Bridging formalisation and expert judgement in searches for studies for systematic reviews

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I certify that all material in this thesis which is not my own work has been identified and that any material that has previously been submitted and approved for the award of a degree by this or any other University has been acknowledged.

Signature:

Abstract

Systematic reviews aim to use pre-specified and explicitly described methods. This entails an element of formalisation in which methods are described according to a fixed structure. However, qualitative studies show that too much emphasis on formalisation can obscure how expert judgement is required even after clearly defined methods are established. Thus, there is a gap between how systematic review methods are formalised in guidance and reported in systematic reviews, and how they are carried out in practice using undisclosed expert judgement. The aim of this thesis is to describe and bridge the gap between formalisation and expert judgement with respect to searching for studies for systematic reviews, with a particular focus on forward citation searching and web searching. Forward citation searching and web searching are useful search methods to consider due to observed variability in both if and how they are used in systematic reviews, in contrast to searches of bibliographic databases which are routine in almost all systematic reviews. To this end, the thesis seeks to fulfil three objectives: first, to formalise the conduct and reporting of forward citation searching and web searching in systematic reviews; secondly, to describe and evaluate the conduct and reporting of forward citation searching and web searching in systematic reviews; thirdly, to explore the role of expert judgement when using forward citation searching and web searching. Both aggregative and configurative review types are considered throughout. The findings show that formalised approaches to searching are apparent in guidance to different degrees. However, systematic reviews do not always reflect formalised guidance. Qualitative investigation describes hitherto hidden practical knowledge which underpins searching decisions. The thesis draws these findings together and proposes that guidance on searching for studies should be framed in terms of the practical understanding which informs how searching is undertaken rather than limited to describing recommended processes.

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Dedication

For my wife and children: Anna, Emily, James and Edmund.

Abbreviations

AMSTAR	A Measurement Tool to Assess Systematic Reviews
CASP	Critical Appraisal Skills Programme
CRD	Centre for Reviews and Dissemination
CEE	Collaboration for Environmental Evidence
EBP	Evidence-based practice
HTA	Health Technology Assessment
JBI	Joanna Briggs Institute
MECIR	Methodological Expectations of Cochrane Intervention Reviews
NICE	National Institute for Health and Care Excellence
PICO(S)	Population, Intervention, Comparator, Outcome and Study design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PRISMA-S	Preferred Reporting Items for Systematic reviews and Meta-Analyses literature search extension
QUOROM	Quality of Reporting of Meta-analyses
RAMESES	Realist And Meta-narrative Evidence Syntheses: Evolving Standards
UK	United Kingdom

Author's declaration

The candidate was either lead author or contributed substantive intellectual input for the supporting articles 1-9 in this thesis (see Table 1). The candidate's contribution to the supporting articles is described in detail in Section 1.9.

Table 1. Supporting articles

Article number	Citation details
1	Booth A, Wright JM, **Briscoe S**. Scoping and searching to support realist approaches. In: Emmel N, Greenhalgh J, Manzano A, Monaghan M, Dalkin S, editors. *Doing Realist Research* London: SAGE Publications; 2018
2	**Briscoe S**. A review of the reporting of web searching to identify studies for Cochrane systematic reviews. Res Synth Methods. 2018 Mar;9(1):89-99. doi: 10.1002/jrsm.1275.
3	Lefebvre C, Glanville J, **Briscoe S**, Littlewood A, Marshall C, Metzendorf M-I*, et al.* Chapter 4: Searching for and selecting studies. In: Higgins J, Thomas J, Chandler J, Cumpston M, Li T, Page M*, et al.*, editors. *Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3 (Updated February 2022)*: Cochrane; 2022
3S*	Lefebvre C, Glanville J, **Briscoe S**, Littlewood A, Marshall C, Metzendorf M-I*, et al.* Technical Supplement to Chapter 4: Searching for and selecting studies. In: Higgins J, Thomas J, Chandler J, Cumpston M, Li T, Page M*, et al.*, editors. *Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3 (Updated February 2022)*: Cochrane; 2022.
4	Booth A, **Briscoe S**, Wright JM. The "realist search": A systematic scoping review of current practice and reporting. Res Synth Methods. 2020 Jan;11(1):14-35. doi: 10.1002/jrsm.1386.
5	**Briscoe S**, Bethel A, Rogers M. Conduct and reporting of citation searching in Cochrane systematic reviews: A cross-sectional study. Res Synth Methods. 2020 Mar;11(2):169-180. doi: 10.1002/jrsm.1355.
6	**Briscoe S**, Nunns M, Shaw L. How do Cochrane authors conduct web searching to identify studies? Findings from a cross-sectional sample of Cochrane Reviews. Health Info Libr J. 2020 Dec;37(4):293-318. doi: 10.1111/hir.12313.
7	**Briscoe S**, Abbott, R, Melendez-Torres, G.J. The phronesis of expert searchers on using forward citation searching and web searching to search for studies for systematic reviews: a hermeneutic phenomenological analysis. Journal of Information Science. 2022. Epub ahead of print. doi: 10.1177/0165551522113023

8	**Briscoe S**, Abbott R, Melendez-Torres, G.J. Expert searchers identified time, team, technology and tension as challenges when carrying out supplementary searches for systematic reviews: A thematic network analysis. 2022. Health Info Libr J. Epub ahead of print. doi: 10.1111/hir.12468
9	**Briscoe S**, Abbott R, Lawal H, Shaw L, Thompson Coon J. Feasibility and desirability of screening search results from Google Search exhaustively for systematic reviews: a cross-case analysis. 2023. Res Synth Methods. May;14(3):427-437. doi: 10.1002/jrsm.1622

*S=supplement (Article 3S is a supplement to Article 3).

Chapter 1. Extended introduction

1.1. Background

Searches for studies for systematic reviews aim to use pre-specified and explicitly described methods, which are reported in sufficient detail to facilitate reproduction and critical appraisal.[1-4] To different degrees, this is true of both aggregative reviews, which use pre-defined concepts and methods to assess empirical data, and configurative reviews, which test and refine theories to understand complex phenomena.[5] Stringent standards, both of conduct and reporting, are a hallmark of systematic review methods generally, the aim of which is to ensure that systematic reviews provide reliable answers to research questions based on appropriately rigorous assessments of the available evidence.[6-10] To this end systematic reviewers and expert searchers (typically information specialists and librarians) have developed recommended approaches of searching conduct and reporting in the form of guidance.[2-4, 11-13] This includes guidance on specific types of search methods, such as forward citation searching and web searching, which are the focus of this thesis (see Table 2). Forward citation searching and web searching are useful search methods to consider due to observed variability in both if and how they are used in systematic reviews, in contrast to searches of bibliographic databases which are routine in almost all systematic reviews.[14-19]

The development of guidance entails an element of formalisation in which the processes required to ensure that systematic reviews are appropriately rigorous are explicitly described in a structured format. Suppes argues that formalisation is fundamental to conducting science, specifically, as the means in which scientific concepts and methods are given explicit, standardised, generalised, and objective form.[20] Without formalisation, confusion and conflict may prevail due to lack of agreement about core concepts and methods.[20] The formalisation of systematic review conduct and reporting has happened gradually over time through the collaborative work of researchers towards shared goals.[21, 22] This has involved both the development of evidence-based practice (EBP) for specific methods, including forward citation searching[23-34] and web searching,[30, 35-44] and the consolidation of these methods into overall approaches for carrying

out and reporting different types of systematic review. The latter is typically achieved through the consensus of experts on the most appropriate methods, with reference to EBP wherever available, for example, this takes place in expert meetings on methods development,[45-47] sometimes including Delphi surveys[48, 49] and in the writing of guidance manuals by experts on different types of systematic review.[4, 6-8, 10, 47, 50, 51]

Although formalisation is central to systematic reviews, too much emphasis on formalisation can obscure how expert judgement remains necessary even after clearly defined guidance is established. The ineliminable need for expertise is revealed in evidence which explores how systematic review methods cannot be entirely formalised due to the need for expert judgement which resists explicit formalisation.[52-56] This type of expertise is characterised by Aristotle as practical knowledge which can only be learnt through exposure to real world situations, as opposed to technical knowledge which is learnt by studying abstract rules and formulae.[57] The Greek term for practical expertise thus conceived is *phronesis*.[57] Thus, a gap is apparent between how searches for studies are described in guidance and systematic reviews, and how expert searchers carry out searches in actual practice. This thesis aims to describe this gap and propose ways to overcome (i.e. bridge) it. The focus is on forward citation searching and web searching within aggregative reviews (using Cochrane reviews as an exemplar category) and configurative reviews (using realist reviews as an exemplar category).[5]

Table 2. Description and purpose of forward citation searching and web searching

Search method	Description	Purpose
Forward citation searching	Forward citation searching uses a citation index to identify studies which cite a source study. Commonly used citation indices include the Science Citation Index, Scopus and Google Scholar. Forward citation searching works on the assumption that studies which cite a study are likely to have similar content, thus the search method is commonly carried out on studies which meet the inclusion criteria for a systematic review.	Forward citation searching uses citation links as an alternative to text-based searching to identify studies. This makes it particularly useful for topics where it is difficult to identify an exhaustive set of search terms.
Web searching	Web searching involves searching websites and search engines which have multiple purposes other than hosting and retrieving studies. This includes the websites of organisations which are topically relevant to a systematic review, such as charity and government websites, and general search engines, such as Google Search.	Web searching is often used to identify grey literature which is not indexed by bibliographic databases, but it can also be used to identify published studies.

1.2. The structure of this thesis

The remainder of this thesis is structured as follows: Section 1.3 sets out the aim and objectives. Section 1.4 reviews the wider relevant literature. Section 1.5 provides an account of the methods used in the supporting articles. Section 1.6 describes the findings and contributions to knowledge of the supporting articles. Section 1.7 presents an account of how the supporting articles form a coherent whole, which fulfils the overall aim of the thesis. Section 1.8 concludes the

thesis. Section 1.9 describes my contributions to the supporting articles. Chapters 2-11 contain reproductions of the supporting articles.

Unless otherwise stated, numbers in parentheses throughout the thesis refer to the supporting articles in Table 1 (i.e. articles 1-9). The phrase *formalised accounts of practice* is used in the thesis to refer to guidance and EBP, and the phrase *descriptive accounts of practice* refers to reports of searching in published systematic reviews. This distinction is particularly important in Section 1.7 where these two accounts of searching are compared and contrasted. However, the term *formalisation* is used throughout the thesis in a general sense to describe both formalised accounts of searching in guidance and EBP, and also descriptive accounts of searching which are reported in systematic reviews.

1.3. Aim and objectives

1.3.1. Aim

The aim of this thesis is to describe and bridge the gap between formalisation and expert judgement in searches for studies for systematic reviews, with a specific focus on forward citation searching and web searching.

1.3.2. Objectives

The thesis includes three objectives which form the basis for achieving the aim:

1. Formalise, in so far as possible, the conduct and reporting of forward citation searching and web searching in aggregative reviews, and of searches for studies more broadly in configurative reviews, including forward citation searching and web searching.
2. Describe and evaluate the conduct and reporting of forward citation searching and web searching in aggregative reviews, and of searches for studies more broadly in configurative reviews, including forward citation searching and web searching.
3. Explore the role of expert judgement when searching for studies using forward citation searching and web searching in both aggregative and configurative reviews.

In fulfilment of objective 1, two guidance publications seek to formalise the conduct and reporting of forward citation searching and web searching for Cochrane reviews (as an example of an aggregative review type) (3 and 3S),[3, 13] and one publication seeks to formalise the conduct and reporting of searches for studies for realist reviews (as an example of a configurative review type), including forward citation searching and web searching (1).[11] Furthermore, one methods paper contributes evidence on the development of a formalised approach to web searching using Google Search (9).[58] In fulfilment of objective 2, three publications describe and evaluate the conduct and reporting of web searching (5 and 2 respectively)[59, 60] and citation searching (6)[37] in Cochrane reviews. Furthermore, one publication describes and evaluates the conduct and reporting of searching for studies for realist reviews (4).[61] In fulfilment of objective 3, one publication explores how expert judgement shapes the conduct of forward citation searching and web searching (7);[57] and one publication explores the logistical challenges of searching for studies using forward citation searching and web searching (8).[62]

In fulfilment of the overall aim of the thesis, Section 1.7 draws on the findings of objectives 1 to 3 to present an account of how the supporting articles form a coherent whole, specifically with the aim of showing how they describe the gap between formalisation and expert judgement, and how the gap can be overcome – thus bridging the gap between formalisation and expert judgement.

