topics (eg, CancerLit for cancer-related topics). MEDLINE is an online bibliographic database created by the US National Library of Medicine (NLM) and now contains more than 11 million references and abstracts published since 1965. As with the Internet in general (eg, Yahoo!, Google, etc), multiple interfaces are available and differ in terms of their appearance and functionality, but they search the same target content. In the case of MEDLINE, NLM has provided free public access to MEDLINE through PubMed since 1997 (available at <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi>). Despite being free, PubMed is a very powerful search engine. The only advantage offered by some of the proprietary interfaces is in terms of access to full text articles of the citations

retrieved by searches. CINAHL (Cumulative Index to Nursing and Allied Health Literature) covers Nursing and allied health literature and information from 1982 to the present, and includes journal articles, books, dissertations, and reports. (www.cinahl.com). EMBASE, for Excerpta Medica database, is produced by Reed Elsevier (Netherlands) and is the European equivalent of MEDLINE. Unless the topic of a systematic review is likely to have a substantial non-English language literature, it is unlikely that searching EMBASE in addition to MEDLINE will be necessary. (www.embase.com). BIOSIS is the organization that first produced *Biological Abstracts* and now produces a number of electronic bibliographic databases, including BIOSIS Previews, which references journals, books, meeting abstracts and patents in the life sciences. The main reason to search this database is the coverage of over 1,500 conferences and their associated abstracts. Since small or negative studies have a better chance of appearing in abstract form than in peer review publications, searching conference proceedings through BIOSIS provides some ability to overcome the effects of publication bias. In some cases, conference abstracts will contain sufficient information to include a study in a systematic review. In other cases, contact with

Table 2. Sources to identify studies for systematic reviews

Database searches
MEDLINE, CINAHL, EMBASE, PsychLit, CancerLit, BIOSIS, PubMed
Reference lists of retrieved articles
Manual searching of related journals, conference proceedings, books
Study registries
Device manufacturers and pharmaceutical companies
Experts in the field
Corresponding or first authors of published studies identified for the systematic review

the listed authors may be required. (www.biosis.org). ClinicalTrials.gov is available from the NLM via PubMed (in the left hand column of the main search page at <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi>) and provides access to descriptions of over 7600 clinical studies sponsored by the National Institutes of Health, other Federal agencies, and pharmaceutical companies. Studies listed in the database are conducted primarily in the United States and Canada, but include locations in approximately 80 countries (www.clinicaltrials.gov).

Specialized search strategies developed with experts in searching databases (eg, a research librarian at a medical school's library) are more likely to identify all relevant articles.^{33,34} A recent article in this series summarizes the steps for ensuring a comprehensive search of a computerized database.³⁵ Once the studies from the computerized databases are retrieved, the reference lists from these articles provide an excellent source to identify additional potentially relevant studies.

Identifying unpublished studies presents difficulties, but it is extremely important to avoid the distorting effects of publication bias. Because negative studies are less likely to be published than positive ones, literature syntheses restricted to the published literature may indicate positive results when the true effect is negative. Publication bias will not usually reverse the inferences from metaanalytic results,³⁶ although striking exceptions have occurred. For example, a meta-analysis examining the effect of magnesium in preventing death from acute myocardial infarction concluded that the drug was beneficial.³⁷ However, a later, large randomized controlled trial found that magnesium had no benefit,³⁸ and the discrepancy may have been due to the fact that the original meta-analysis was strongly affected by publication bias.

The ideal way to identify unpublished studies is to contact experts in the field who have conducted studies in the area under investigation and device manufacturers or pharmaceutical companies that have studied or tested the intervention under review. When this method is pursued assiduously, substantial unpublished evidence may be uncovered. For example, in an

analysis of original research on the health effects of passive smoke, investigators identified 14 unpublished studies from a total of 61 studies.³⁹ Median time to publication was 5 years for statistically nonsignificant studies and 3 years for statistically significant studies. Because of this time lag in publication of negative studies, abstracts published in conference proceedings provide an excellent source for studies not yet published in peer-reviewed journals. In fact, a review of the ophthalmology literature revealed that only approximately 50% of all abstracts went on to full publication.⁴⁰ Thus, searching abstracts could substantially expand the yield of searching peer-reviewed journals, and the results of such searches are likely to contain studies with smaller sample sizes or non-significant results.⁴⁰

