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REVIEW ARTICLE

A systematic review identified few methods and strategies describing when and how to update systematic reviews

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Abstract

Objective: Systematic reviews (SRs) are convenient summaries of evidence for health care practitioners. They form a basis for clinical practice guidelines and suggest directions for new research. SRs are most helpful if they are current; however, most of them are not being updated. This SR summarizes strategies and methods describing when and how to update SRs.

Study Design and Setting: We searched MEDLINE (1966 to December 2005), PsycINFO, the Cochrane Methodology Register, and the 2005 Cochrane Colloquium proceedings to identify records describing when and how to update SRs in health care.

Results: Four updating strategies, one technique, and two statistical methods were identified. Three strategies addressed steps for updating, and one strategy presented a model for assessing the need to update. One technique discussed the use of the ''entry date'' field in bibliographic searching. The statistical methods were cumulative meta-analysis and a test for detecting outdated meta-analyses with statistically nonsignificant results.

Conclusion: Little research has been conducted on when and how to update SRs in contrast to other methodological areas of conducting SRs (e.g., publication bias, variance imputation). The feasibility and efficiency of the identified approaches is uncertain. More research is needed to develop pragmatic and efficient methodologies for updating SRs.

Keywords: Systematic reviews; Updating; Cumulative meta-analysis; Strategy; Methods; Techniques

1. Introduction

A systematic review (SR) is a form of convenient synthesis of evidence for the busy health care practitioner. SRs are increasingly gaining acceptance as a starting point in the development of evidence-based clinical practice guidelines (CPGs) [1,2], and in the design and ethical guidance of primary research [3]. Governments and other groups are investing heavily in commissioning and using the results of SRs to inform health care practice and policy [4]. Recent estimates suggest that approximately 2,500 new SRs are published annually [5].

SRs are most useful if they are up to date [4,6]. As science evolves with the accumulation of new research and publications, health care interventions previously considered to be effective and safe may in future be shown to be ineffective or harmful, or vice versa [7]. There may also be subtle changes in interventions over time (e.g., changes in dosing of medications, improved surgical skills). As well, new interventions or health outcomes will emerge [8]. Ignoring these changes could undermine the validity of SRs and CPGs. Updating SRs can also be useful in the identification and incorporation of delayed publications or gray literature, allowing to minimize the impact of publication bias (or time lag bias) on results of SRs [9–11].

Organizations such as the Cochrane Collaboration update SRs routinely. In contrast, non-Cochrane SRs, which account for about 80% of all published reviews [5], are not usually updated. Within 2 years of their publication,

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only 3% of SRs published in peer-reviewed journals had been updated compared to 38% of those published by Cochrane groups [5,12].

Another problem related to updating SRs is the lack of a definition of what an update is, leading to inconsistent conceptualization of this process and rendering surveys of updating practices noncomparable. In a recent commentary, we (D.M. and A.T.) elucidated the concepts and definitions regarding updating SRs [13]. We defined the updating process as "a discrete event aiming to search for and identify new evidence to incorporate into a previously completed systematic review." Thus, corrections or re-analysis of a previous assembly of evidence without a search for new evidence would not be an update, whereas extending a search to new sources or an exhaustive but fruitless search for new evidence would still be considered an update.

Although updating an SR may yield important additional information, this process can be as costly and time consuming as conducting the original review or developing the original CPG [6,8]. Whether it is appropriate to expend resources for updating depends on many factors such as the rapidity and scope of scientific developments, the nature of the health condition, and public health importance. To bring some clarity to this topic and to highlight gaps in the evidence, an SR of methods, techniques, or strategies describing when and/or how to update SRs was conducted.

2. Methods

2.1. Search strategy

MEDLINE (1966 to December 2005), PsycINFO (1955 to June, Week 1, 2005), and the Cochrane Methodology Register (CMR) (Cochrane Library Issue 1, 2006) were searched using the Ovid interface. The complete MEDLINE search strategy is available (see Appendix on the journal's website at www.elsevier.com). It was appropriately modified when searching the other databases.

Additionally, 54 updated SRs identified from a cross-sectional sample of 297 SRs indexed in MEDLINE (November 2004) were obtained and screened for descriptions of updating methods, techniques, or strategies.