1.4. Literature review

The wider literature relevant to this thesis falls within three main areas linked to objectives 1 to 3:

1. Guidance manuals and EBP in the form of methodological studies which formalise the conduct and reporting of forward citation searching and web searching in systematic reviews;
2. Epidemiology and characteristics of forward citation searching and web searching in systematic reviews;
3. Qualitative research on the role of expertise in systematic reviews.

In this section I review this literature. No substantive reference is made to the supporting articles in order to emphasise in Section 1.6 the contribution these publications have made to the pre-existing literature.

1.4.1. Guidance and EBP on forward citation searching and web searching

Guidance on the conduct and reporting of searches for studies for systematic reviews is typically found in systematic review guidance manuals, such as the Cochrane Handbook,[3, 7] and in reporting standards such as PRISMA-S.[4] To provide clarity about recommended approaches to conduct and reporting, a degree of formalisation is required, in which recommendations are standardised and generalised (albeit sometimes for specific types of review) and explicitly and objectively stated.[20] EBP is partly what justifies recommended approaches in guidance. (In addition, expert-consensus is required to interpret evidence and fill gaps where no EBP exists). Thus, the relevant literature to consider for objective 1, on the formalisation of forward citation searching and web searching, comprises guidance and EBP. This is summarised below.

1.4.1.1. Forward citation searching

Guidance on the conduct of forward citation searching is presented in systematic review guidance manuals.[2, 6, 9-11, 13, 50, 63-65] This includes the Cochrane Handbook v5.1[66] which was published prior to the current version (3).[3] This stated that forward citation searching can be used to identify citations of “an important article”, thus emphasising using selected studies of interest as source studies rather than all known relevant studies.[67] It also described forward citation searching as “an important adjunct” (i.e. supplementary) to searching bibliographic databases and hand-searching, citing one case study on the effectiveness of forward citation searching in support of this recommendation.[25] The Centre for Reviews and Dissemination (CRD) guidance also recommends using selected “key papers” for forward citation searching.[6] In contrast, NICE guidance[63] and Collaboration for Environmental Evidence (CEE) guidance[65] take the emphasis off key studies, stating that forward citation searching should be carried out using “known relevant studies” (e.g. “such as those identified for inclusion in the review”).[63] Commenting on guidance, Cantrell et al. note that, other than in Lefebvre et al. (3S) in the context of

Cochrane Reviews,[13] there is limited guidance on how to select source studies for forward citation searching.[23]

On the rationale for forward citation searching, Campbell Collaboration guidance,[2] the Joanna Briggs Institute (JBI) guidance[50] and Petticrew et al.[9] follow the Cochrane Handbook v5.1 in describing forward citation searching as supplementary to searching bibliographic databases. The Campbell Collaboration guidance[2] cites the same case study in support of this recommendation as the Cochrane Handbook v.5.1.[25] Petticrew et al.[9] cites a methodological review in which forward citation searching was used and a monograph on online searching techniques.[68, 69] Campbell Collaboration guidance[2] and Petticrew et al.[9] both note the value of forward citation searching for social science reviews, and Petticrew et al. specifically recommend this where free-text searching is challenging due to inconsistent use of terminology.[9] Guidance for realist reviews recommends forward citation searching for identifying programme theories.[10, 64] In particular, Pawson et al. note that theory development makes use of associations between studies which share theoretical assumptions, which makes citation searching particularly useful compared to text-based searching in bibliographic databases.[64]

Hirt et al. describe a planned Delphi survey of expert searchers on how to carry out backward and forward citation searching with a view to extending the detail currently presented in guidance.[48] They aim to include more detail on specific situations in which the search methods should be used than currently available, and how the approach should vary between different situations.[48] At the time of writing, the findings of this Delphi survey have not been published.

Most methodological studies which develop EBP for forward citation searching are case studies of its effectiveness for identifying relevant studies.[23-26, 28, 31, 33, 34, 70] Several case studies measure its effectiveness using studies identified by bibliographic databases as source studies.[23, 25, 31, 33, 34] The majority of these use all included studies,[23, 31, 33, 34] and a minority use selected studies.[25 31] Only one of these studies was cited in guidance manuals prior to the publication of Lefebvre et al. (3S).[25] Some studies include a comparative element in which two or more citation indices are compared with respect to studies retrieved by forward citation searching.[23, 28, 33, 34] Hirt et al.'s scoping review of

methodological studies on citation searching, including both forward and backward approaches, concluded that the extent of heterogeneity in the included studies prohibited drawing generalisable conclusions about the findings.[71] However, there does appear to be consensus in EBP that forward citation searching is useful where keyword terminology is used inconsistently or is difficult to specify exhaustively for the purpose of searching bibliographic databases,[23, 25, 26, 31, 72] or where seeking to identify studies closely related to a key paper.[29, 70]

A small number of studies consider alternative approaches to forward citation searching, i.e. where this is not limited to supplementary searching.[24, 28, 70] Booth et al. develop Pawson et al.'s recommendation to use forward citation searching for identifying programme theories.[70] This takes place within a multifaceted approach which involves forward citation searches and checking reference lists of pre-identified relevant studies, and checking publication lists of lead authors. Cooper et al. compared two formalised approaches to searching for studies for a Cochrane review, including: a *conventional* approach where forward citation searching followed bibliographic databases; and a *tailored* approach where forward citation searching preceded searching bibliographic databases, using studies recommended by experts or identified by web searches as source studies.[24] They found the tailored approach was more effective and concluded it is unhelpful to categorise search methods as supplementary or otherwise.[24] Levay et al. compared the effectiveness of Google Scholar and Web of Science for forward citation searching.[28] In particular, they assessed the value of forward citation searching as a main search method for a NICE rapid review, in place of bibliographic databases. Source studies were identified by expert solicitation and checking reference lists of recommended studies. They concluded that forward citation searching is an effective alternative to bibliographic databases for rapid policy reviews.[28] They noted that forward citation searching is an established supplementary search method in the NICE methods guidance, but that it is important to move away from only using it as a supplementary search method.[28, 63] Collectively, these studies advocate alternatives to the conventional approach of using forward citation searching as a supplementary search method.

Guidance on reporting forward citation searching is presented in PRISMA-S.[4] This recommends reporting the citation indices and source studies which were used.[4] Forward citation searching is not explicitly mentioned in the MECIR standards but it is mandatory to list all sources searched, which includes citation indices.[73] Realist guidance in RAMESES states that "sufficient detail should be given to enable the reader to judge whether searching was likely to have located sources needed for theory building and/or testing." However, no specific guidance is presented on forward citation searching.[10]

In summary, guidance on the conduct of forward citation searching is broadly similar, with the main differences relating to whether searches should use all included studies or selected key studies as source studies. However, beyond this dichotomous category-driven approach, limited additional guidance is provided on choosing source studies, which is commented on by Cantrell et al.[23] In the small number of guidance documents where a rationale is stated, there is agreement about its value for review topics where terminology is used inconsistently.[2, 9] EBP in the form of methodological studies is sparsely mentioned in guidance, and approaches which challenge the convention of using forward citation searching solely as a supplement to bibliographic databases are not mentioned.[24, 28, 70]

1.4.1.2. Web searching

Guidance on web searching is presented in the same systematic review guidance as forward citation searching,[2, 6, 9, 11, 50, 63-65, 67] including the Cochrane Handbook v5.1.[66] Guidance is broadly similar (as per forward citation searching) albeit the level of detail is more varied. The Cochrane Handbook v5.1 recommended searching for studies via the websites of research funders and device manufacturers.[67] It also recommended investigating whether pharmaceutical company websites host trials registries. One case study was cited in support of web searching,[41] accompanied by the warning that there is "little empirical evidence" on its value.[67] No practical recommendations were made on how to carry out web searching. In contrast, some practical advice is provided in the Campbell Collaboration guidance, which recommends using the advanced search interfaces of search engines where available, claiming that these facilitate Boolean logic and "limiting commands".[2] The CRD guidance[6]

recommends that targeting specific websites is likely to be more useful than using a search engine, whereas Campbell,[2] Petticrew et al.[9] and JBI guidance[50] all recommend using general search engines despite potential marginal gains. The JBI guidance also notes that no one search engine indexes the entire web, thus it recommends searching more than one search engine.[50]

On the rationale for web searching, the Campbell Collaboration guidance recommends that web searches are carried out towards the end of a search process to "pick up the most current information".[2] The CRD guidance[6] and Petticrew et al.[9] recommend web searching is used for retrieving grey literature, with specific reference in Petticrew et al. to its importance for social science topics where studies are sometimes not published in journals.[9]

Similarly to forward citation searching, methodological studies which develop EBP for web searching are mainly in case study format, and focus on its effectiveness for study identification.[39, 41, 42, 74-76] Detail on the rationale and conduct of web searching is reported in some studies. Identification of grey literature is commonly noted as a strength of web searching in addition to journal articles.[41-43, 76] In keeping with guidance, general search engines such as Google Search are evaluated as supplementary sources,[39-42] whereas Google Scholar is considered equivalent to bibliographic databases in scope.[35, 43, 77-79] Cooper et al. compared two different approaches to web searching in a Cochrane review: one where web searching conventionally followed bibliographic database searches to identify studies missed by the databases; and a tailored approach where web searching was used prior to bibliographic databases to identify studies which could be used to refine the bibliographic database search strategy.[24] They concluded that the tailored approach led to the identification of more relevant studies with fewer studies to screen overall.[24] In another study, Cooper et al. showed that geographical location can affect the results retrieved when searching Google Search.[40]

Some aspects of EBP are not discussed in guidance manuals. This includes how web searches are typically simplified versions of bibliographic database searches,[39-42] e.g. Godin et al. reported searching Google Search in multiple iterations, as the required search terms would not fit within a single search string.[42] Stopping-rules are often reported in EBP when screening the results of

web searches, such as limiting the screening process to the first 100[42] or 50 results,[39] or until a page of results identifies no relevant content,[44] due to the high number of results that are sometimes retrieved – particularly when using Google Search. However, Briscoe and Rogers reported that the viewable number of results in Google Search is much lower than the number estimated by the search engine, and is often feasible to screen in full.[38] EBP also suggests logging out of personal Google accounts and clearing search histories and cookies in order to avoid personalisation of search results.[39, 40]

Detailed guidance on reporting web searching is presented in the MECIR standards,[73] CEE guidance,[65] PRISMA-S[4] and CRD guidance.[6] All these sources recommend that authors list all websites searched, the corresponding URL addresses, and the date searched.[4] In addition, PRISMA-S recommends that authors report whether they searched a website via the website search interface or via a search engine (e.g. via Google Search using the site command).[4] CEE[65] and CRD guidance,[6] and MECIR[73] also recommend reporting search terms, but peculiarly this is not stipulated in PRISMA-S.[4] The Cochrane Handbook v5.1 stipulated only that the names of "internet sources" should be listed and the date searched.[67] Realist guidance in RAMESES stipulates that reporting should be "sufficient" for the reader to know what was done, but does not state specifically what to report.[10]

In summary, as per forward citation searching, only a small selection of the available evidence on the conduct of web searching is cited in guidance manuals. Furthermore, guidance is framed around a standardised approach where web searches follow bibliographic database searches, rather than discussing approaches which challenge this model, as in Cooper et al.[24] Engagement with guidance on web searching is sparse within EBP, usually only to note its existence rather than to draw useful insights on conducting searches.[39, 40]

1.4.2. Epidemiology and characteristics of forward citation searching and web searching in systematic reviews

This section reviews literature related to the second objective of this thesis, which is to describe and evaluate the conduct and reporting of forward citation searching and web searching in published systematic reviews. Descriptive

accounts of search methods within systematic reviews are typically found in cross-sectional studies.[14-19, 80-86] This includes studies which focus specifically on searching,[15-17, 19, 80-82, 84-86] and studies which present descriptive accounts of systematic review methods more broadly, e.g. including data analysis methods.[14, 18, 83] In some such studies, the epidemiology and characteristics of searches for studies are evaluated, often with reference to guidance on best practice, including AMSTAR,[17, 19, 87] CASP,[17, 88] the CRD guidance manual,[6, 15] the Cochrane Handbook,[13, 15, 19, 80, 81, 86] NICE guidance,[15, 63] the PRISMA statement,[16-18, 47, 85] and RAMESES.[10, 14]

Almost all studies which report the epidemiology and characteristics of searches for studies focus on bibliographic database searches. However, basic detail about supplementary searches is sometimes reported, typically limited to the existence of supplementary search methods. Of studies which consider either forward citation searching or web searching, Berg and Nanavati reported that 20% (n=9) of realist reviews in a 10-year cross-sectional sample of MEDLINE reported using Google Search or other “grey literature search method”.[14] Layton reported that 9% (n=9) of systematic reviews in a 17-month cross-sectional sample of prosthodontic journals searched Google Scholar and 2% (n=2) searched Google Search.[17] Koffel et al. reported that 2% (n=5) of systematic reviews in a 12-month cross-sectional sample of paediatrics, cardiology and surgery journals reported web searching.[16] Page et al. reported that 12% (n=35) of systematic reviews in a 1-month cross-sectional sample of MEDLINE reported forward citation searching or “other” supplementary search method.[18] Yaylali et al. reported that 4% (n=3) of systematic reviews on the topic of endodontics in a 6 year cross-sectional sample of MEDLINE reported searching Google Scholar.[19]

Briscoe reported that 36% (n=108) of systematic reviews in a 10-year cross-sectional sample of systematic reviews indexed in the now defunct HTA database reported web searching using either a search engine (n=48, 16%) or website (n=88, 29%).[15] Of the systematic reviews that reported using a search engine, Google Search was the most frequently reported (n=21), followed by Copernic (n=17), Google Scholar (n=9), AltaVista (n=5) and Dogpile (n=2).[15] Briscoe also used guidance on searching for studies to evaluate whether the

detail reported about web searches was sufficiently transparent and reproducible.[15] In most systematic reviews, insufficient detail was reported.[15]

In summary, there is very little published evidence on the characteristics of forward citation or web searching in systematic reviews. Only Briscoe reports detailed analysis of web search reporting, which found that searches were typically poorly reported.[15] Briscoe is also the only study to use guidance to evaluate the conduct or reporting of supplementary search methods.[15] The existence of search methods is somewhat more discussed in the literature, generally finding that the use of forward citation searching and web searching is relatively infrequent in systematic reviews. Further studies are required to understand how these search methods are carried out in actual practice.