Most systematic reviews and meta-analyses assessing the safety and efficacy of interventions rely on only the highest quality evidence: the randomized controlled trial. This greatly simplifies the process because all other types of study designs can be excluded. Furthermore, several groups, including the Cochrane Collaboration (www.cochrane.org), have developed databases of randomized controlled trials and are, therefore, invaluable resources for identifying studies, especially ones from lower profile and non-English language journals.⁴¹

Step 4: Study selection

Once the search is completed and all potentially relevant articles are identified, the investigators must determine which studies are relevant and suitable for inclusion in the systematic review. As noted before, it is crucial that the criteria for study selection be determined ahead of time to the extent possible, so investigators cannot, for example, decide to exclude certain types of studies that do not show a positive result. The specific inclusion criteria will depend on the study question. Take, for example, the following study question: "Does intranasal mupirocin reduce the incidence of postoperative *Staphylococcus aureus* bacteremia?" The inclusion criteria for a systematic review will likely include the following: studies evaluating the use of intranasal mupirocin (perhaps specifying a specific regimen) that enrolled surgical patients and evaluated both those in the intervention and those in the control group for evidence of *S aureus* bacteremia (based on positive blood cultures). If enough trials are available so that statistical pooling becomes appropriate (at least 3 studies), then the investigators can consider performing a meta-analysis, thereby providing readers with a quantitative estimate of how much mupirocin reduces (or increases) the risk of *S aureus* bacteremia.

In general, systematic reviews should have relatively broad inclusion criteria and, thus, should examine all

evidence related to a specific topic. All exclusion criteria should be carefully examined to determine whether they might preferentially exclude either positive or negative studies, thereby introducing bias into the results. Rather than have extensive exclusion criteria, investigators often choose to perform sensitivity or subgroup analyses (best to specify these analyses a priori) to examine more specific questions related to a topic. For example, when evaluating the effect of a silver-coated catheter to prevent catheter-related urinary tract infection, the investigators specified a priori that they were going to examine the overall effect of the silver catheters and then stratify the results by gender in that the benefit in women was theorized to be different than in men.²⁰

Step 5: Quality assessment

The first Table in most systematic reviews reports key features of the included studies (eg, study year and setting, numbers of patients, and major design elements, such as the method of randomization), analogous to the “Table 1” in clinical trials listing key characteristics of enrolled patients. This Table allows readers to determine whether the conclusions and the summary estimate are strongly supported by high-quality data or merely speculative based on studies of limited quality.

Some systematic reviews formally rate the quality of each included study (instead of simply reporting some key elements of study design). Because studies with both poor quality and negative results are particularly unlikely to be published, one might expect positive results to be overrepresented among poor quality studies. A study examining the efficacy of selective digestive tract decontamination and the risk of ventilator-associated pneumonia bore out this expectation, demonstrating an inverse association between quality score and efficacy of the intervention.⁴²

Many scales for evaluating the quality of randomized controlled trials exist.⁴³ One study evaluated 17 meta-analyses and excluded “low quality” studies based on the ratings from 25 different scales. In several cases, the use of different scales to exclude the “low quality” studies actually reversed the conclusions of the meta-analysis.⁴⁴ Thus, some authorities recommend that quality scales be developed specifically for use in a particular meta-analysis, taking into account quality elements that are most relevant to the question of interest.¹⁶ For instance, in reviewing studies of strategies for preventing ventilator-associated pneumonia (VAP), details of randomization might be less important than details regarding outcome assessment: the definition of VAP used, who applied it, and were they blinded to study group? Unfortunately, there is no accepted “gold standard” scale for measuring study

quality. Therefore, the most conservative way to assess the impact of the quality of the included studies on the overall results of a meta-analysis is to conduct sensitivity analyses, observing whether the results of the meta-analysis change when the lowest quality studies are excluded. If the findings are unchanged, then the overall results are more robust; if however, the overall findings change significantly with exclusion of low-quality studies, this prompts a consideration of what aspect of the low-quality studies led to the different result.