The reference lists of potentially relevant reports were scanned. The proceedings of the 13th Cochrane Colloquium (August 2005) were hand-searched to identify relevant reports not yet indexed in the CMR. The authors of relevant reports were contacted for further information.

All the searches were conducted by one experienced information specialist (M.S.). The searches were not restricted by language, publication type, or study design.

2.2. Eligibility criteria

A record was included if it represented (1) a report (descriptive or empirical) describing the development, use, and/or comparison of one or more methods, techniques, or strategies for updating and/or determining the need for updating SRs in health care or (2) an updated SR, commentary, editorial, or other short report describing or suggesting one or more methods, techniques, or strategies for updating SRs.

Records regarding updating methods for CPGs were retained for discussion purposes because guideline updating may involve updating evidence from SRs. Guideline updating was not the a priori focus of this review.

2.3. Screening

Three investigators (A.T., A.C.T., and M.S.) independently screened titles, abstracts, and full-text reports of all the retrieved bibliographic records. An initial screening of titles and abstracts excluded records that were obviously not relevant. Afterward, full-text reports of the remaining potentially eligible records and the 54 updated SRs indexed in MEDLINE (November 2004) were comprehensively examined. Disagreements were resolved by discussions.

2.4. Data abstraction

Two investigators (A.T. and A.C.T.) independently abstracted detailed information using a prespecified 15-item data extraction form. The abstracted data included author's name, country, year, type of report, form of publication, and area of health care. Descriptive information (e.g., "when" and "how" aspects, underlying assumptions, feasibility, comprehensiveness), the applicability (i.e., whether the method or strategy is applicable to updating only meta-analyses or SRs in general), strengths, and limitations of each updating approach included in the review were ascertained. The strengths and limitations were ascertained and extracted directly from the reports, and they also were determined through consensus-based judgment reached by the review authors. Disagreements regarding the extracted data were resolved by discussions.

Approaches for updating SRs were grouped as strategies, techniques, and statistical methods. The identified statistical methods, techniques, and strategies were compared descriptively in terms of "when" and "how" to update, comprehensiveness (e.g., clinical, statistical, or other domains), strengths, and limitations.

3. Results

A total of 2,548 records (titles and abstracts) were initially screened. Of these, full-text reports of 221 records were reviewed and 15 articles met the inclusion criteria [11,14–27]. None of the 54 updated SRs, identified from the cross-sectional sample of SRs, reported a description of an updating method, technique, or strategy. The screening process is summarized in the study flow chart (Fig. 1). The 15 articles included in the review reported four

