

RESEARCH METHODS & REPORTING

Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement



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David Moher and colleagues introduce PRISMA, an update of the QUOROM guidelines for reporting systematic reviews and meta-analyses

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Systematic reviews and meta-analyses have become increasingly important in health care. Clinicians read them to keep up to date with their specialty,^{1,2} and they are often used as a starting point for developing clinical practice guidelines. Granting agencies may require a systematic review to ensure there is justification for further research,³ and some medical journals are moving in this direction.⁴ As with all research, the value of a systematic review depends on what was done, what was found, and the clarity of reporting. As with other publications, the reporting quality of systematic reviews varies, limiting readers' ability to assess the strengths and weaknesses of those reviews.

Several early studies evaluated the quality of review reports. In 1987 Mulrow examined 50 review articles published in four leading medical journals in 1985 and 1986 and found that none met all eight explicit scientific criteria, such as a quality assessment of included studies.⁵ In 1987 Sacks and colleagues evaluated the adequacy of reporting of 83 meta-analyses on 23 characteristics in six domains.⁶ Reporting was generally poor; between one and 14 characteristics were adequately reported (mean 7.7, standard deviation 2.7). A 1996 update of this study found little improvement.⁷

In 1996, to address the suboptimal reporting of meta-analyses, an international group developed a guidance called the QUOROM statement (Quality Of Reporting Of Meta-analyses), which focused on the reporting of meta-analyses of randomised controlled trials.⁸ In this article, we summarise a revision of these guidelines, renamed PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses), which have been updated to address several conceptual and practical advances in the science of systematic reviews (see box).

Terminology

The terminology used to describe a systematic review and meta-analysis has evolved over time. One reason for changing the name from QUOROM to PRISMA was the desire to encompass both systematic reviews and meta-analyses. We have adopted the definitions used by the Cochrane Collaboration.¹⁷ A systematic review is a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review. Statistical methods (meta-analysis) may or may not be used to analyse and summarise the results of the included studies. Meta-analysis refers to the use of statistical techniques in a systematic review to integrate the results of included studies.

Developing the PRISMA statement

A three-day meeting was held in Ottawa, Canada, in June 2005 with 29 participants, including review authors, methodologists, clinicians, medical editors, and a consumer. The objective of the Ottawa meeting was to revise and expand the QUOROM checklist and flow diagram as needed.

The executive committee completed the following tasks before the meeting: a systematic review of studies examining the quality of reporting of systematic reviews; a comprehensive literature search to identify methodological and other articles that might inform the meeting, especially in relation to modifying checklist items; and an international survey of review authors, consumers, and groups commissioning or using systematic reviews and meta-analyses (including the

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Extra material supplied by the author (see <http://www.bmj.com/content/339/bmj.b2535?tab=related#datasupp>)

Checklist of items to include when reporting a systematic review or meta-analysis (downloadable template document for researchers to re-use)

Flow of information through the different phases of a systematic review (downloadable template document for researchers to re-use).

Conceptual issues in the evolution from QUOROM to PRISMA

Completing a systematic review is an iterative process

The conduct of a systematic review depends heavily on the scope and quality of included studies: thus systematic reviewers may need to modify their original review protocol during its conduct. Any systematic review reporting guideline should recommend that such changes can be reported and explained without suggesting that they are inappropriate. The PRISMA statement (items 5, 11, 16, and 23) acknowledges this iterative process. Aside from Cochrane reviews, all of which should have a protocol, only about 10% of systematic reviewers report working from a protocol.⁹ Without a protocol that is publicly accessible, it is difficult to judge between appropriate and inappropriate modifications.

Conduct and reporting of research are distinct concepts

This distinction is, however, less straightforward for systematic reviews than for assessments of the reporting of an individual study, because the reporting and conduct of systematic reviews are, by nature, closely intertwined. For example, the failure of a systematic review to report the assessment of the risk of bias in included studies may be seen as a marker of poor conduct, given the importance of this activity in the systematic review process.¹⁰

Study-level versus outcome-level assessment of risk of bias

For studies included in a systematic review, a thorough assessment of the risk of bias requires both a study-level assessment (such as adequacy of allocation concealment) and, for some features, a newer approach called outcome-level assessment. An outcome-level assessment involves evaluating the reliability and validity of the data for each important outcome by determining the methods used to assess them in each individual study.¹¹ The quality of evidence may differ across outcomes, even within a study, such as between a primary efficacy outcome, which is likely to be carefully and systematically measured, and the assessment of serious harms,¹² which may rely on spontaneous reports by investigators. This information should be reported to allow an explicit assessment of the extent to which an estimate of effect is correct.¹¹