Step 6: Data abstraction

Precise and complete data abstraction is an essential element of systematic reviews. Once the important elements of each study are abstracted onto a standardized form (eg, study date, intervention, sample size, outcome in each group, side effects), the investigators then rarely have to return to the full article. Focusing on the 1 or 2 page abstract form becomes much less cumbersome compared with reviewing the full article every time a study-specific question arises. High-quality reviews usually specify that at least 2 separate individuals abstracted data and compared results to ensure consistency. Some have suggested that 1 of the reviewers be blinded to the date, title, journal, authors, and year of publication of all studies. However, this “blinding” of 1 reviewer can be cumbersome and has not been proven to have any effect on the results of published studies.⁴⁵

Step 7: Data analysis

The data analysis section of a systematic review involves 3 main components: generating a summary estimate, assessing heterogeneity, and assessing publication bias.

Generating a summary estimate. One of the most useful aspects of a systematic review is the summary Table of all included studies. This Table generally displays each of the studies, indicating important features of the study, such as date, number of participants, setting, exact intervention, exact outcome, and study quality (often the same elements abstracted). Ideally, the reader can quickly scan the summary Table and be able to examine the features and results of the individual studies, thereby forming an impression of what the summary estimate of the research will likely be. If the studies all used similar high-quality methods, and all indicate a relatively consistent result, then the evidence is relatively clear. On the other hand, if the individual studies are of suboptimal quality, use differing methods, or reveal variable effects in the outcome measure, the statistical analysis is likely to mirror this intuitive assessment by

demonstrating uncertainty in the summary measure or significant heterogeneity between studies.

The process of generating a summary estimate begins with identifying a summary measure of effect from each included study. The individual study estimates are then combined in a process that gives greater weight to the studies with lower variance in the outcome measure. Lower variance in a study's summary estimate is almost always a function of sample size: Larger studies have lower variance. Two different types of models can be used to generate summary measures: a fixed effects model and a random effects model. The fixed effects model assumes that the identified studies include all possible studies on a given topic and, therefore, simply generates a weighted summary effect. The random effects model assumes that the identified studies represent a sample of all possible studies and, therefore, makes a conservative adjustment to the summary measure that takes into account the variability in summary measures between studies. When there is a large amount of variability between the study-specific estimates, the random effects model generates much wider confidence intervals for the overall summary measure than what would be seen if using a fixed effects model. When there is little variability in the summary measures from individual studies, the fixed effects and random effects models generate similar overall results. Neither model is "correct"; each reflects a different interpretation of how studies should be combined. Because the random effects model is generally more conservative (ie, provides wider confidence intervals around the estimate effect), it is often preferred by journal editors.

Assessing heterogeneity. Tests for heterogeneity assess the degree of variability in the summary measures between the included studies. If the summary measures from each study are very different, then statistical tests of heterogeneity will generally be positive. When the authors report that "statistical tests of heterogeneity were positive," it indicates that the results of the studies were not consistent. As noted above, this may be evident from a simple visual review of the data presented in the Table summarizing all of the included studies. The presence of heterogeneity often indicates that the studies used some different methodology (different patient populations, interventions, methods of outcome assessment, blinding, length of follow-up, and others). When significant heterogeneity is present, authors should attempt to determine and explain why the heterogeneity was found.⁴⁶ Heterogeneity should not necessarily always be viewed as a negative aspect of a systematic review. It may simply alert the investigators to different aspects of the intervention or study designs that have the potential to affect the results. For example, when exploring the effect of

silver-coated urinary catheter in preventing catheter-related urinary tract infection, Saint et al found significant heterogeneity in their results.²⁰ After stratifying by the type of silver catheter—alloy versus oxide—they could explain most of the heterogeneity in their results. Indeed, their findings that silver alloy catheters appeared effective, whereas silver oxide catheters did not, was potentially useful to decision makers.