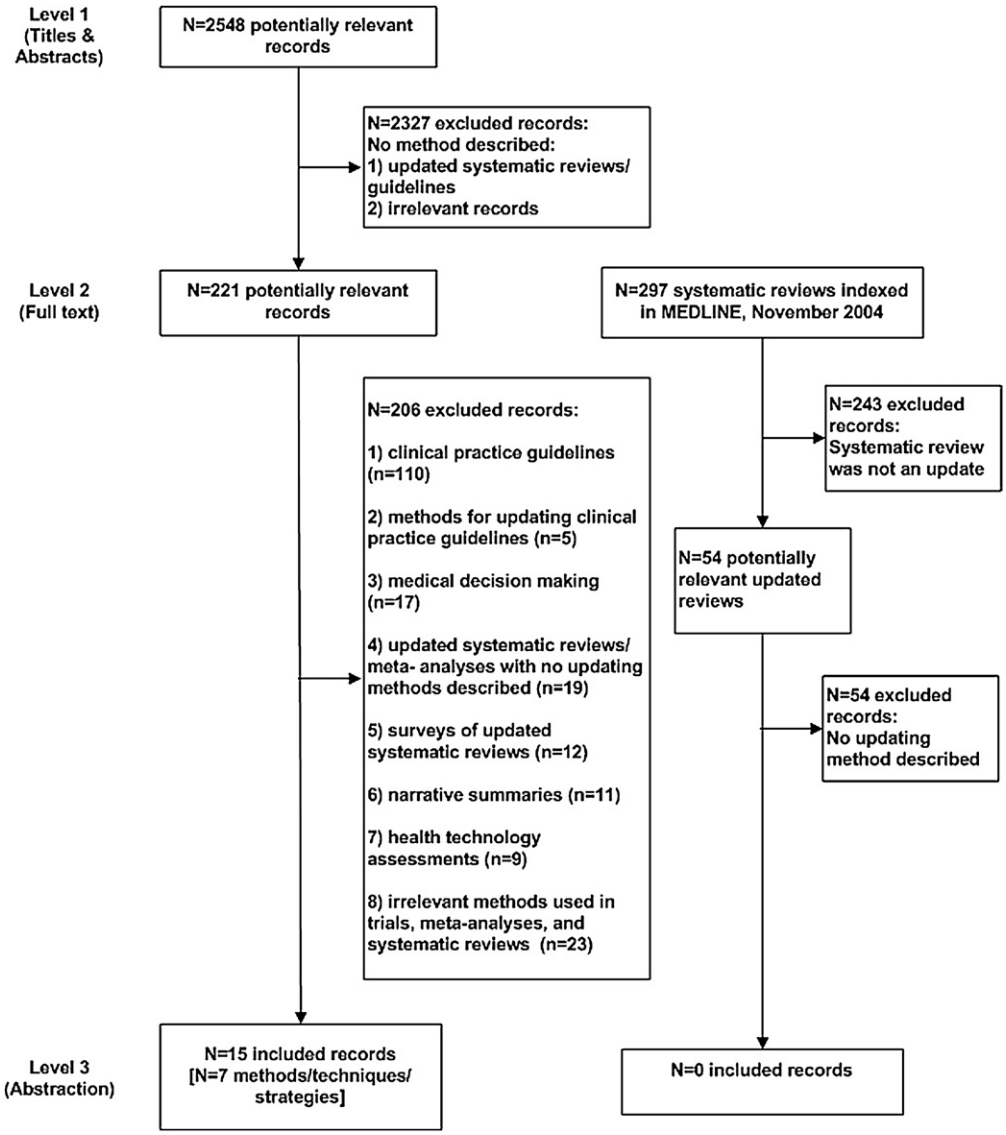

Fig. 1. Flow diagram of records, citations, and articles throughout the review process.

strategies [14–18], one technique [19], and two statistical methods [11,20–27] describing when and/or how to update SRs (Tables 1 and 2).

The four updating strategies were (1) steps in maintaining an updated review [14], (2) maintaining an updated review [15,16], (3) assessment of the need to update [17], and (4) strategies for updating a review [18]. One technique described the use of the ''entry date'' field when updating a review [19]. One of the four strategies was published in a peer-reviewed journal [14], two strategies were Internet documents [15,16,18], one strategy [17] and the technique [19] were reported as conference abstracts. The two statistical methods were as follows: (1) test for identifying ''null'' meta-analyses that are ripe for updating [20] and (2) cumulative meta-analysis (CMA) [21–24] (with methodological extensions: using the cumulative slope [25], sequential monitoring boundaries [26], and recursive CMA [11,27]). Both statistical methods were published in peer-reviewed journals.

Although the objective of the present SR was to summarize evidence of updating methods directly applicable to SRs, the search identified five updating methods for CPGs (Table 3) [8,28–31]. The updating of SRs and the updating of CPGs are closely related because the development of the latter often relies on scientific evidence collected and summarized in an SR.

4. Strategies for updating SRs

4.1. Steps in maintaining an updated review

Chalmers et al. described the process of maintaining updated SRs of randomized controlled trials evaluating the

Table 1
Strategies and techniques for updating systematic reviews—characteristics, strengths, and limitations

Strategy (Reference) country	Domains[a]	Strengths	Limitations
Steps in maintaining an updated review (Chalmers et al., 1993 [14]) UK	Search strategy Administrative issues	a) Minimizes publication bias by obtaining gray literature and contacting authors for further information, clarifications	a) Inefficient b) Cumbersome to implement
Maintaining an updated review (Cochrane 2005, 2002 [15,16]) International	Search strategy Administrative issues Clinical Updating format	a) Periodic updating ensures validity at some time b) Timing is known (e.g., every 2 years)	a) Inefficient b) 2-year updating cycle may lead to outdatedness in rapidly developing fields,[b] or wasted resources in slowly developing fields
Assessment of need to update (Lutje et al., 2005 [17]) UK	Search strategy Administrative issues Clinical Public health	a) Assesses the need to update b) Prioritizes reviews requiring updating c) Efficient d) Evidence-based editorial consensus on whether or not to update e) Algorithm of administrative actions	a) Unclear how to determine whether a review is out of date b) Unclear how to determine the importance of the topic in order to reach editorial consensus
Strategies for updating a review (Weller, 1998 [18]) Australia	Clinical Public health Economic Updating format	a) Applicable to systematic reviews, clinical practice guidelines, and health technology assessments	a) General description of actions b) Low practical utility
Searching using the "entry date" field (Bergerhoff et al., 2004 [19]) Germany	Search strategy	a) Compensates for indexing lag by retrieving records indexed since the last search regardless of publication date	a) It may not retrieve non-English records or those without abstracts