1.4.3. Qualitative research on expertise in systematic reviews.

A small number of studies have used qualitative methods to explore how systematic reviewers and expert searchers carry out searching and reviewing tasks.[53, 55, 56, 89] In this section, I review these studies with a specific focus on how they draw attention to the role of expert judgement in the otherwise rule-following domain of systematic reviews, which relates to the third objective of this thesis. Taken together, they show that systematic reviews require expertise which cannot be acquired through guidance or EBP, and that exploration of this phenomenon is very sparse within the domain of searching for studies.

At the time of writing, Cooper et al. is the only qualitative study – prior to the supporting articles in this thesis – to focus on searching for studies for systematic reviews.[89] Cooper et al. explored how systematic reviewers and expert searchers define the meaning of *effectiveness* of searches for studies for systematic reviews.[89] They claimed that, traditionally, effectiveness has been measured using diagnostic test accuracy metrics, namely sensitivity, specificity and precision, in relation to a gold standard test set of studies.[89] However, the development of new forms of systematic review requires different standards for understanding the effectiveness of searches; for example, rapid reviews may seek to identify a smaller set of studies than full systematic reviews, and theory-based reviews seek to identify themes or theories within studies which cannot be measured using a quantitative metric.[89] To explore these issues, Cooper et al. sent survey questions via email to 89 authors of published evaluations of the

effectiveness of searches for systematic reviews.[89] They received responses from 38 authors which were analysed thematically. Data analysis identified five understandings of the meaning of effectiveness: (i) effectiveness is described as a metric (i.e. the traditional understanding); (ii) effectiveness is a balance between metrics; (iii) effectiveness can be categorised by search purpose; (iv) effectiveness is an outcome; (v) effectiveness is an experimental concept.[89]

On systematic review methods more widely (i.e. not limited to searching for studies), Shepherd aimed to explore systematic reviewers' experiences of learning how to carry out systematic reviews.[56] In particular, Shepherd sought to understand the key challenges that reviewers face and how they deal with them.[56] Semi-structured interviews were undertaken with 17 systematic reviewers. Data analysis used a content analysis approach. Shepherd found that systematic reviewers most commonly learnt to carry out systematic reviews through training courses (n=10, 59%) or practice (n=11, 65%).[56] The latter was considered particularly helpful, and aided by contact with colleagues and mentors with experience of systematic reviews. Around half of the participants reported that written resources were part of their learning experience (n=9, 53%). The most commonly cited challenge of carrying out a systematic review was lack of resources and time (n=11, 65%). When asked about the best way of training systematic reviewers, practical experience and mentorship were considered important.[56]

Lorenc et al. used interviews to understand how systematic reviewers work with heterogeneous data, and the factors which influence their decisions.[53] They noted that, as systematic reviews increasingly seek to answer complex questions, the data they draw on are more heterogeneous, which poses challenges for evidence synthesis. Semi-structured interviews were undertaken with 19 systematic reviewers with experience of complex systematic reviews. They reported that the participants were aware of guidance for working with heterogeneous data, but considered that this should be used pragmatically in order to avoid uninformative conclusions. This required negotiating a difficult path between rigid application of rules and taking "an excessively lax approach", which would compromise the integrity of a systematic review.[53]

Finally, Moreira's ethnographic study sought to understand how researchers "disentangle" data from primary studies and re-present it in "qualified" form which is suitable for informing health care policy decisions. This involved observing researchers carrying out systematic reviews in a UK-research setting between 2002 and 2003. The research team included a director, a statistician, four systematic reviewers and one information scientist. Data collection involved fieldnotes, in-depth interviews, and tape-recordings of researcher discussions. Data analysis was interwoven with data collection, and used an analytic induction approach which sought to simultaneously "define the problem" and "fit all the evidence".[55] Moreira reported that, whereas policy makers present a public face of systematic reviews which emphasise unbiased decision making, there is also an undisclosed or supressed requirement for qualification of data which is unavoidably value-based and pragmatic in its approach.[55] Although an information scientist was part of the research team, there is no explicit mention of searching for studies in Moreira.[55]

These qualitative studies, although varied in focus, draw attention to the limitations of rule-following or formalised approaches to systematic reviews. In particular, the interview studies by Shepherd[56] and Lorenc et al.[53] both draw attention to the importance of practical understanding which is gained through experience, particularly when encountering complex problems for which guidance is unable to provide solutions. The interview format used by Lorenc et al.[53] and Shepherd[56] is particularly suited to drawing out the requirement for expertise, as this facilitates exploration of how systematic reviewers make decisions in their naturalistic settings, and which are not explicitly avowed in systematic reviews.[90] Similarly, but from an ethnographic perspective, Moreira draws attention to how systematic reviewers frame data to meet the requirements of policy customers.[55] Moreira shows how ethnography facilitates an understanding of how the technical work of systematic reviews intersects with more mundane tasks, including how the complexities of biomedical science are represented for public consumption within health policy and debate.[55] This approach is more polemical than the interview study approach used by Lorenc et al.[53] and Shepherd,[56] but similarly shows that rule-following approaches are insufficient in the conduct of systematic reviews.

Cooper et al. provides some insight on the role of expertise when searching for studies.[89] In particular, evidence that researchers judge effectiveness according to the outcome achieved intimates that *how* this is achieved (i.e. the processes or formalisation of methods) is a secondary consideration, which opens up a space for expert judgement which extends beyond the simple application of formalised approaches in guidance manuals. However, the use of survey data in Cooper et al. provide limited means for probing how these judgements are made. Thus, there is a need to further explore the role of expert judgement when searching for studies for systematic reviews, and to more explicitly draw out how this contrasts with current formalised approaches.[89] As per Lorenc et al.[53] and Shepherd,[56] interview methods are the most appropriate for this task.

1.5. Methods used in the supporting articles

The methods used for the majority of supporting articles are described in full within each article and summarised in Table 3. The exceptions are Booth et al. (1),[11] Lefebvre et al. (3)[3] and Lefebvre et al. (3S)[13] which are guidance articles, for which there is no methods section within the published articles. Thus, a short narrative summary of how these articles were written is provided below in Section 1.5.1 in addition to the detail in Table 3. Furthermore, in Section 1.5.2 additional detail is provided on the rationale for selecting hermeneutic phenomenological analysis and thematic network analysis for Briscoe et al. (7) and Briscoe et al. (8) respectively.

Table 3. Summary of methods used in supporting articles

Article number	Study design	Data source	Sample, n	Data collection	Data analysis
1	Guidance	Shared Endnote Library/Horizon scanning	n/a	n/a	n/a
2	Cross-sectional analysis	Cochrane reviews	423	Bespoke data-extraction form	Epidemiological and summary of characteristics
3/3S	Guidance	Shared Endnote Library/Horizon scanning	n/a	n/a	n/a
4	Cross-sectional analysis	Realist reviews	35	Bespoke data-extraction form	Epidemiological and summary of characteristics
5	Cross-sectional analysis	Cochrane reviews	198	Bespoke data-extraction form	Epidemiological and summary of characteristics
6	Cross-sectional analysis	Cochrane reviews	423	Bespoke data-extraction form	Epidemiological and summary of characteristics
7	Qualitative	Expert searchers	15	Semi-structured interviews	Hermeneutic phenomenological analysis
8	Qualitative	Expert searchers	15	Semi-structured interviews	Thematic network analysis
9	Cross-case analysis	Google Search results from SRs	2 SRs; 8 sets of search results	Documentation of search results	Summary of characteristics

Abbreviations: SR=systematic review

1.5.1 Additional detail on writing the guidance documents

I was invited by Andrew Booth to contribute to Booth et al. (1)[11] following a presentation I gave at the 2nd International Conference on Realist Evaluation and Synthesis (CARES).[91] Andrew Booth was commissioned to write the chapter by the editors of a planned monograph on realist methods, and invited Judy Wright and myself to co-author the chapter. We planned the chapter by telephone-call, and continued to meet by telephone-call throughout the writing process.

I was invited by Carol Lefebvre to contribute to Lefebvre et al. (3)[3] and Lefebvre et al. (3S)[13] following a presentation I gave on web searching at the InterTASC Information Specialist Sub-Group Workshop.[92] The team of co-authors discussed how to write the chapter via email and telephone-call. It was agreed to use the phrase “It is good practice” when recommending an approach to searching which was supported by evidence but not mandated by MECIR.[73] The chapter was peer reviewed by the Cochrane Information Retrieval Methods Group.

1.5.2 Additional detail on the rationale for using hermeneutic phenomenological analysis and thematic network analysis for the qualitative studies

Hermeneutic phenomenological analysis was used in Briscoe et al. (7)[57] due to the emphasis in this research method on seeking to understand how people make sense of their lived experiences, in particular, giving close attention to how they interpret situations that confront them.[93] This seemed appropriate for seeking to understand how expert searchers interpret situations in which forward citation searching or web searching are potentially useful, and how they develop and carry out their approach to searching. Hermeneutic phenomenology also afforded the opportunity to use the concept of *phronesis* (i.e. practical knowledge), which is used by phenomenologists such as Gadamer to describe how the way we understand the world is not fundamentally theoretical, but rather is shaped by our ability to act competently through practical knowledge gained from lived experiences.[94] Finally, Gadamer’s writing on hermeneutic phenomenology helpfully elucidates the concepts of the hermeneutic circle and fusion of horizons, which informed how

the analysis unfolded through reading and re-reading of interview transcripts to reach shared understandings amongst the study participants.[95, 96]

Thematic network analysis was used in Briscoe et al. (8)[62] as a way of organising themes relating to logistical challenges around a global theme.[97] Initially, the study aimed to use thematic analysis without the use of networks, however it became apparent during the analysis that there was a global theme (i.e. tension) around which the other themes were organised. The study emerged out of the data collected for Briscoe et al. (7) as it became clear that the participants were frequently sharing their perspectives on the logistical challenges of using forward citation searching and web searching despite this not being the main focus of Briscoe (7).[57] The use of themes was considered appropriate for Briscoe et al. (8)[62] as the analysis was at a relatively semantic level compared to the more in-depth analysis undertaken in Briscoe et al. (7).[57]

1.6. Findings and novel contributions of the supporting articles

In this section, the findings (or, in the case of guidance, the main points of relevance) and novel contributions to the field of the supporting articles are summarised.

1.6.1. Booth A, Wright JM, Briscoe S. Scoping and searching to support realist approaches. In: Emmel N, Greenhalgh J, Manzano A, Monaghan M, Dalkin S, editors. Doing Realist Research London: SAGE Publications; 2018.

Booth et al. (1) presents guidance on scoping and searching to support realist reviews.[11] The guidance is divided into six stages: formulating the question; background searches; searching for programme theories; search for empirical evidence; search to refine programme theories; and reporting the search process.[11] Guidance is further tailored to realist reviews through emphasis on the exploratory nature of searching, and the increased use of search methods such as citation searching and web searching alongside bibliographic databases. In particular, forward citation searching, web blogs, social media and web search engines are all recommended for identifying programme theories. The novel contribution of Booth et al. (1) was the attempt to formalise searches for studies and programme theories for realist reviews.[11] At the time of

writing, searching for realist reviews was informed by *ad hoc* adaptation of systematic review guidance, and guidance by Pawson et al. which presented an outline but with limited guidance on step-by-step approaches.[98] Booth et al. (1)[11] addressed this gap by providing tailored and in-depth guidance, particularly, at a critical time when realist reviews were being undertaken with increasing frequency.[61]

1.6.2. Briscoe S. A review of the reporting of web searching to identify studies for Cochrane systematic reviews. Res Synth Methods. 2018 Mar;9(1):89-99.