Assessing publication bias. Publication bias exists when there is preferential publication of positive versus negative studies. If a systematic review includes only published studies and publication bias exists for that specific research question, then the review may inappropriately conclude that an intervention is effective. Several different statistical techniques have been developed to assess for publication bias, and a high-quality systematic review should include at least 1 measure of this bias.^{36,47,48} A funnel plot is perhaps the most intuitive method for assessing publication bias. The technique involves plotting studies on a graph of study size (y-axis) versus magnitude of effect (x-axis). If publication does not exist, the plot should reveal that the largest studies (with the most precision) cluster around the midpoint or "top" of the funnel; an equal number of smaller studies should be present on both sides of the funnel (in that smaller studies should randomly overestimate and underestimate the true effect). If the funnel plot shows a "hole" in the lower left-hand corner—indicating that smaller studies showing no effect or negative effects are absent—this suggests that publication bias may exist. A summary measure would thus overestimate the true treatment effect (Figures 1 and 2).

Although funnel plots are somewhat intuitive and easy to construct, recent work has questioned the interpretation of these plots.⁴⁹ Other methods model the effects of publication bias with probability functions that predict publication on the basis of the magnitude of the effect size and the *P* value. Some methods (eg, trim-and-fill techniques) even supply estimates of the results of unpublished studies. Although these more sophisticated techniques have their strengths, they also have limitations.^{36,47,48} The bottom line, therefore, is that prevention is the best medicine, ie, better to avoid publication bias as much as possible by searching for unpublished material as part of the systematic review than to rely on statistical methods to deal with an incomplete search.⁵⁰

Step 8: Interpretation

A systematic review or meta-analysis usually provides a concise "bottom-line" message for readers. For example, a systematic review of selective decontami-

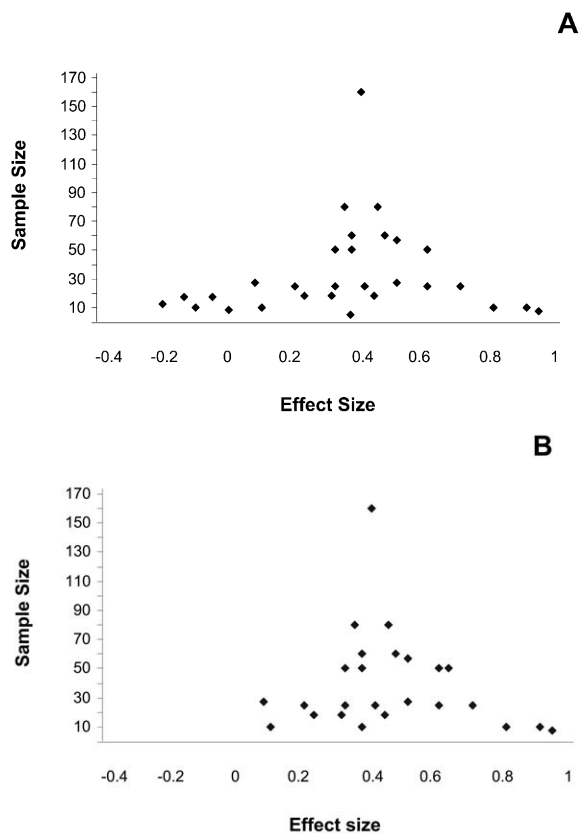


Fig 1. A, The expected random distribution of study estimates of effect (effect sizes-x-axis); study size is shown on the y-axis, with larger studies clustering around the center or “funnel” of the plot, which is believed to be the true estimate of effect. Smaller studies are equally likely to overestimate and underestimate the true effect. **B,** publication bias is present. There is a “hole” in the left lower corner of the graph, suggesting that the small negative studies were not published.

nation of the digestive tract (SDD) to prevent VAP may conclude that use of SDD does indeed appear to prevent VAP based on evidence from several randomized trials. However, this is not all that the reader or health care decision maker requires when deciding whether or not to use this strategy for infection prevention in his or her hospital. Thus, the investigators performing the systematic review or meta-analysis should also strive to position the results of their study into a larger context. Ideally, they should help the readers interpret the findings and provide guidance as to whether or not additional factors should be considered prior to translating the results into clinical practice. Using the example of SDD, one important issue that those conducting a systematic review would likely highlight is the fear that wide-