Importance of reporting biases

Different types of reporting biases may hamper the conduct and interpretation of systematic reviews. Selective reporting of complete studies (such as publication bias),¹³ as well as the more recently empirically demonstrated "outcome reporting bias" within individual studies,^{14 15} should be considered by authors when conducting a systematic review and reporting its results. Although the implications of these biases on the conduct and reporting of systematic reviews themselves are unclear, some research has identified that selective outcome reporting may occur also in the context of systematic reviews.¹⁶

International Network of Agencies for Health Technology Assessment and the Guidelines International Network) to ascertain views of QUOROM, including the merits of the existing checklist items. The results of these activities were presented during the meeting and are summarised on the PRISMA website, www.prisma-statement.org/.

Only items deemed essential were retained or added to the checklist. Some additional items are nevertheless desirable, and review authors should include these, if relevant.¹⁸ For example, it is useful to indicate whether the systematic review is an update of a previous review¹⁹ and to describe any changes in procedures from those described in the original protocol.

Shortly after the meeting, a draft of the PRISMA checklist was circulated to the group, including those invited to the meeting but unable to attend. A disposition file was created containing comments and revisions from each respondent, and the checklist was subsequently revised 11 times. The group approved the checklist, flow diagram, and this summary paper.

Although no direct evidence was found to support retaining or adding some items, evidence from other domains was believed to be relevant. For example, item 5 asks authors to provide registration information about the systematic review, including a registration number if available. Although systematic review registration is not yet widely available,^{20 21} the participating journals of the International Committee of Medical Journal Editors²² now require all clinical trials to be registered in an effort to increase transparency and accountability.²³ Those aspects are also likely to benefit systematic reviewers, possibly reducing the risk of an excessive number of reviews addressing the same question^{24 25} and providing greater transparency when updating systematic reviews.

The PRISMA statement

The PRISMA statement consists of a 27 item checklist (table 1) and a four phase flow diagram (figure 1) (also available as extra items on bmj.com for researchers to download and re-use). The aim of the PRISMA statement is to help authors improve the reporting of systematic reviews and meta-analyses. We have focused on randomised trials, but PRISMA can also be used as a basis for reporting systematic reviews of other types of

research, particularly evaluations of interventions. PRISMA may also be useful for critical appraisal of published systematic reviews. However, the PRISMA checklist is not a quality assessment instrument to gauge the quality of a systematic review.

From QUOROM to PRISMA

The new PRISMA checklist differs in several respects from the QUOROM checklist, and table 2 lists the substantive specific changes. Generally, the PRISMA checklist "decouples" several items present in the QUOROM checklist and, where applicable, several checklist items are linked to improve consistency across the systematic review report.

The flow diagram has also been modified. Before including studies and providing reasons for excluding others, the review team must first search the literature. This search results in records. Once these records have been screened and eligibility criteria applied, a smaller number of articles will remain. The number of included articles might be smaller (or larger) than the number of studies, because articles may report on multiple studies and results from a particular study may be published in several articles. To capture this information, the PRISMA flow diagram now requests information on these phases of the review process.

Endorsement

The PRISMA statement should replace the QUOROM statement for those journals that have endorsed QUOROM. We hope that other journals will support PRISMA; they can do so by registering on the PRISMA website. To emphasise to authors and others the importance of transparent reporting of systematic reviews, we encourage supporting journals to reference the PRISMA statement and include the PRISMA web address in their instructions to authors. We also invite editorial organisations to consider endorsing PRISMA and encourage authors to adhere to its principles.

The PRISMA explanation and elaboration paper

In addition to the PRISMA statement, a supporting explanation and elaboration document has been produced²⁶ following the style used for other reporting guidelines.²⁷⁻²⁹ The process of completing this document included developing a large database of exemplars to highlight how best to report each checklist item, and identifying a comprehensive evidence base to support the inclusion of each checklist item. The explanation and elaboration document was completed after several face to face meetings and numerous iterations among several meeting participants, after which it was shared with the whole group for additional revisions and final approval. Finally, the group formed a dissemination subcommittee to help disseminate and implement PRISMA.

Discussion

The quality of reporting of systematic reviews is still not optimal.^{9 30-34} In a recent review of 300 systematic reviews, few authors reported assessing possible publication bias,⁹ even though there is overwhelming evidence for its existence¹³ and its impact on the results of systematic reviews.³⁵ Even when the possibility of publication bias is assessed, there is no guarantee that systematic reviewers have assessed or interpreted it appropriately.³⁶ Although the absence of reporting such an assessment does not necessarily indicate that it was not done, reporting an assessment of possible publication bias is likely to be a marker of the thoroughness of the conduct of the systematic review.