Of 423 Cochrane reviews published August 2016-January 2017, 61 (14%) reported using a search engine or website to search for studies. This included 24 reviews (6%) that reported searching one or more search engine, and 39 reviews (9%) that reported searching one or more website. The majority of these reviews reported the name of the search engines (96%) or websites (64%), but other details were less frequently reported. This included date of search (search engines=63%; websites=23%), URL (search engines=29%; websites=38%), search terms (search engines=21%; websites=13%) and number of results screened (search engines=21%; websites=8%). Thus, the reporting of web searching was not sufficiently transparent and reproducible in the majority of reviews. However, the reporting was still compliant with MECIR, which at the time of publication only required the reporting of the name of search engines or websites used.[73] At the time the Cochrane reviews were carried out, the Cochrane Handbook v5.1 only stipulated that the name of a search engine or website should be reported and the date accessed (or searched).[67] The novel contribution of Briscoe (2) was a descriptive account of the reporting of web search in Cochrane reviews which drew attention to shortcomings.[59] In particular, Briscoe (2) raised awareness amongst information specialists and systematic reviewers of the need to report web searching sufficiently, to which end the study also included recommendations for how to achieve this.[59] Only one other study evaluates the reporting of web searching in systematic reviews, specifically, Health Technology Assessment reviews, which was authored by myself.[15]

1.6.3. Lefebvre et al. Chapter 4: Searching for and selecting studies. In: Higgins et al., eds. Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3 (Updated February 2022); 2022 *and* Lefebvre et al. Technical Supplement to *ibid*.

1.6.3.1 Lefebvre C, Glanville J, Briscoe S, et al. Chapter 4: Searching for and selecting studies. In: Higgins J, Thomas J, Chandler J, et al., eds. Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3 (Updated February 2022); 2022

Section 4.5 of Lefebvre et al. (3) presents guidance on reporting searches for Cochrane reviews, including web searching.[3] This notes that the results of web searches will not be reproducible to the same extent as bibliographic databases because web content and search engine algorithms frequently change, but that it is still important to report web searches sufficiently for the searches to be transparent. To this end Section 4.5 refers to PRISMA-S, noting that this "provides enough detail and specific examples for systematic review authors to report search methods and information sources in a clear, reproducible way".[3] In addition, Section 4.5 stipulates that documenting the search terms used for sources other than databases (i.e. including websites and search engines) is required if searches are to be reproducible – which is a detail omitted from the web searching section of PRISMA-S.[3, 4] Section 4.5 also recommends that the number of results screened should be reported rather than the total identified when the total is too high to screen in full. This was a novel contribution to the Cochrane Handbook, which at the time of writing did not recommend reporting sufficient detail about web searching to ensure transparency.[3]

1.6.3.2. Lefebvre C, Glanville J, Briscoe S et al. Technical Supplement to Chapter 4: Searching for and selecting studies. In: Higgins J, Thomas J, Chandler J, et al., editors. Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3 (Updated February 2022); 2022.

Lefebvre et al. (3S)[13] is a supplement to Lefebvre et al. (3).[3] Sections 1.1.4 and 1.3.5 of Lefebvre et al. (3S) present guidance on forward citation searching and web searching respectively.[13] In particular, each section recommends good practice, with reference to EBP, on the conduct of these search methods for Cochrane reviews. In summary, Section 1.1.4 recommends that forward citation

searching is carried out using studies identified by searching bibliographic databases which meet the eligibility criteria for a systematic review. It notes that citation searching is particularly useful for reviews where keywords are hard to define, and can be used iteratively on studies identified by citation searching (i.e. snowballing). Section 1.3.5 recommends web searching is conducted using simplified versions of bibliographic database searches. In particular, multiple searches per web resource may be required to search a sufficient set of search terms due to basic search interfaces. It is recommended to log out of personal web accounts to avoid personalisation of results, and that screening may be limited to the first 100 results or until the prevalence of relevant results diminishes. The novel contribution of Lefebvre et al. (3S)[13] was a formalised approach to forward citation searching and web searching for Cochrane reviews, with reference to a much-expanded evidence-base since the previous edition of the Cochrane Handbook.[66] This resulted in more thorough and detailed guidance on using these search methods than previously available in the Cochrane Handbook.[67]

1.6.4. Booth A, Briscoe S, Wright JM. The "realist search": A systematic scoping review of current practice and reporting. Res Synth Methods. 2020 Jan;11(1):14-35.

Thirty-five realist reviews published in 2016 were included in Booth et al. (4).[61] Information specialists were co-authors of three identified reviews and acknowledged in 12 identified reviews. The majority of reviews appeared to use a comprehensive sampling approach to searching for studies (i.e. aimed to identify all relevant studies), but reviews which used a convenience sample, maximum-variation sample, snowball sample, purposive sampling, and theoretical sampling were also identified. Background searches were reported in 18 reviews as a way of sensitisation to the relevant literature. This included web searches using Google Scholar, searches for grey literature, and website searches of relevant organisations. Supplementary searches were reported narratively but not with the necessary detail to facilitate reproducibility. Similarly, iterative approaches to searching were reported in name (e.g. “we used an iterative approach”) but not in detail. The novel contribution of Booth et al. (4) was a descriptive account of searches for studies for realist reviews, which drew attention to iterative and exploratory approaches alongside more conventional

systematic searches for studies.[61] This highlighted areas of searching practice which had the potential to be developed in a more realist direction (e.g. more use of supplementary search methods) (see Booth et al. [1]),[11] and also highlighted where reporting needs improvement. One other study presents findings on the conduct and reporting of realist reviews in a similarly sized cross-sectional sample.[14] However, Berg et al. included descriptive detail of every aspect of the identified realist reviews rather than specifically focusing on searching for studies. Subsequently, they reported considerably less information on searching for studies.[14]

1.6.5. Briscoe S, Bethel A, Rogers M. Conduct and reporting of citation searching in Cochrane systematic reviews: A cross-sectional study. Res Synth Methods. 2020 Mar;11(2):169-180.

Of 198 Cochrane reviews published November 2016-January 2017, 172 (87%) reported backward citation searching and 18 (9%) reported forward citation searching. Of those which reported forward citation searching, 15 (83%) reported a named set of source studies, including: 8 (53%) reported using all included studies; 2 (13%) reported using “identified studies” (without stating explicitly whether these were included or not); 1 (7%) reported using topically relevant systematic reviews; and 5 (33%) reported using key studies of interest, including 2 (13%) which reported which studies were used. Fifteen reviews (83%) reported the name of the citation index used. One review reported using two citation indices. No reviews reported using snowballing approaches to citation searching. There are no MECIR standards on the conduct and reporting of forward citation searching with which to compare these results.[73] The novel contribution of Briscoe et al. (5) was a descriptive account of citation searching in Cochrane reviews.[60] This highlighted a potential need for more research and guidance on forward citation searching (partly fulfilled through Lefebvre et al. [3S]),[13] including on the reporting of searching, which lacked sufficient detail to ensure transparency. At the time of writing, Briscoe et al. (5) was unique in investigating the conduct and reporting of backward and forward citation searching in Cochrane reviews.[60] Booth et al. (4) was the only other cross-sectional investigation of searches for studies within a specific type of systematic review which also reported detail on these two search methods.[61]

1.6.6. Briscoe S, Nunns M, Shaw L. How do Cochrane authors conduct web searching to identify studies? Findings from a cross-sectional sample of Cochrane Reviews. Health Info Libr J. 2020 Dec;37(4):293-318.

Briscoe et al. (6)[37] uses the same cross-sectional sample as Briscoe (2).[59] Fifty of 61 reviews that reported web searching stated the aim of web searching: 41 aimed to identify grey literature and 9 aimed to identify published studies in journal article format. Web searching conduct was described using best-practice criteria derived from Lefebvre et al. (3S).[13] In summary, web searches were typically simplified versions of the bibliographic database searches. The median number of search terms used for search engines was 4 (range 3—13) and the median number of search terms used for websites was 5 (range 1-17). Searches using search engines combined either two or three PICO(S) components (either population and intervention, or population, intervention and study design).[99] Searches using websites sometimes used one PICO(S) component (either population or intervention). No web searches reported using phrase, truncation or proximity searching. Screening of Google Scholar searches was limited (range 100-500). No search results or screening limits were reported for Google Search. The mean number of websites searched per review was 2 (range 1-30). The findings reflect guidance in Lefebvre et al. (3S) in some respects, for example, simplified versions of bibliographic database searches were typically observed.[13] However, potentially advantageous approaches such as iterative searching were not widely reported. The novel contribution of Briscoe et al. (6) was a descriptive account of web searching conduct in Cochrane reviews.[37] This highlighted ways in which web searching could be developed more extensively (or indeed carried out at all) in Cochrane reviews. No equivalent descriptive account of web searching conduct has been published, although there are two related papers on the reporting of web searching (Briscoe [2][59] and Briscoe[15]).

1.6.7. Briscoe S, Abbott R, Melendez-Torres GJ. The phronesis of expert searchers on using forward citation searching and web searching to search for studies for systematic reviews: A hermeneutic phenomenological analysis. Journal of Information Science. 2022. 01655515221130237.

Fifteen expert searchers in health and social care settings agreed to be interviewed. The mean number of years' experience of participants was 15 (SD 5.99). Twelve participants were based in the UK, two were based in Canada and one was based in Germany. Analysis of interview data identified five habits of *phronesis* that guide searching for studies using forward citation searching and web searching. First, *outcome-oriented searching* prioritises the identification of relevant studies above how studies are identified. Participants contrasted outcome-oriented searching with *process-oriented searching*, which aims to show that a search fulfils the expected criteria for systematic searching. Process-oriented searching was based on rule-following, whereas outcome-oriented searching was predicated on expert judgement about how to achieve the desired outcome. Secondly, *persistent searching* uses multiple attempts to search a resource to identify relevant studies. This approach was sometimes contrasted with *comprehensive searching*, which typically aimed to search for all relevant studies using a single large-scale search of a resource. Thirdly, *adaptive searching,* which is closely related to persistent searching, involves incrementally altering a search with each new attempt at searching a resource to identify different results. Fourthly, *critically engaged searching* extends the searchers' involvement beyond the practical knowledge required to develop and carry out searches to a reviewer role in study selection. For example, searching and screening roles sometimes overlapped when carrying out forward citation searching or web searching. Finally, *holistic searching* seeks to ensure that search methods complement each other in such a way that is consistent with an overall plan. This was sometimes contrasted with the assemblage of long lists of search methods or resources without consideration of how they fit together. The novel contribution of Briscoe et al. (7) was an account of how rule-following approaches to searching have limited applicability, and how expert judgement which is resistant to explicit formalisation is used to develop and carry out searches for studies in situations where rule-following is not possible or helpful.[57] The findings drew attention to searching as an area of systematic reviews that is central to their credibility but as yet poorly understood in terms of its expert practice. At the time of writing, there were no studies of expert judgement when searching for studies which used qualitative methods for both data collection and analysis. The closest such study analysed free-text survey

data on expert views of effectiveness of searches for systematic reviews using thematic analysis.[89]

1.6.8. Briscoe S, Abbott R, Melendez-Torres GJ. Expert searchers identified time, team, technology and tension as challenges when carrying out supplementary searches for systeamtic reviews: A thematic network analysis. Health Info Libr J. 2022. Epub ahead of print.

Briscoe et al (8)[62] used the same interview data as Briscoe et al. (7).[57] Data analysis using thematic network analysis identified three organising themes characterising logistical challenges of forward citation searching and web searching, which were organised around the global theme of *tension*: *time*, *team* and *technology*. In summary, logistical challenges that related to time included three subthemes: allocating time, justifying time and keeping to time. Logistical challenges arising from team working included two subthemes: reviewer expectations and contact with review teams. Logistical challenges arising from technology included two subthemes: access to resources and reference management. The participants described how the logistical challenges of time, team and technology sometimes created tension between the expert searcher and the wider review team. The novel contribution of Briscoe et al. (8) was an account of how logistical challenges, which are relatively unseen in the formal write up of systematic reviews, can affect the way in which searches for studies develop and are carried out.[62] Based on the findings, the study recommended that expert searchers and review teams maintain good communication channels in order to facilitate improved working relationships and better quality searching. At the time of writing, studies on logistical challenges when searching for studies were limited to library-based contexts rather than systematic review research teams, and did not draw out in detail the specific challenges of supplementary searching.[100-102] Shepherd reported that time and resources were amongst the main challenges to completing a systematic review experienced by systematic reviewers.[56]

1.6.9. Briscoe S, Abbott R, Lawal H, Shaw L, Thompson Coon J. Feasibility and desirability of screening search results from Google Search exhaustively for systematic reviews: a cross-case analysis. Res Synth Methods. 2023 May;14(3):427-437.