[a] Domains: search strategy, statistical method/technique, clinical (expert opinion, long/short–term outcomes, intervention, pace of development in the field, nature of condition), public health importance (severity of condition and prevalence), economical (e.g., resource availability), updating format (preference for electronic vs. paper-based format; information steps), and administrative issues (e.g., those related to the implementation of updating process of systematic reviews).

[b] May not be the case if effects of complex interventions (e.g., educational, behavioral, other interventions at organizational level) are reviewed.

effects of perinatal care [14]. This seven-step process entails the identification, retrieval, and incorporation of new information into a database as well as the dissemination of updated SRs.

4.2. Maintaining an updated review

When registering a review with the Cochrane Collaboration, the review authors agree to keep it up to date [15,16]. The Cochrane Collaboration recommends periodic updating of the literature search (e.g., every 2 years) to determine whether or not relevant new studies are available for inclusion in a previously conducted/completed SR. If a review is updated less frequently than once in 2 years, the Collaboration requires that reviewers provide a commentary explaining the reasons why.

The electronic-based format of Cochrane reviews allows for easy, rapid updating or correcting, with the publication of a new issue of the Cochrane Library every 3 months. An important limitation of the Cochrane Group's strategy is its arbitrarily preset updating frequency, which may result in an inefficient use of resources in slowly developing fields of health care or delayed incorporation of new knowledge in rapidly evolving fields.

4.3. Assessment of the need to update

The Cochrane Infectious Disease Group has proposed an editorial strategy for updating their reviews and an algorithm of administrative actions needed for updating SRs [17]. The strategy involves two steps and follows a 2-year cycle updating policy. The first step is to assess whether or not a given SR is up to date by considering the age of the review, availability of new relevant trials, and the number of participants in the new trials. The second step is to assess the importance of the topic through ascertaining the burden of disease and pace of development of the field. The latter is useful for planning topic-specific priorities in terms of updating. Both steps of the strategy involve judgment decisions reached by an editorial consensus. This strategy provides information on when and how to update SRs and assists in assigning an order of priority to reviews in need of updating. However, it is not clear how to determine whether a given review is up to date.

4.4. Strategies for updating a review

Weller proposed updating strategies that are designed to guide authors as to when and how to update evidence reported in SRs, health technology assessment reports, and CPGs [18]. When planning and conducting an update, these strategies suggest considering clinical endpoints (e.g., short- vs. long-term clinical outcomes), treatment characteristics (e.g., state of evolution of the field), statistical methodology (e.g., the conduct of CMAs), public health impact of treatments, and the availability of resources. This

Table 2
Statistical methods for updating systematic reviews—strengths and limitations