Several approaches have been developed to conduct systematic reviews on a broader array of questions. For example, systematic reviews are now conducted to investigate cost effectiveness,³⁷ diagnostic³⁸ or prognostic questions,³⁹ genetic associations,⁴⁰ and policy making.⁴¹ The general concepts and topics covered by PRISMA are relevant to any systematic review, not just those summarising the benefits and harms of a healthcare intervention. However, some modifications of the checklist items or flow diagram will be necessary in particular circumstances. For example, assessing the risk of bias is a key concept, but the items used to assess this in a diagnostic review are likely to focus on issues such as the spectrum of patients and the verification of disease status, which differ from reviews of interventions. The flow diagram will also need adjustments when reporting meta-analysis of individual patient data.⁴²

We have developed an explanatory document to increase the usefulness of PRISMA.²⁶ For each checklist item, this document contains an example of good reporting, a rationale for its inclusion, and supporting evidence, including references, whenever possible. We believe this document will also serve as a useful resource for those teaching systematic review methodology. We encourage journals to include reference to the explanatory document in their instructions to authors.

Like any evidence based endeavour, PRISMA is a living document. To this end we invite readers to comment on the revised version, particularly the new checklist and flow diagram, through the PRISMA website. We will use such information to inform PRISMA's continued development.

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In order to encourage dissemination of the PRISMA statement, this article is freely accessible on bmj.com and will also be published in *PLoS Medicine*, *Annals of Internal Medicine*, *Journal of Clinical Epidemiology*, and *Open Medicine*. The authors jointly hold the copyright of this article. For details on further use, see the PRISMA website (www.prisma-statement.org/).

- 1 Oxman AD, Cook DJ, Guyatt GH. Users' guides to the medical literature. VI. How to use an overview. Evidence-Based Medicine Working Group. *JAMA* 1994;272:1367-71.
- 2 Swingle GH, Volmink J, Ioannidis JP. Number of published systematic reviews and global burden of disease: database analysis. *BMJ* 2003;327:1083-4.
- 3 Canadian Institutes of Health Research. Randomized controlled trials registration/application checklist (12/2006). 2006. www.cihr-irsc.gc.ca/e/documents/rct_reg_e.pdf (accessed 19 May 2009).
- 4 Young C, Horton R. Putting clinical trials into context. *Lancet* 2005;366:107.
- 5 Mulrow CD. The medical review article: state of the science. *Ann Intern Med* 1987;106:485-8.
- 6 Sacks HS, Berrier J, Reitman D, Ancona-Berk VA, Chalmers TC. Meta-analysis of randomized controlled trials. *N Engl J Med* 1987;316:450-5.
- 7 Sacks HS, Reitman D, Pagano D, Kupelnick B. Meta-analysis: an update. *Mt Sinai J Med* 1996;63:216-24.
- 8 Moher D, Cook DJ, Eastwood S, Olkin I, Rennie D, Stroup DF, for the QUOROM group. Improving the quality of reporting of meta-analysis of randomized controlled trials: The QUOROM statement. *Lancet* 1999;354:1896-1900.
- 9 Moher D, Tetzlaff J, Tricco AC, Sampson M, Altman DG. Epidemiology and reporting characteristics of systematic reviews. *PLoS Med* 2007;4:e78, doi:10.1371/journal.pmed.0040078.

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Tables

Table 1| Checklist of items to include when reporting a systematic review or meta-analysis