In eight searches of Google Search carried out for two systematic reviews (SR1 and SR2), the mean number of estimated results for the six searches in SR1 was 9,798,667 (range 342,000-16,800,000) and the mean number of viewable results was 324 (range 272-364). The mean number of estimated results for the two searches for SR2 was 36,318,500 (range 337,000-72,000,000) and the mean number of viewable results was 326 (range 319-332). The number of journal articles was highest on page one (i.e. the first 100 results), and gradually diminished throughout subsequent pages of results. Journal articles which met the inclusion criteria were more likely to be identified in the first 100 results. Across the two reviews, Google Search retrieved two uniquely identified relevant studies. One was the 74th result of a search (SR2; grey literature item) and the other was the seventh result of a search (SR1; journal article). For the eight Google Search searches it was most desirable to screen at least the first 100 results in order to identify the two uniquely retrieved studies. It was also desirable to screen until the third page of results to identify all first appearances of relevant studies, as a potentially useful strategy for ensuring that studies were not missed by bibliographic databases. The novel contribution of Briscoe et al. (9)[58] was to further establish a recently developed approach for screening the results of web searches using Google Search, as set out in Briscoe and Rogers.[38] The recommended approach is a type of formalisation of web searching which uses evidence to challenge the received convention of using stopping-rules, such as limiting to the first 100 results.

1.7. Integration of the supporting articles

This section draws on the findings produced in fulfilment of objectives 1 to 3 to show how the supporting articles present an account of the gap between formalisation and expert judgement when using forward citation searching and web searching. In Section 1.7.1 I show how the supporting articles are interrelated. In Section 1.7.2 I show how the supporting articles point to the gap between formalisation and expert judgement. In Section 1.7.3 I discuss the implications for practice, in particular, how to bridge the gap between formalisation and expert judgement.

1.7.1. Descriptive account of how the supporting articles are interrelated

Figure 1 shows how the supporting articles are interrelated across the three areas of inquiry in this thesis (i.e. formalised, descriptive and exploratory accounts of practice), which map onto the three objectives.

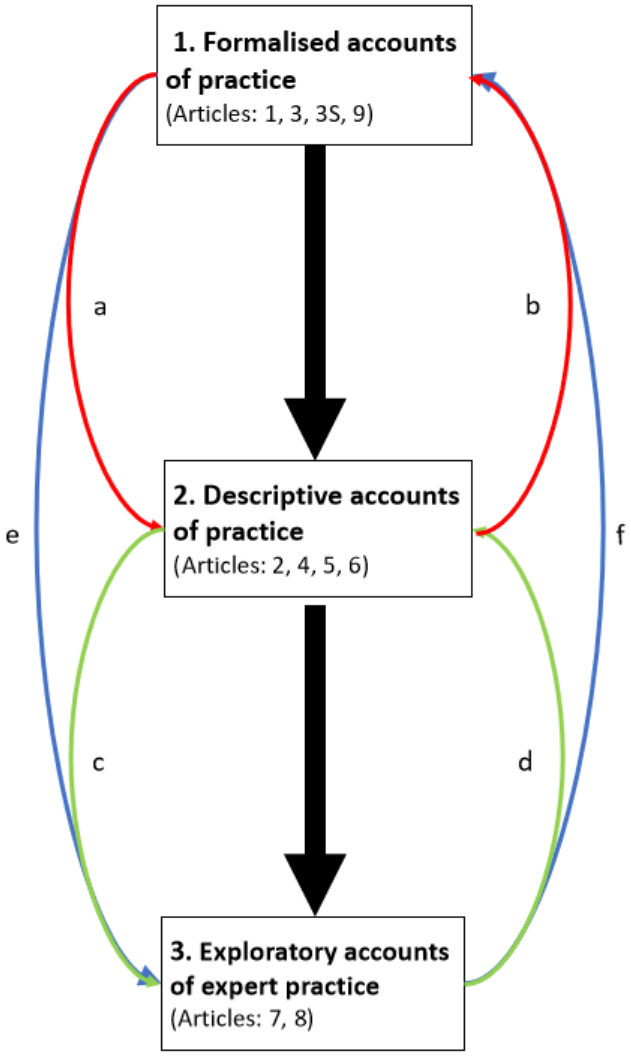

Figure 1. Interrelation of formalised, descriptive and exploratory accounts of practice.

a) Descriptive accounts of practice were evaluated using formalised accounts of practice; b) Formalised accounts of practice were informed by descriptive accounts of practice; c) Interview schedule development for exploratory accounts of practice were informed by descriptive accounts of practice; d) Descriptive accounts of practice can be interpreted using exploratory accounts of practice; e) Exploratory accounts of practice were informed by formalised accounts of practice; f) Exploratory accounts of practice can be used to evaluate the shortcomings of formalised accounts of practice.

The black arrows linking the three sets of supporting articles from 1-3 in Figure 1 are demonstrative of the sequential movement in this thesis between formalised, descriptive and exploratory accounts of practice. Contrastingly, the coloured arrows labelled a-f extend both forwards and backwards, reflecting

how supporting articles from later stages in the aforementioned sequential movement can be used to gain understanding of supporting articles in earlier stages and vice versa. In this respect, the thesis as a whole represents linked hermeneutic circles of gaining understanding by moving back and forth between different accounts of practice. Furthermore, the two types of document which comprise formalised accounts of practice (i.e. guidance and EBP) are interrelated through the process of interpretation of EBP to inform guidance, and the way in which guidance provides a framework through which EBP is interpreted. This is depicted as a hermeneutic circle in Figure 2, in which the development of guidance and EPB is a circular process wherein the formalisation of searching in guidance can both be supported and challenged by EBP. This, however, is an ideal situation which is not always realised, as the limited overlap of guidance and EBP evinced in the literature review.

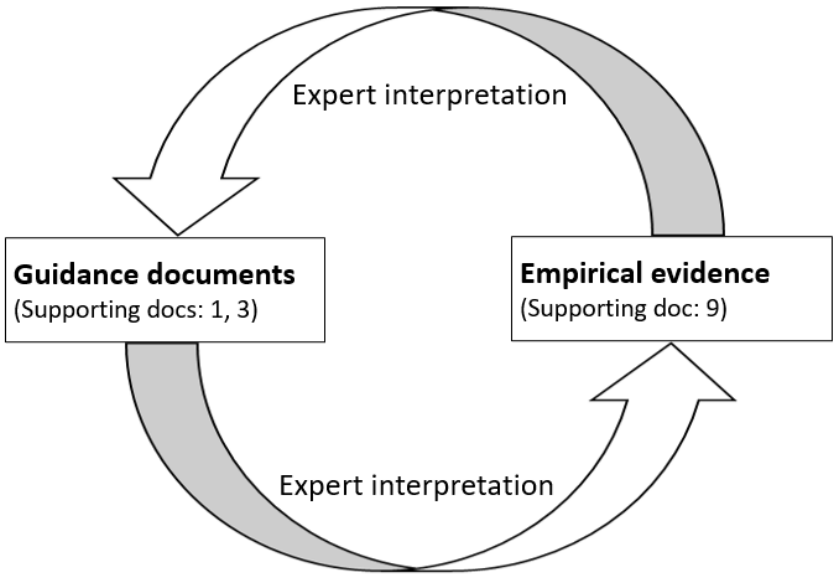

Figure 2. Expert interpretation of how to integrate guidance and empirical evidence

The supporting articles are linked by arrows a-f in Figure 1 in the following ways:

a) First, formalised accounts of practice were used as a basis for evaluating descriptive accounts of practice. Specifically, the guidance in Booth et al. (1)[11] and Lefebvre et al. (3S)[13] were used as a framework for data collection and analysis in Booth et al. (4)[61] and Briscoe et al. (6)[37] respectively.

b) Second, descriptive accounts of practice were used to inform the development of formalised accounts of practice. Specifically, Briscoe (2)[59] and Briscoe et al. (5)[60] were produced prior to Lefebvre et al. (3)[3] and Lefebvre et al. (3S),[13] and were used to gain understanding of how searching is carried out prior to the development of this guidance.

c) Third, the descriptive accounts of practice were used as context for the qualitative studies which comprise the exploratory accounts of expert practice. Specifically, awareness of actual practice gained from Briscoe (2),[59] Booth et al. (4),[61] Briscoe et al. (5)[60] and Briscoe et al. (6)[37] informed how the interviews unfolded.

d) Fourth, exploratory accounts of practice can be used to understand the challenges and limitations of descriptive accounts of practice. This is explored in Sections 1.7.2 and 1.7.3 below.

e) Fifth, formalised accounts of practice provide context for the qualitative studies which comprise the exploratory accounts of practice. Specifically, awareness of recommended formalised approaches presented in Booth et al. (1),[11] Lefebvre et al. (3)[3] and Lefebvre et al. (3S)[13] informed how the interviews unfolded.

f) Finally, exploratory accounts of practice were used to evaluate formalised accounts of practice. This is undertaken in the discussion section of Briscoe et al. (7),[57] and also in Sections 1.7.2 and 1.7.3 below.

Additional detail on how the exploratory accounts of practice are interrelated

The exploratory accounts of practice presented in Briscoe et al. (7)[57] and Briscoe et al. (8)[62] make use of different qualitative methodologies: hermeneutic phenomenological analysis and thematic network analysis. As noted in Section 1.5.2, the aim and analytical approach for each of these methodologies is different. This difference leads to distinct types of knowledge: The knowledge attained through hermeneutic phenomenological analysis in Briscoe et al. (7) is interpretive and resistant to explicit formalisation in terms of theory or formula;[57] in contrast, the knowledge attained through thematic network analysis in Briscoe et al. (8) is descriptive and framed in terms of explicitly formalised themes.[62] These differences are in part complementary, but are also in tension.

In comparing and contrasting the findings arising from these two different approaches, caution must be taken not to conflate one type of knowledge into the other. For example, the themes in Briscoe et al. (8) cannot be interpreted in terms of practically oriented *phronesis*;[62] similarly, the identified habits of *phronesis* in Briscoe et al. (7)[57] cannot be conceptualised as themes for the purpose of comparison with themes in Briscoe et al. (8).[62] However, despite these differences, the findings from these two studies may complement each other by providing insights into a shared phenomenon of interest, i.e. the need to exercise judgement when searching for studies which is not typically encapsulated in formalised guidance or descriptive accounts of searching in published systematic reviews.

1.7.2. The gap between formalisation and expert judgement

Viewed together, the supporting articles show that formalised accounts of forward citation searching and web searching in guidance, and descriptive accounts in systematic reviews, provide only a partial account of why and how searches are carried out in practice. An important reason why this occurs is the requirement for expert judgement, which is neither encapsulated in guidance nor reported in systematic reviews. However, there is also a preliminary gap between formalised accounts in guidance and descriptive accounts in systematic reviews. This needs to be considered first as the context for the gap between formalisation and expert judgement.