Method (Reference)	Strengths	Limitations
Identifying "null" meta-analyses that are ripe for updating (Barrowman et al., 2003 [20])	a) Relatively efficient b) Easy to use/compute formula c) Reduced type I error relative to conventional CMA d) Test sensitivity/specificity easily modifiable	a) Applicability limited to meta-analyses with statistically nonsignificant results b) Assumes no secular trend in effect and that the variance of pooled estimate shrinks at a rate inversely proportional to the total number of participants in all studies c) Test results sensitive to studies' sizes
Conventional CMA (Lau et al., 1992, 1995; Baum et al., 1981; Berkey et al., 1996 [21–24])	a) Defines the earliest time at which an intervention can be shown to be efficacious, noninferior, or harmful b) Monitors the effect size and direction over time c) Timing for each update is known d) Ascertains the contribution of individual studies to the cumulatively pooled effect estimate e) Allows one to explore heterogeneity and perform sensitivity analysis f) Provides up-to-date information g) Useful in stopping ongoing trials or planning future trials	a) Inefficient—if an update is conducted every time a new study becomes available b) Inflated type I error due to multiple testing c) Affected by publication bias
CMA using the cumulative slope as an indicator of stability (Mullen et al., 2001 [25])	a)–g) of "Conventional CMA" h) Explores the stability of the effect size and informs the need for updating	a)–c) of "Conventional CMA" d) Judging extent of stability is arbitrary e) The variance of the "cumulative slope" is invalid f) The minimum size of a meta-analytic database for fitting a regression line whose slope would be a valid indicator of (in)stability of effect not specified
CMA using sequential monitoring boundaries (Pogue and Yusuf, 1997 [26])	a)–g) of "Conventional CMA" h) Controls type I error by using sequential monitoring boundaries	a) and c) of "Conventional CMA" d) Requires prior calculation of the OIS e) Does not account for heterogeneity or bias among studies
Recursive CMA (Ioannidis and Lau, 2001 [11]; Ioannidis, 1999 [27])	a)–g) of "Conventional CMA" h) Incorporates results from unpublished studies and follow-up or more detailed data for studies already included in the CMA i) Documents the evolution of results as missing, updated, and new data are incorporated in information steps j) Evaluates updated follow-up information, publication bias or lag, and heterogeneity k) Treatment effect estimates are based on relatively accurate and complete data	a) and b) of "Conventional CMA" c) Unpublished and updated information must be carefully studied and verified to minimize bias d) Analysis of updated follow-up data may sometimes be inappropriate because many poststudy patients will cross over e) More costly and resource consuming than conventional CMA

Abbreviations: CMA = cumulative meta-analysis; OIS = optimal information size.

strategy is broadly applicable but lacks the detail needed for practical utility.

5. Techniques for updating SRs

5.1. Using the "entry date" field when updating a review

It is important that database searches performed for updating SRs retrieve all relevant records. Bergerhoff et al. suggested that reviewers use the "entry date" field rather than the publication year when performing updating searches for SRs [19]. This search technique results in more complete retrieval of relevant records including those that have become available since the date of the last search, thereby minimizing publication bias in SRs.

6. Statistical methods for updating SRs

6.1. Identification of "null" meta-analyses that are ripe for updating

Meta-analysis may not demonstrate a statistically significant difference between intervention groups due simply to

Table 3
Methods for updating clinical practice guidelines—characteristics, strengths, and limitations

Reference/organization, country	Comprehensiveness (described domains)[a]	Strengths	Limitations
Clinton, 1994 [28]/Agency for Health Care Policy and Research,[b] USA	Search strategy Clinical Administrative issues	a) Minimizes publication bias by asking the public for literature b) When sufficient data have been obtained, a meeting is held to reach consensus as to whether the guideline requires updating	a) Unclear what constitutes sufficient data to call a consensus meeting b) Unclear which individuals would be involved in the meeting
Shekelle et al., 2001 [8,44]/AHRQ, International	Search strategy Clinical Public health importance Economic Updating format	a) Efficient—targeted literature searches are used instead of a full systematic review b) Assesses when an update is required based on six situations c) Provides a decision model to assess validity of current guidelines d) Decreases bias by using a multidisciplinary team of experts from the original guideline plus additional experts e) Minimizes publication bias by asking experts for further literature	a) A targeted literature search might miss important studies b) There is a stronger emphasis on when to update than how to update c) Including additional experts may increase costs d) The number of outdated recommendations warranting the update of an entire guideline is arbitrary e) Subjective judgment as to whether the guideline needs updating
Dillon, 2005 [29]/National Institute for Clinical Excellence, UK	Search strategy Clinical Economical Updating format Administrative issues	a) Provides a decision process for determining the need to update b) Decreases bias with members from the original guideline development team plus additional members to conduct the update c) Minimizes publication bias by obtaining data from national audits and other sources	a) Inefficient—public consultation is required for every decision b) Updates are only considered 2 or 3 years post—guideline development, which may cause out-datedness
Johnston et al., 2003 [30]/Cancer Care Ontario, Canada	Search strategy Clinical Updating format Communication strategy	a) Minimizes publication bias by obtaining data from the Cochrane library, colleagues, and hand searches	a) Inefficient—suggests searching the literature every month, and routinely hand-searching journals
Gartlehner et al., 2004 [31], USA	Search strategy Clinical Administrative issues	a) Efficient—targeted literature searches are conducted instead of full systematic reviews b) Minimizes publication bias by obtaining studies from websites of federal agencies and the Internet in general c) The validity of the method was evaluated in an empirical study d) Provides a schematic map of administrative and updating processes to update a guideline	a) A targeted literature search may miss important studies b) There is a stronger emphasis on when to update than how to update