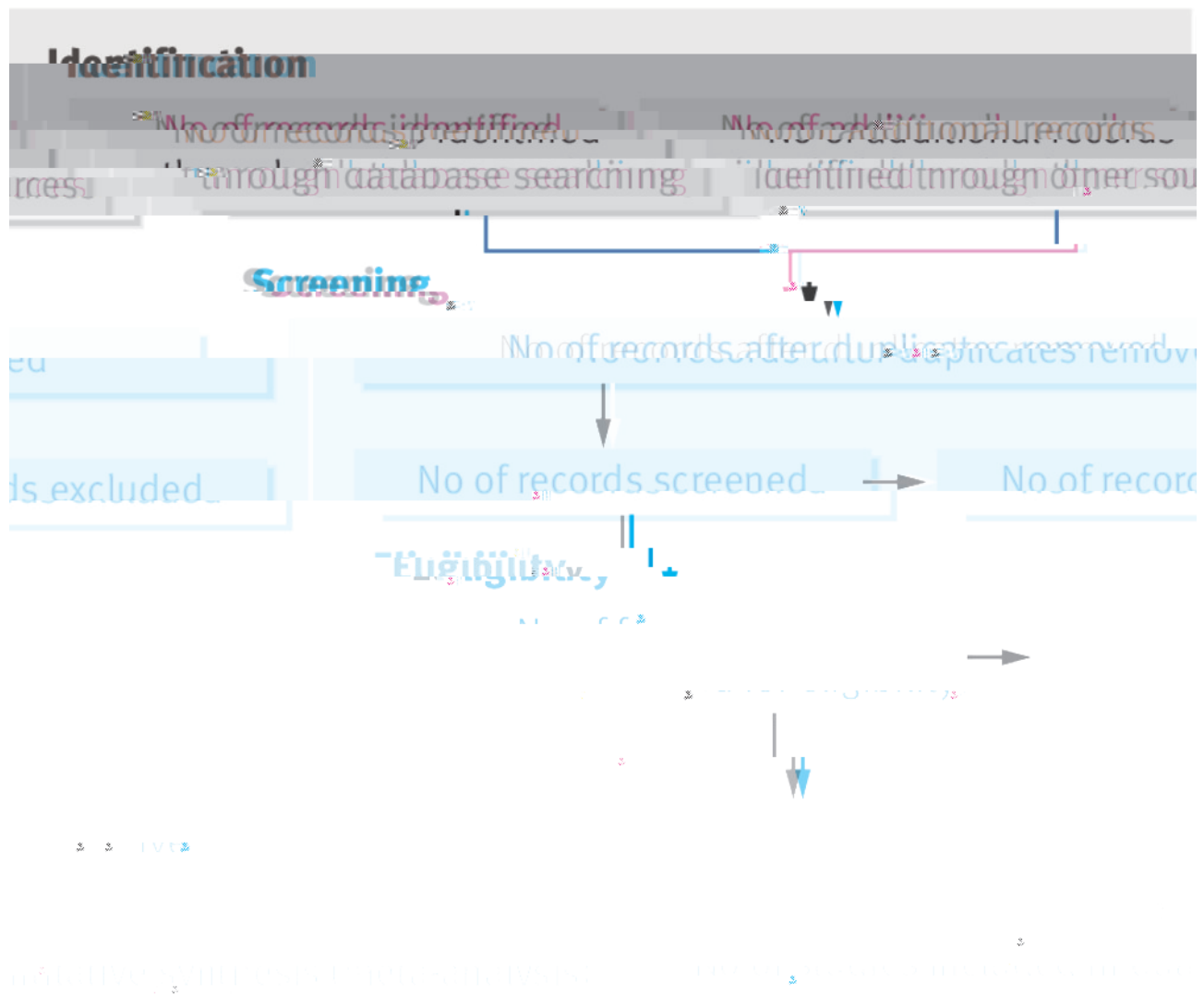
Table 1 (continued)

Section/topic	Item No	Checklist item	Reported on page No
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research	
Funding			
Funding	27	Describe sources of funding for the systematic review and other support (such as supply of data) and role of funders for the systematic review	

Table 2| Substantive specific changes between the QUOROM checklist and the PRISMA checklist (a tick indicates the presence of the topic in QUOROM or PRISMA)

Section/topic and item	QUOROM	PRISMA	Comment
Abstract	√	√	QUOROM and PRISMA ask authors to report an abstract. However, PRISMA is not specific about format
Introduction:			
Objective		√	This new item (4) addresses the explicit question the review addresses using the PICO reporting system (which describes the participants, interventions, comparisons, and outcome(s) of the systematic review), together with the specification of the type of study design (PICOS); the item is linked to items 6, 11, and 18 of the checklist
Methods:			
Protocol		√	This new item (5) asks authors to report whether the review has a protocol and if so how it can be accessed
Search	√	√	Although reporting the search is present in both QUOROM and PRISMA checklists, PRISMA asks authors to provide a full description of at least one electronic search strategy (item 8). Without such information it is impossible to repeat the authors' search
Assessment of risk of bias in included studies	√	√	Renamed from "quality assessment" in QUOROM. This item (12) is linked to reporting this information in the results (item 19). The new concept of "outcome level" assessment has been introduced
Assessment of risk of bias across studies		√	This new item (15) asks authors to describe any assessments of risk of bias in the review, such as selective reporting within the included studies. This item is linked to reporting this information in the results (item 22)
Discussion	√	√	Although both QUOROM and PRISMA checklists address the discussion section, PRISMA devotes three items (24-26) to the discussion. In PRISMA the main types of limitations are explicitly stated and their discussion required
Funding		√	This new item (27) asks authors to provide information on any sources of funding for the systematic review.

Figure



Flow of information through the different phases of a systematic review.