1.7.2.1. The gap between formalised and descriptive accounts of practice

The gap between formalised and descriptive accounts of forward citation searching and web searching is first apparent in how descriptive accounts often fail to report the necessary detail recommended by guidance for ensuring transparency and reproducibility. For example, Briscoe (2)[59] found that web searches in Cochrane reviews did not report the minimal detail required by the contemporaneous Cochrane Handbook v5.1[67] and MECIR standards;[73] nor, by implication, the more recent and detailed guidance in Lefebvre et al. (3).[3] Similarly, Booth et al. (4) found that searches for studies in realist reviews (including forward citation searching and web searching) were not reported in sufficient detail to facilitate reproducibility.[61] Wider evidence of suboptimal reporting of supplementary searching[15] and bibliographic database searches[16,

[84] show these findings are not isolated. In a less prescriptive approach than Lefebvre et al. (3),[3] realist review guidance in Booth et al. (1) recommends reporting relevant detail wherever possible, but acknowledges this is challenging due to the iterative and exploratory nature of realist reviews.[11] Similarly, reporting guidance in RAMESES lacks specifics of what to report, stating only that reporting should be "sufficient" to see what was done.[10] This difference between Cochrane reviews and realist reviews may reflect that aggregative and configurative reviews differ with respect to reporting expectations as well as conduct.[5]

There are also examples of descriptive accounts of practice in both Cochrane reviews (2 and 5)[59, 60] and realist reviews (4)[61] which exceed the reporting requirements in guidance. These examples suggest what is possible when making recommendations in guidance. However, even here, the exploratory elements of searching required for realist reviews are not typically transparently reported (4).[61]

Secondly, the gap between formalised and descriptive accounts is apparent in differences between recommended and actual conduct. This was difficult to ascertain due to limited detail in reviews. However, in Briscoe et al. (5)[60] and Briscoe et al. (6),[37] the fact that a minority of Cochrane reviews reported forward citation searching (n=18; 9%) and web searching (n=61; 14%) is surprising given the recommendations (albeit tentative) to use them in the contemporaneous Cochrane Handbook v5.1.[67] Low uptake of these search methods is also reported in other cross-sectional analyses.[16, 18] Evaluation of web searching conduct in Briscoe et al. (6)[37] with reference to Lefebvre et al. (3S)[13] showed that web searches did sometimes reflect this guidance, including multiple iterations of searches, use of simplified versions of bibliographic database searches, and use of stopping-rules for search engines.[37] There were also noticeable differences; for example, Lefebvre et al. (3S) recommends several different search engines, whereas only Google search engines are reported in Briscoe et al. (6).[37] With respect to realist reviews, Booth et al. (4)[61] acknowledged the relative paucity of detailed guidance on searching for realist reviews prior to Booth et al. (1),[11] which – despite a rudimentary framework in Pawson et al.[64, 98] – left review authors to develop their own approaches. Booth et al. (4) also acknowledged that realist reviews require a flexible approach for

which step-by-step guidance may not be helpful.[61] However, Booth et al. (4) still found that large scale comprehensive bibliographic database searches were widely reported, and advocated that more use of supplementary search methods might be beneficial.[61]

Finally, there are gaps between guidance and EBP, which may partly be accounted for by the challenge of incorporating heterogeneous methodological studies into guidance,[71] and by the fact that new EBP takes time to incorporate into guidance, e.g. Briscoe et al. (9).[58] Relatedly, guidance typically recommends a conventional model of searching which focuses on bibliographic database searching despite EBP sometimes challenging this model. For example, EBP where supplementary search methods are used more prominently than bibliographic databases is not always reflected in guidance.[24, 28] This further contributes to the gap between EBP and guidance. The gap between novel EBP and conventional guidance is discussed more in the next section.

1.7.2.2. The gap between formalisation and expert judgement

The existence of EBP which challenges guidance may be indicative of the start of a paradigm shift away from one paradigm of searching to another[103] – in Kuhn's terms, the *normal science* of searching for studies, as set out in formalised guidance, is still apparent, but the *extraordinary science* proposed in some accounts of EBP challenges this.[24, 28, 70] The cause of this paradigm shift may be the increase in complexity of reviews,[53] with respect to both aggregative and configurative review types, and emergence of other review types such as rapid review,[28, 89] which require new approaches to searching. In these scenarios, not only are explicit formalisations of searching challenged, but also the expertise required to carry out searches is challenged. The qualitative research in this thesis draws out the hidden complexities that experts navigate when encountering situations where conventional approaches are inadequate (7, 8).[53, 57, 62] This does not mean that expert judgement is *only* required in situations where novel approaches are used; for example, Moreira's ethnography of a systematic review team appears to describe conventional systematic review conduct which nonetheless demands expert judgement due to external factors such as the needs of policy customers.[55] Thus, whether

established or new approaches to systematic review are used, there is a potential requirement for expertise which is not explicitly avowed in guidance or published systematic reviews.

Briscoe (7) et al. described how such expert judgement, conceptualised as *phronesis*, shapes the conduct of searches for studies for systematic reviews when using forward citation searching and web searching.[57] The Greek term *phronesis*, as used by Aristotle, describes practical knowledge which can only be learnt through exposure to real world situations, as opposed to technical knowledge which is learnt by studying abstract rules and formulae.[57] The analysis in Briscoe et al. (7) identified five habits of *phronesis* which were presented in a schematic diagram reproduced here in Figure 3.[57] Outcome-oriented, persistent and adaptive approaches describe how searches are carried out; critically engaged describes the dual process of searching and screening the results of searches; and holistic approaches concern the overall approach to searching in conjunction with other search methods.[57] Furthermore, the three searching habits (i.e. outcome-oriented, persistent and adaptive) were shown to contrast with conventional systematic review approaches, specifically process-oriented, exhaustive and uniform approaches to searching – each of which points to a gap between formalised approaches to searching and expert judgement.

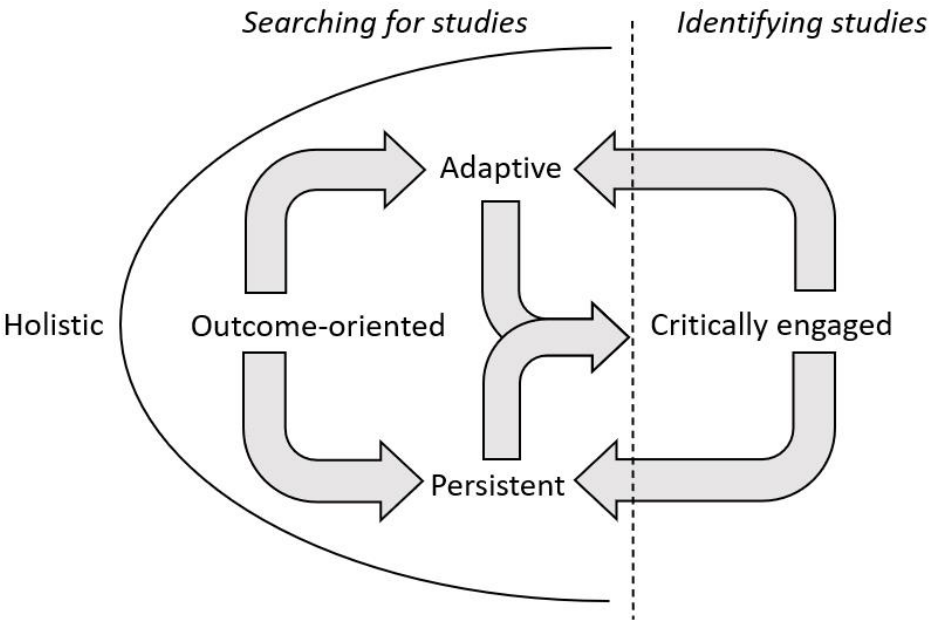

Figure 3. Habits of phronesis when searching for studies using forward citation searching and web searching

The identification of *phronesis* provides a critical perspective from which to view the gap between expertise and formalised accounts of practice, such as in searching guidance (1, 3, 3S),[3, 11, 13] EBP (9)[58] and cross-sectional analyses of searching conduct (4, 5, 6).[37, 59, 61] Regarding guidance, Briscoe et al. (7)[57] suggests that a prescriptive approach, such as Lefebvre et al.'s (3S)[13] use of the phrase "it is good practice to…" (see Section 1.5), may be unhelpful for expert searchers if this cannot be flexibly interpreted on a case-by-case basis. By contrast, Booth et al. (1) is more interpretive and flexible, stating that "there are no prescriptive rules about when to use a particular approach [to searching for realist reviews], only that you explain the logic of your approach".[11] However, the reader must know when and how to implement guidance, and decide between different options. Sometimes implementation will depend on hitherto unarticulated *phronesis* described in Briscoe et al. (7).[57] Similarly, EBP must be interpreted by the searcher – as noted by Hirt et al., it is unlikely that the mechanical application of EBP as presented in case studies will lead to the same results when repeated in different contexts.[71] This includes both conventional approaches and novel approaches such as set out in Briscoe et al. (9),[58] Booth et al,[61] Cooper et al.[24] and Levay et al.[28] Thus, whether formalised accounts of searching are prescriptive or relatively flexible, a gap between formalisation and expert judgement is still apparent.

The problems associated with explicitly defining a formalised approach to searching also challenges the reporting of searches – particularly where this attempts to map onto formalised accounts in guidance, despite the more iterative and exploratory approaches that may have been used. Both Briscoe et al. (7)[57] and Briscoe et al. (8)[62] suggest that descriptive accounts of forward citation searching and web searching in systematic reviews may only be a partial account of actual practice due to these unavowed elements of searching conduct.

1.7.3. How to bridge the gap: Implications for practice

1.7.3.1. Bridging the gap between formalised and descriptive accounts of practice

In a relatively superficial sense, a gap between formalised and descriptive accounts of practice accrues from insufficiently detailed guidance on the

reporting of searches, and suboptimal reporting in systematic reviews. Two implications of this are that, first, guidance needs to be clearer about what to report, and, secondly, review authors must be prepared to report this detail. To this end, more detailed web search reporting for Cochrane reviews is recommended in Lefebvre et al. (3)[3] (and proposed in Briscoe et al. (5) for forward citation searching[60]), and more detailed guidance is increasingly available for other reviews.[4, 6, 65] Contrastingly, Booth et al. (1) acknowledges that iterative and exploratory searching is challenging to report.[11] Nonetheless, sufficient detail must be reported for a review to be defensible – RAMESES guidance describes this in general terms as "sufficient to know what was done",[10] but whether and how this is achievable for exploratory and iterative searching needs stating more clearly (4).[61] This is one area in which configurative review guidance is less clear than aggregative review guidance. Hirt et al.'s Delphi survey on best practices for backward and forward citation searching, which is not published at the time of writing, may also contribute to improved guidance.[48]

Furthermore, developers of guidance should consider how to incorporate into guidance EBP which challenges conventional searching.[24, 28, 58, 70] There is a role for expert judgement in this context, specifically, for experts who produce guidance to consider how to most appropriately develop guidance which makes full use of EBP, including where this challenges conventional approaches (Figure 2). This may also help to close the gap between guidance and actual conduct, by eliminating the expectation that searchers follow conventional approaches. However, as previously discussed in Section 1.7.2.2, there are challenges in incorporating the practical understanding required to make sense of non-conventional approaches into guidance.

1.7.3.2. Bridging the gap between formalisation and expert judgement

As more formalisations of searching are presented in EBP, the emphasis in guidance may need to move away from prescriptive approaches to flexible and interpretive approaches which leave the searcher to decide how to adapt the various options available. As noted above, this may be an example of a shift from an established to a reconfigured normal science via the emergence of extraordinary practices which become increasingly standardised.[103] This was

partly achieved in Booth et al. (1) for realist reviews,[11] which provides suggestions on how to search whilst leaving the searcher to determine the most appropriate approach on a case-by-case basis, including approaches to searching which challenge conventions. Here, formalisation of guidance is less about rule-following, and more about the framework within which searching takes place. Importantly, the need for such a shift in perspective is not limited to configurative reviews – at least two case studies of non-conventional approaches are aggregative reviews.[24, 28] However, there is an additional challenge, which is how to convey the expertise required to know when and how to undertake different approaches to searching (see Section 1.7.2.2). Thus, even within a revised framework for searching, there remains the need to consider how to bridge the gap between formalisation and expert judgement. The remainder of this section will consider the prospect of integrating elements of expert judgement learnt from qualitative research into formalised accounts of searching for studies.

In Section 1.7.2.2 the findings of Briscoe et al. (7) on the *phronesis* of expert searchers when using forward citation searching and web searching were depicted in a schematic diagram (Figure 3).[57] Of the three searching habits (i.e. outcome-oriented, persistent and adaptable), outcome-oriented searching was described in Briscoe et al. (7) as the *main factor determining whether searches were carried out*.[57] It was also noted in Briscoe et al. (7) that by focusing on the outcome of searching rather than the process of searching, outcome-oriented searching *explicitly challenges the ideal of methodological rigour when carrying out a systematic review to a greater degree than other identified habits*.[57] Thus, outcome-oriented searching is both central to *phronesis,* and contrasts strongly with approaches to searching which prioritise processes – for example, as sometimes set out in formalised approaches to searching in guidance. If the gap between formalisation and expert judgement is to be bridged, outcome-oriented searching may be a good starting point for thinking about how formalised approaches must be adapted to take account of expert judgement.