[a] Domains: search strategy, statistical method/technique, clinical (expert opinion, long-/short-term outcomes, intervention, pace of development in the field, nature of condition), public health importance (severity of condition and prevalence), economical (e.g., resource availability), updating format (preference for electronic vs. paper-based format; information steps), and administrative issues (e.g., those related to the implementation of updating process of systematic reviews).

[b] Now called the Agency for Healthcare Research and Quality.

small sample sizes. With the emergence of additional clinical trials, the accumulated evidence may eventually be sufficient to turn a statistically nonsignificant result of a meta-analysis into a significant one, if it were to be updated.

Barrowman et al. proposed a diagnostic test to assess whether additional amount of evidence may have been accrued, which would be sufficient to turn a statistically nonsignificant result of a meta-analysis into a significant one thereby rendering it in need for updating [20]. Computer simulations indicated that the diagnostic test identified whether or not a meta-analysis was out of date with a sensitivity between 49% and 62% and a specificity between 80% and 90%, depending on the configuration of the simulation. This method predicts the appropriate timing

for an update, requiring the conduct of search, screening, and only partial data extraction (e.g., number of additional participants), rather than spending considerable resources performing a full-scale update including a comprehensive data extraction with the emergence of each new trial or with an arbitrarily set frequency. The application of this method is limited to meta-analyses with ''statistically nonsignificant'' results under the assumption that this may have been due to insufficient power.

6.2. Cumulative meta-analysis

CMA is a statistical procedure in which the combined effect estimate is sequentially updated by incorporating results from each newly available study [21–24]. It documents trends in a treatment effect over time and provides clinicians and policy makers with up-to-date information. CMA is now a commonly used technique in health care research; its methodology has been well described [32,33]. When done prospectively, CMA may identify the earliest time at which there is sufficient statistical evidence that an intervention is noninferior, efficacious, or harmful, thereby serving as a signal to stop trials that are under way earlier than planned (or at least not to initiate any new ones) because of ethical concerns as well as economic implications [22].

Although it can be very useful, the application of CMA is a costly and cumbersome process. One important limitation of CMA is an inflated rate of type I error due to repeated hypothesis testing, which necessitates the adjustment of the alpha level of statistical significance [26,34].

6.3. CMA using the cumulative slope as an indicator of stability

Mullen et al. introduced the ''cumulative slope'' as an indicator of stability of the pooled effect size in CMA, arguing that it is a more objective alternative to visual inspection of CMA [25]. A least-squares regression line is fitted to N data points corresponding to the effect size of each successive study plotted cumulatively across k waves at which a new study is added. The slope of the regression line fitted over N data points and k waves is the rate of change in Z effect size corresponding to the addition of each new study. The smaller the magnitude of the slope of the regression line, the greater the confidence that the pooled effect size is becoming stable, suggesting no need for further updating.

The cumulative slope may be used prospectively to discern when it is appropriate to stop updating an SR to avoid waste of resources. The retrospective use of the cumulative slope may help to uncover heterogeneity among studies, or to expose the conduct of possibly unnecessary studies. Important limitations of this method are its subjectivity and that it does not yield a valid estimate of variance for the cumulative slope.

6.4. CMA using sequential monitoring boundaries

Repeated hypothesis testing as data accumulate leads to an inflated type I error. The significance levels of the individual hypothesis tests therefore need to be adjusted so that the cumulative overall error rate does not exceed the prespecified level of statistical significance. Lan and DeMets alpha-spending functions were initially used in the settings of individual trials and are illustrated in the Friedman et al. book [35]. Pogue and Yusuf [26] simply described the adaptation of these formulas provided in [35] for the use in CMA.