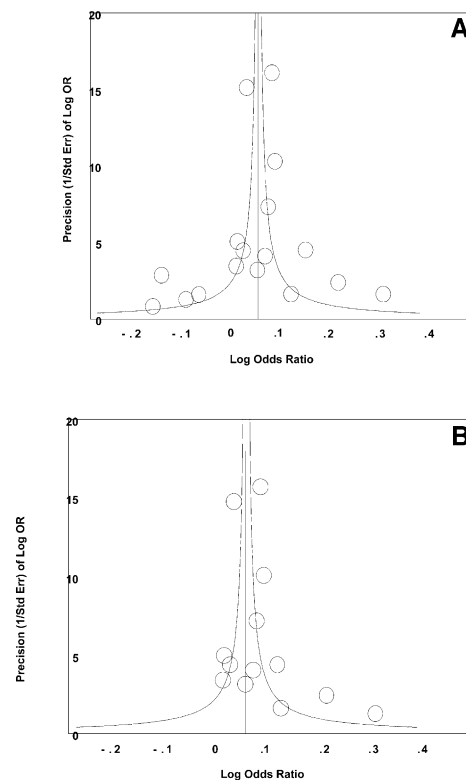


Fig 2. Studies with dichotomous outcomes, in which the outcome is expressed as the log odds ratio (rather than as a continuous variable). When no publication bias is present (**A**), the distribution of odds ratios clusters around the center of the funnel with smaller studies equally distributed on both sides. When publication bias is present (**B**) studies with lower odds ratios are “missing” from the left lower corner.

spread use of SDD would promote antimicrobial resistance. A systematic review may therefore conclude that, although SDD is likely to prevent VAP, perhaps it should not be used routinely for fear of increasing the incidence of infections caused by antimicrobial-resistant pathogens.

Another important aspect usually alluded to in a systematic review of a new technology is the incremental cost associated with the new intervention. The systematic review or meta-analysis is very useful in clarifying the relative efficacy of a new intervention, such as an antiseptic-coated vascular catheter to prevent catheter-related bloodstream infection.⁸ A systematic review, however, usually does not provide the detailed economic information that a formal cost-effectiveness study would. Decision makers within health care, in general, and infection control, in particular, are increasingly requiring a formal economic

evaluation prior to initiating new interventions. The estimates of effectiveness provided by a meta-analysis are usually necessary when a formal cost-effectiveness analysis is performed.⁵¹ In fact, a previous article in this series describes how estimates of efficacy derived from a meta-analysis can be incorporated into a formal economic evaluation of an infection control intervention.⁵² Indeed, several examples within infection control exist of how economic evaluations of a new intervention often follow meta-analyses of those same interventions.^{8,53}

CONCLUSION

Systematic reviews are becoming a common source of information to help clinicians decide how best to care for their patients. Meta-analysis, a specific type of systematic review, has been referred to as “a quantitative approach for systematically combining the results of previous research in order to arrive at conclusions about the body of research.”⁵⁴

Like any research method, systematic reviews and meta-analyses have both strengths and drawbacks.⁵⁵⁻⁵⁹ Strengths of these techniques include the following: (1) the ability to summarize an enormous amount of data to provide decision makers with relatively concise “bottom-line” estimates of effectiveness, (2) reduction of bias compared with the traditional narrative review article, and (3) the ability to provide possible explanations of disparate results of existing trials. Limitations of a systematic review or meta-analysis include the following: (1) the possible introduction of bias during selection of studies, eg, limiting to English language³⁰ or published studies^{31,32,60}; (2) pooling several studies despite the finding that the marked heterogeneity of the individual studies likely invalidates such statistical pooling⁴⁶; and (3) focusing exclusively on the summary estimate of effect even though the quality of pooled studies may be so poor that the overall limited quality of evidence warrants high-quality additional individual studies rather than any purportedly definitive summary of the evidence.⁶¹

Despite some limitations, systematic reviews and meta-analyses are now reasonably well accepted as techniques that further medical knowledge and provide information useful to decision makers. Infection control professionals and hospital epidemiologists will increasingly be required to interpret the results of both systematic reviews and meta-analyses to help administrators at their health care systems decide how best to enhance patient safety. We hope that this brief overview provides the readers of *American Journal of Infection Control* with a place to begin in order to become savvier users of the medical literature. For those of you seeking additional reading, several recent journal articles and books on this subject provide

lengthier discussions of these important methods.^{2,12,15,16,25,27,44,50,54,62,63}

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