One implication of outcome-oriented searching may be that guidance on using forward citation searching and web searching should be framed in terms of the purpose of searching (with reference to the type of systematic review that is

being undertaken), rather than around what good practice entails in terms of specific processes (as in Lefebvre et al. [3]),[13] or requiring the reader to choose between different approaches to searching (as in Booth et al. [1]).[11] Other habits of *phronesis* identified in Briscoe et al. (7) could also be described within this framework.[57] This may appear similar to specifying the sampling approach that a search is aiming to achieve, e.g. whether exhaustive, as in Cochrane reviews (3)[3], or convenience, maximum-variation, snowball, purposive or theoretical sampling, as described in Booth et al. (4) with respect to realist reviews.[61] However, whereas sampling approaches describe the *aim of searching*, the habits of *phronesis* describe the *practical understanding which informs how searching is undertaken*. This is not necessarily to the exclusion of recommending or suggesting approaches to searching that can be used, but to acknowledge that such approaches require additional practical understanding to be carried out proficiently. In the Aristotelian tradition to which *phronesis* is traced, this may be described as a teleological account of searching for studies, in which a shared practical understanding within a community of practice is necessary for the successful pursuit of the end goal.[104]

There are significant challenges to achieving this, which are implicit in the notion that *phronesis* is resistant to explicit formalisation. However, it may be possible to preface specific options for searching in guidance with a short discussion of how outcome-oriented considerations provide a framework for searching decisions. Either in the same place, or at appropriate points throughout guidance, it may also be possible to describe other habits of *phronesis,* such as persistent and adaptable searching, and critically engaged and holistic approaches. Although this may appear a minor suggestion, it nonetheless challenges conventional approaches to systematic searching such as process-oriented, exhaustive and uniform, and brings to the foreground the practical understanding of expert searchers on how to most appropriately carry out forward citation searching and web searching (7).[57] More research is required to further establish the role of *phronesis* beyond forward citation searching and web searching in the full-spectrum of searches for studies.

However, by definition, there is no substitute for repeated immersion in searching for studies to learn the habits of *phronesis*. Repeated practice is therefore a requirement of gaining the practical understanding which underpins

searching decisions. Thus, the gap between formalisation and expert judgement cannot be bridged to the degree that all the required expertise is encapsulated in guidance.[105] This means that isolated individuals cannot learn solely from guidance how to carry out searching for systematic reviews. Indeed this may not have been achievable even with more prescriptive forms of guidance for relatively simple systematic reviews. As per other scientific disciplines, there is an important role for training amongst a community of practitioners who are custodians of their specialism.[106] Mentorship and close working with experienced practitioners has been highlighted as central to successful training as a systematic reviewer.[56] Furthermore, guidance should continue to recommend that systematic review teams consult an experienced expert searcher if they do not have one within their team.[1, 3]

In addition to changes to guidance, descriptive accounts of forward citation searching and web searching in systematic reviews must supply more than the minimum level of detail of what was done, including narrative detail of how the approach was developed and carried out. Aspects of searching may still not be reported entirely transparently, but there should be more effort than currently visible to capture why certain decisions are made. This may partly be achieved through search narratives which describe how a search was developed.[107, 108] This may also help to capture unanticipated logistical challenges that arise during the searching process as described in Briscoe et al. (8).[62]

1.7.4. Strengths and limitations

A main strength of this thesis is that the focus on two search methods has afforded a greater depth of analysis than would have been possible by considering search methods more broadly. This is further strengthened by considering these search methods in the context of two very different types of systematic review, namely, Cochrane reviews and realist reviews, which can be seen as exemplars of aggregative and configurative reviews respectively.[5] Conversely, by focusing only on two search methods, the scope for deriving implications for search methods (i.e. bridging the gap between formalisation and expert judgement) is more limited than if searching for studies had been considered more broadly. Not least, it is a limitation that the thesis does not include investigation of the gap between formalisation and expert judgement

when searching bibliographic databases, which are typically the main source of studies for systematic reviews. Furthermore, as automated methods are increasingly used in systematic reviews, this may also create challenges for developing formalised approaches to searching which are appropriately sensitive to the need for expert judgement.[109] Future studies on the gap between formalisation and expert judgement, and how to bridge this gap, could usefully focus on bibliographic databases and automated approaches to searching for studies.

A second strength of the thesis is the inclusion of studies which use qualitative methods to investigate searching for studies. Prior to the publication of Briscoe et al. (7)[57] and Briscoe et al. (8),[62] existing qualitative research on searching for studies was relatively limited.[89] Furthermore, by comparing and contrasting the findings of studies which use very different methods (including cross-sectional analyses and qualitative methods), the thesis draws out insights into searching conduct and reporting that extend beyond any of the studies individually. A potential limitation in the qualitative studies is the relatively homogenous selection of participants, most of whom were based in the UK and all of whom were based in high-income countries. Thus, there was limited scope to ascertain whether expert judgement varied between geographical settings, and no scope to consider differences between high- and middle- or low-income countries. Additionally, almost all participants were highly experienced practitioners of searching for studies for systematic reviews; thus there was limited scope to consider whether less experienced practitioners approach the challenges of complex situations which require expert judgement differently to more experienced practitioners. This might have helped to draw out more negative cases where participants were reluctant to use expert judgement, of which there are few examples in Briscoe et al. (7).[57]

Finally, the findings of the thesis are limited to systematic reviews in the fields of health and social care. Additional research is required to ascertain whether gaps between formalisation and expert judgement are apparent in systematic reviews in other fields of research.

1.8. Conclusion

Searching for studies for systematic reviews may be entering a new era of complexity which requires new forms of guidance, descriptive detail in published systematic reviews, and increased awareness of the role of practical understanding shaped by expertise. Addressing these issues will require moving away from prescriptive forms of guidance to more flexible and interpretive forms. However, this is only part of the solution. In addition, guidance needs to reflect the *phronesis* required to operate successfully in this new environment. A continuing, and perhaps increased, awareness of the importance of learning within a supportive community of expert practitioners is also key to success in this new era of searching for studies.

1.9. Candidate's contribution to supporting articles

This section summarises the candidate's contribution to the supporting articles (see Table 1 for citation details for each article alongside corresponding numerical label).

Article 1. I co-authored this book chapter. This included contributing to the initial draft, commenting on the final draft, and responding to peer review comments. Writing of sections within the chapter were divided equally between co-authors. Andrew Booth led on the design and final revision of the chapter. Final approval was the responsibility of the senior monograph editors.

Article 2. I am sole author of this article.

Article 3. There is one relevant section in this book chapter: Section 4.5 on Documenting and Reporting the Search Process. I co-authored this section with Maria-Inti Metzendorf. This section was a major revision of Section 6.6 of the previous version of the Cochrane Handbook.[67] My contribution included revising and writing updated guidance, with particular responsibility for detail on web searching, and responding to peer review comments. Final approval was the responsibility of lead chapter authors and the Cochrane Handbook senior editors.

Articles 3S. There are two relevant sections in this article: Section 1.1.4 on citation indices and Section 1.3.5 on web searching. I was the lead author of

both sections, which are major revisions of Section 6.2.1.6 and Section 6.2.2.6 in the Cochrane Handbook v5.1.[67] My contribution included revising and writing updated guidance and responding to peer review comments. Final approval was the responsibility of lead chapter authors and the Cochrane Handbook senior editors.

Article 4. I contributed to data collection, data analysis and interpretation, drafting the article and reading and commenting on the final draft. These tasks were divided equally between the co-authors according to section headings. The article was conceived by Andrew Booth.

Article 5. I conceived and designed this study, and led and carried out all stages including data collection, data analysis and interpretation, drafting the article and final draft of the article. Alison Bethel and Morwenna Rogers contributed to data collection and read and commented on the final draft.

Article 6. I conceived and designed the study and led and carried out all stages including data collection, data analysis and interpretation, drafting the article and final draft of the article. Michael Nunns contributed to the presentation of results and commented on the final draft. Liz Shaw sense-checked the framework of key principles and commented on the final draft.

Article 7. I contributed to the conceptualisation and design of the study, and carried out all stages including data collection, data analysis and interpretation, drafting the article and final version of the article. G.J. Melendez-Torres and Rebecca Abbott contributed to conceptualisation and design of the study, supervised all stages, and commented on the final draft.

Article 8. I contributed to the conceptualisation and design of the study, and carried out all stages including data collection, data analysis and interpretation, drafting the article and final version of the article. G.J. Melendez-Torres and Rebecca Abbott contributed to conceptualisation and design of the study, supervised all stages, and commented on the final draft.

Article 9. I conceived and designed the study and led and carried out all stages including data collection, data analysis and interpretation, drafting the article and final draft of the article. Rebecca Abbott and Hassanat Lawal contributed to

data analysis and commented on the final draft. Liz Shaw and Jo Thompson Coon commented on the final draft.

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Chapter 2. Article 1

Booth A, Wright JM, Briscoe S. Scoping and searching to support realist approaches. In: Emmel N, Greenhalgh J, Manzano A, Monaghan M, Dalkin S, editors. Doing Realist Research London: SAGE Publications; 2018.

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Chapter 3. Article 2

Briscoe S. A review of the reporting of web searching to identify studies for Cochrane systematic reviews. Res Synth Methods. 2018 Mar;9(1):89-99. doi: 10.1002/jrsm.1275.

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Chapter 4. Article 3

Lefebvre C, Glanville J, Briscoe S, Littlewood A, Marshall C, Metzendorf M-I, et al. Chapter 4: Searching for and selecting studies. In: Higgins J, Thomas J, Chandler J, Cumpston M, Li T, Page M, et al., editors. Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3 (Updated February 2022): Cochrane; 2022.

The relevant text in this chapter is Section 4.5 titled "Documenting and reporting the search process".

The references for this chapter are provided in full in back matter headed "References for articles 3 and 3S".

identified (Booth 2016). The reasons for stopping need to be documented and it is suggested that explanations or justifications for stopping may centre around saturation (Booth 2016). Further information on searches for qualitative evidence can be found in Chapter 21.

4.5 Documenting and reporting the search process

Review authors should document the search process in enough detail to ensure that it can be reported correctly in the review (see MECIR Box 4.5.a). The searches of all the databases should be reproducible to the extent that this is possible. By documenting the search process, we refer to internal record-keeping, which is distinct from reporting the search process in the review (discussed in online Chapter III).

MECIR Box 4.5.a Relevant expectations for conduct of intervention reviews

C36: Documenting the search process (**Mandatory**)	
Document the search process in enough detail to ensure that it can be reported correctly in the review.	The search process (including the sources searched, when, by whom, and using which terms) needs to be documented in enough detail throughout the process to ensure that it can be reported correctly in the review, to the extent that all the searches of all the databases are reproducible.

Medical/healthcare librarians and information specialists involved with the review should draft, or at least comment on, the search strategy sections of the review prior to publication.

Suboptimal reporting of systematic review search activities and methods has been observed (Sampson et al 2008, Roundtree et al 2009, Niederstadt and Droste 2010). Research has also shown a lack of compliance with guidance in the *Handbook* with respect to search strategy description in published Cochrane Reviews (Sampson and McGowan 2006, Yoshii et al 2009, Franco et al 2018). The lack of consensus regarding optimal reporting has been a challenge with respect to the values of transparency and reproducibility. The PRISMA-Search (PRISMA-S) Extension (Rethlefsen et al 2021), an extension to the PRISMA Statement (Page et al 2021a, Page et al 2021b), addresses the reporting of search strategies in systematic reviews. PRISMA-S (together with the major revision of PRISMA itself) provides enough detail and specific examples for systematic review authors to report search methods and information sources in a clear, reproducible way. In Box 2 of the PRISMA 2020 guidance under "Noteworthy changes to the PRISMA 2009 statement" the guidance has been strengthened to stipulate: "Modification of the 'Search' item to recommend authors present full search strategies for all databases, registers and websites searched, not just at least one database (see item #7)". This brings the

PRISMA 2020 guidance more into line with Cochrane standards for reporting of database search strategies.

There is also a recommendation in the PRISMA 2020 guidance (see item 27) that "authors state whether data used in the review are publicly available and if so, where they can be accessed"(Page et al 2021a). These recommendations may influence record keeping practices of searchers.

It is recommended that review authors seek guidance from their medical/healthcare librarian or information specialist at the earliest opportunity with respect to documenting the search process (Rethlefsen et al 2015, Meert et al 2016). For Cochrane Reviews, the bibliographic database search strategies should be copied and pasted into an appendix exactly as run and in full, together with the search set numbers and the total number of records retrieved by each search strategy. The search strategies should not be re-typed, because this can introduce errors. The same process is also good practice for searches of trials registers and other sources, where the interface used, such as introductory or advanced, should also be specified. Creating a report of the search process can be accomplished through methodical documentation of the steps taken by the searcher. This need not be onerous if suitable record keeping is performed during the process of the search, but it can be nearly impossible to recreate post hoc. Many database interfaces have facilities for search strategies to be saved online or to be emailed; an offline copy in text format should also be saved. For some databases, taking and saving a screenshot of the search may be the most practical approach (Rader et al 2014).

Documenting the searching of sources other than databases, including the search terms used, is also required if searches are to be reproducible (Atkinson et al 2015, Chow 2015, Witkowski and Aldhouse 2015).