The optimal information size (OIS), a measure of the total amount of information estimated for CMA, is similar to the total sample size needed to detect a prespecified effect size with a given statistical power calculated for a single planned trial. The OIS calculation involves a priori specification of assumed realistic event rates in the control arm for the disease and outcome(s) of interest, the clinically important minimum treatment effect size, and type I and type II error rates. Estimation of the OIS and the use of monitoring boundaries provide a prospective context in which to examine trends as evidence accumulates, and to evaluate the statistical strength of the evidence of the treatment benefit (or harm) by taking into account the number of patients observed as a proportion of OIS each time an analysis is performed, while adjusting for multiple testing. Limitations of using monitoring boundaries and the OIS are that a large amount of data and a priori specification of various parameters are required.

6.5. Recursive CMA

Ioannidis et al. proposed recursive CMA as an extension of conventional CMA [11,27]. Recursive CMA allows investigators to explore and document the evolution of the pooled treatment effect of meta-analysis by incorporating into the results new, updated/corrected/more detailed or unpublished data as it becomes available. The pooled effect estimate is recalculated at each information step. When recursive CMA is restricted to recalculating the pooled treatment effect only when a new study is published without incorporating updated, corrected, more accurate, or unpublished data, it is no different from a traditional CMA [27]. Recursive CMA is useful for evaluating and comparing the impact of updating, publication bias, and publication lag on the pooled treatment effect estimates in meta-analyses of individual patient data vs. summary data. However, unpublished and updated data for detailed analyses need careful scrutiny for accuracy and completeness to avoid bias, rendering the conduct of recursive CMA cumbersome and costly.

7. Discussion

Because health care evidence continually evolves as new research becomes available, SRs need to be kept up to date.

Ignoring the emergence of new information may undermine the validity of not only SRs but also CPGs [7,36].

A recent example indicates how updating an SR using CMA can change our belief about the effects of an intervention [37]. The results of the CRASH study showed that patients with head injuries treated with corticosteroids were at higher risk of death than those treated with placebo (relative risk (RR) = 1.18, 95% confidence interval [CI]: 1.09, 1.27) [37]. When a meta-analysis [38] on this topic was updated by including the CRASH study findings, the estimated pooled treatment effect shifted from an RR of 0.96 (95% CI: 0.85, 1.08) in the original meta-analysis, to an RR of 1.12 (95% CI: 1.05, 1.20) in the updated meta-analysis, suggesting a harmful effect of corticosteroids [37]. It should be noted that a change in the statistical significance of a summary estimate should always be considered in conjunction with the clinical importance associated with this change to assess the need for an update (or the benefit of updating) more adequately. Another example highlighting the consequences of not updating evidence has also been reported [39]. In a recent study, French et al. surveyed SRs first published in Issue 2, 1998 of *The Cochrane Library's* Cochrane Database of Systematic Reviews and updated in Issue 2, 2002 in the library. The authors found that over the 4 years, 254 (70%) of the 362 SRs they identified were updated. Of those updated SRs, 23 (9%) had changes in their conclusions [40]. The authors did not provide information on clinical areas in which the SRs were conducted. Such information would help one to ascertain whether or not the updated SRs were conducted predominantly in slowly developing clinical areas.

The present SR identified four strategies, one technique, and two statistical methods describing when and/or how to update SRs. In general, the identified four updating strategies and one technique do not include quantitative techniques [14–19], are arbitrary in nature [15–17], may be inefficient (time/resource-wise) [14–16,18], are limited in their practical applicability [15,16,18], and/or are not sufficiently comprehensive (i.e., covering only one or two domains—search strategy and/or administrative steps) [14–19]. The practical performance of these approaches is unclear because they have not been empirically tested or compared to one another.

Conventional CMA and its methodological extensions [11,21–27] are resource-consuming approaches for updating many SRs. Although the method by Barrowman et al. is less resource intensive than CMA, it is strictly a statistical approach with limited application to only meta-analyses with statistically nonsignificant results [20]. It appears that this method has not been widely used.

The relative paucity of well-elaborated methods for updating SRs contrasts sharply with substantial developments in other methodological areas of conducting SRs. For example, a recently completed SR identified more than 30 methods of variance imputation for SRs [41]. Likewise, many methods have been proposed to identify and adjust for publication bias [42,43].

Apparently more attention, work, and resources have been devoted to the development and empirical evaluation of the methodology for updating CPGs [8,28–31] than for SRs. These methods [8,28–31] are sufficiently comprehensive (e.g., covering ''when'' and ''how'' to update information, search strategy, clinical field, public health importance, economics, and administrative actions) and pragmatic. Their performance in terms of validity and efficiency has also been evaluated [30,31,44].

One of the reasons underlying the disparities in scientific attention directed at the development of updating methods for CPGs vs. SRs may be that CPGs are developed by organizations committed to updating, whereas SRs are largely conducted by researchers who may lack necessary resources needed for updating and/or academic motivation to update the previously completed SR.

The findings of this review suggest that the importance of updating SRs has not been well recognized, and that considerably more investment should be made to investigate issues regarding updating SRs. The development of adequate and cost-effective methodologies for updating SRs would be an important step toward maintaining SRs up to date. Additional efficiency may be gained with international harmonization of aspects of the updating process. Electronic formats, similar to the one used by the Cochrane Collaboration, would offer an efficient and convenient way of maintaining, modifying, and disseminating the findings of SR updates [45].

Moreover, future research should focus on identifying predictors and/or triggers for the need to update SRs. Such information would help to estimate the probability that a new study will appear and indicate the need for an update within a specified period of time after completing the original SR. We also need to gain a better understanding of the impact that time lags may have on the updating process (e.g., the time between the last date of search and the submission date of an SR). Mechanisms to minimize these time lags should also be investigated. Similarly, exploration of differences in the rates of growth of literature across various clinical fields, using bibliometric methodology, is likely to provide a better understanding of the practical implications of different approaches to updating SRs. Finally, a survey of national and international organizations that fund or conduct SRs would provide valuable insights into the updating practices and/or policies of such groups.

Many researchers are now publishing SRs, particularly non-Cochrane ones [5]. We believe that updating SRs is both a scientific and an ethical obligation shared between the investigators and the journals publishing the reviews, and where applicable, the agencies commissioning them.

We did not identify literature on the economic issues of updating SRs. The cost-effectiveness of alternative techniques for identifying reviews in need of updating should be explored (e.g., the acceptability of the incremental cost of updating per unit of change in study results). Methods

developed in other fields could also be considered for their potential to inform when and/or how to update SRs. For example, value-of-information analysis may identify a benefit for decision making of reduced uncertainty, even if the clinical conclusions of the updated review remain unchanged [46].

Although methods for assessing publication bias can be used as a supplementary tool for updating SRs, they were not included in this review and are reviewed elsewhere [42,43]. Because the identification of methods for updating CPGs was not the focus of this SR, it is possible that other methods exist beyond the ones identified. Furthermore, due to budget constraints, this SR could not conduct a search for unpublished updating methods.

In summary, very few methods, techniques, and/or strategies exist for updating SRs. Although SRs account for a large body of health care literature, only a small fraction of them is being updated [5,12]. Updating SRs may be a time- or resource-consuming process. The identified strategies are not pragmatic and have not been empirically tested. More concerted research efforts are needed to illuminate further knowledge gaps in the field of updating SRs and to ascertain the potential benefits of developing internationally harmonized, efficient, yet valid, ways of updating SRs.

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Appendix

MEDLINE search—Ovid, 1966 to September Week 4 2005

1. Meta-Analysis/
2. Practice Guidelines/
3. Technology Assessment, Biomedical/
4. exp ''Review Literature''/
5. (systematic review$ or cumulative meta-analys$ or hta or ((clinical or prevent$) adj2 guideline$)).mp.
6. or/1-5
7. ((updat$ or maintain$) adj5 (systematic review$ or cumulative meta-analys$ or hta or ((clinical or prevent$) adj2 guideline$))).mp.
8. Time Factors/
9. 6 and 8
10. An update.ti.
11. (update$ and maintain$).ab.
12. updat$.ti. and (updat$ or maintain$).ab.
13. updat$.ab. /freq=2
14. updating.ti.
15. or/11-14
16. 15 not 10
17. 16 and (or/1-4)
18. ''value of information''.mp.
19. or/7,9,17-18
20. limit 19 to (editorial or letter)
21. cochrane database of systematic reviews.jn.
22. limit 19 to meta analysis
23. ''systematic review of the literature''.ti.
24. or/20-23
25. 19 not 24