Details about contacting experts or manufacturers, searching reference lists, scanning websites, and decisions about search iterations can be produced as an appendix in the final document and used for future updates. The purpose of search documentation is transparency, internal assessment, and reference for any future update. It is important to plan how to record searching of sources other than databases since some activities (contacting experts, reference list searching, and forward citation searching) will occur later on in the review process after the database results have been screened (Rader et al 2014). The searcher should record any correspondence on key decisions and report a summary of this correspondence alongside the search strategy in a search narrative. The narrative describes the major decisions that shaped the strategy and can give a peer reviewer an insight into the rationale for the search approach (Craven and Levay 2011). A worked example of a search narrative is available (Cooper et al 2018b).

It is particularly important to save locally or file print copies of any information found on the Internet, such as information about ongoing and/or unpublished trials, as this information may

no longer be accessible at the time the review is written. Local copies should be stored in a structured way to allow retrieval when needed. There are also web-based tools which archive webpage content for future reference, such as WebCite (Eysenbach and Trudel 2005). The results of web searches will not be reproducible to the same extent as bibliographic database searches because web content and search engine algorithms frequently change, and search results can differ between users due to a general move towards localization and personalization (Cooper et al 2021b). It is still important, however, to document the search process to ensure that the methods used can be transparently reported (Briscoe 2018). In cases where a search engine retrieves more results than it is practical to screen in full (it is rarely practical to search thousands of web results, as the precision of web searches is likely to be relatively low), the number of results that are documented and reported should be the number that were screened rather than the total number (Dellavalle et al 2003, Bramer 2016).

Decisions should be documented for all records identified by the search. Details of the flow of studies from the number(s) of references identified in the search to the number of studies included in the review will need to be reported in the final review, ideally using a flow diagram such as that proposed in the PRISMA guidance (see online Chapter III); these can be generated using software including Covidence, DistillerSR, EPPI-Reviewer, the METAGEAR package for R, the PRISMA Flow Diagram Generator, and RevMan. A table of 'Characteristics of excluded studies' will also need to be presented (see Section 4.6.5). Numbers of records are sufficient for exclusions based on initial screening of titles and abstracts. Broad categorizations are sufficient for records classed as potentially eligible during an initial screen of the full text. Authors will need to decide for each review when to map records to studies (if multiple records refer to one study). The flow diagram records initially the total number of records retrieved from various sources, then the total number of studies to which these records relate. Review authors need to match the various records to the various studies in order to complete the flow diagram correctly. Lists of included and excluded studies must be based on studies rather than records (see also Section 4.6.1).

4.6 Selecting studies

4.6.1 Studies (not reports) as the unit of interest

A Cochrane Review is a review of studies that meet pre-specified eligibility criteria. Since each study may have been reported in several articles, abstracts or other reports, an extensive search for studies for the review may identify many reports for each potentially relevant study. Two distinct processes are therefore required to determine which studies can be included in the review. One is to link together multiple reports of the same study; and the other is to use the information available in the various reports to determine which studies are eligible for inclusion. Although sometimes there is a single report for each study, it should never be assumed that this is the case.

Chapter 5. Article 3S

Lefebvre C, Glanville J, Briscoe S, Littlewood A, Marshall C, Metzendorf M-I, et al. Technical Supplement to Chapter 4: Searching for and selecting studies. In: Higgins J, Thomas J, Chandler J, Cumpston M, Li T, Page M, et al., editors. Cochrane Handbook for Systematic Reviews of Interventions. Version 6.3 (Updated February 2022): Cochrane; 2022.

The relevant text in this chapter is Section 1.1.4 titled "Citation indexes" and Section 1.3.5 titled "General web searching (including search engines/Google Scholar, etc.)".

The references for this chapter are provided in full in back matter headed "References for articles 1, 3 and 3S".

addition to MEDLINE searches while CINAHL identified no new publications; and in a tuberculosis review, searching CINAHL identified over 5% of the included publications in addition to MEDLINE, whereas the HMIC database identified no additional publications (Levay et al 2015). A review of database sources for a food science systematic review found that the specialist agriculture and food science databases AGRICOLA and FSTA had the highest precision of all databases searched, but did not return any unique citations alongside Academic Science Premier (ASP), CAB Direct, PubMed and Web of Science (Urhan et al 2019).

For a list of subject-specific healthcare databases, see Appendix.

1.1.4 Citation indexes

Citation indexes are bibliographic databases which index citations in addition to the standard bibliographic content. They were originally developed to identify efficiently the reference lists of scholarly authors and the number of times a study or author is cited (Garfield 2007). Citation indexes can also be used creatively to identify studies which are similar to a source study, as it is probable that studies which cite or are cited by a source study will contain similar content.

Searching using a citation index is usually called 'citation searching' or 'citation chasing' and is further defined as 'forwards citation searching' or 'backwards citation searching' depending on which direction the citations are searched. Forwards citation searching identifies studies which cite a source study and backwards citation searching identifies studies cited by the source study. Citation indexes are mainly used for forwards citation searching, which is practically impossible to conduct manually, whereas backwards citation searching is relatively easy to conduct manually by consulting reference lists of source studies (see Section 1.3.4). Thus the focus in this section is on forwards citation searching. Citation indexes also facilitate author citation searching which is used to identify studies that are carried out by an author and studies that cite an author.

It is good practice to carry out forwards citation searching on reports of studies that meet the eligibility criteria of a systematic review. Thus forwards citation searching usually takes place after the results of the bibliographic database searches have been screened and a set of potentially includable studies has been identified (Briscoe et al 2020a). Because citation searching is not based on pre-specified terminology it has the potential to retrieve studies that are not retrieved by the keyword-based search strategies that are conducted in bibliographic databases and other resources. This makes citation searching particularly effective in systematic reviews where the search terms are difficult to define, usefully extending to iterative citation searching of citations identified by citation searching (also known as 'snowballing') in some reported cases (Booth 2001, Greenhalgh and Peacock 2005, Papaioannou et al 2010, Linder et al 2015). Since researchers may selectively cite studies with positive results, forwards citation searching should be used with caution as an adjunct to other search methods in Cochrane Reviews.

There are varied findings on the efficiency of forwards citation searching, measured as the labour required to export and screen the results of searches relative to the number of unique

relevant studies identified (Wright et al 2014, Hinde and Spackman 2015, Levay et al 2016, Cooper et al 2017b). Most studies, however, which compared the results of forwards citation searching with other search methods found that citation searching identified one or more unique studies which were relevant to the review question (Greenhalgh and Peacock 2005, Papaioannou et al 2010, Wright et al 2014, Hinde and Spackman 2015, Linder et al 2015). Reviews of recently published studies, such as review updates, are less likely to benefit from forwards citation searching than reviews with no historical date limit for includable studies due to the relatively limited time for recent studies to be cited. When conducting a review update, however, searchers should consider carrying out forwards citation searching on the studies included in the original review and on the original review itself.

The two main subscription citation indexes are Web of Science, which was launched in 1964 and is currently provided by Clarivate Analytics, and Scopus, which was launched in 2004 by Elsevier. Google Scholar, which was also launched in 2004, can be used for forwards but not backwards citation searching. Microsoft Academic was relaunched in 2015 (Sinha et al 2015) but closed in December 2021. It could be used for both forwards and backwards citation searching. A new resource, OpenAlex, is due to be launched in early 2022. A summary of each of the currently available resources is provided below. There are published comparative studies which can be consulted for a more detailed analysis (Kulkarni et al 2009, Wright et al 2014, Levay et al 2016, Cooper et al 2017a).

Web of Science

Web of Science (formerly Web of Knowledge), produced by Clarivate Analytics, comprises several databases. The 'Core Collection' databases cover the sciences (1900 to date), social sciences (1956 to date), and arts and humanities (1975 to date). The sciences and social sciences collections are divided into journal articles and conference proceedings, which can be searched separately. In total, the Web of Science Core Collection contains approximately 80 million records from more than 21,000 journal titles, books and conference proceedings (Web of Science 2020). Additional databases are available via the Web of Science platform, also on a subscription basis. Author citation searching is possible in Web of Science but it does not automatically distinguish between authors with the same name unless they have registered for a uniquely assigned Web of Science ResearcherID.

https://clarivate.com/products/web-of-science/

Scopus

Scopus, produced by Elsevier, covers health sciences, life sciences, physical sciences and social sciences. As of December 2021, it contains approximately 85 million records from approximately 25,000 journal titles and approximately 10 million conference abstracts. Records date back to 1788, with approximately 60 million post-1995 records, including references, and approximately 25 million pre-1996 records (Scopus 2021). A unique identification number is automatically assigned to each author in the database which enables it to distinguish between authors with the same names when author citation searching. Errors

are still possible, however, as publications are not always assigned correctly to author ID numbers and authors are sometimes erroneously assigned more than one ID number.

https://www.elsevier.com/solutions/scopus

https://www.elsevier.com/solutions/scopus/how-scopus-works/content

Google Scholar

Google Scholar is a freely available scholarly search engine which uses automated web crawlers to identify and index scholarly references, including published studies and grey literature. Although it can only be used for forwards citation searching, this limitation has little practical significance as backwards citation searching can be easily conducted manually by checking reference lists. The precise number of journals indexed by Google Scholar is not known because it does not use a pre-specified list of journals to populate its content. There is, however, evidence that it has sufficient citation coverage to be used as an alternative to Web of Science or Scopus, if these databases are not available (Wright et al 2014, Levay et al 2016).

A disadvantage of Google Scholar's automated study identification method is that it produces more duplicate citations than Web of Science, which indexes pre-specified journal content (Haddaway et al 2015). Scopus, which uses a similar indexing method to Web of Science, is also likely to produce fewer duplicates than Google Scholar. A further disadvantage of Google Scholar is that the export features are basic; however, this can be improved by searching it via the freely available Publish or Perish software (Harzing 2007). Finally, Google Scholar limits the number of viewable results to 1000 and does not disclose how the top 1000 results are selected, thus compromising the transparency and reproducibility of search results (Levay et al 2016).

https://scholar.google.com/

OpenAlex

OpenAlex is a tool produced by the non-profit organization OurResearch. In its documentation, OpenAlex is described as a free and open catalogue of the world's scholarly entities, including scholarly works, authors, journals and other repositories, and institutions. OpenAlex's first beta data release was in mid-November 2021, positioning itself as a successor to Microsoft Academic, which was retired on 31 December 2021. OpenAlex's full website is due to be launched in early 2022.

According to the OpenAlex website, "Using OpenAlex, you can build your own scholarly search engine, recommender service, or knowledge graph. You can help manage research by tracking citation impact, spotting promising new research areas, and identifying and promoting work from underrepresented groups. And you can do research on research itself, in areas like bibliometrics, science and technology studies, and Science of science policy."

https://openalex.org/about

Web of Science, Scopus, Google Scholar and (until 31 December 2021) Microsoft Academic all provide or provided wide coverage of healthcare journal publications. There are, however, differences in the number of records indexed in each citation index and in the methods used to index records, and there is evidence that these differences affect the number of citations which are identified when citation searching (Kulkarni et al 2009, Wright et al 2014, Rogers et al 2016, Rogers et al 2020). It is not a requirement for Cochrane Reviews, however, to conduct exhaustive citation searching using multiple citation indexes. Review authors and information specialists should consider the time and resources available and the likelihood of identifying unique studies for the review question, when planning whether and how to conduct forwards citation searching.

Further evidence-based analysis of the value of citation searching for systematic reviews can be found on the regularly updated SuRe Info portal in the section entitled Value of using different search approaches (https://sites.google.com/york.ac.uk/sureinfo/home/value-of-using-different-search-approaches).

1.1.5 Dissertations and theses databases

It is highly desirable, for authors of Cochrane Reviews of interventions, to search relevant grey literature sources such as reports, dissertations, theses, and conference abstracts (MECIR C28). Dissertations and theses are a subcategory of grey literature, which may report studies of relevance to review authors. Searching for unpublished academic research may be important for countering possible publication bias but it can be time consuming and in some cases yield few included studies (van Driel et al 2009). In some areas of medicine, searching for and retrieving unpublished dissertations has been shown to have a limited influence on the conclusions of a review (Vickers and Smith 2000, Royle et al 2005). In other areas of medicine, however, it is essential to broaden the search to include unpublished trials, for example in oncology and in complementary medicine (Egger et al 2003). In a study of 129 systematic reviews from three Cochrane Review Groups (the Acute Respiratory Infections Group, the Infectious Diseases Group and the Developmental, Psychosocial and Learning Problems Group) there was wide variation in the retrieval and inclusion of dissertations (Hartling et al 2017). It is possible that a study which would affect the conclusions would be missed if the search is not comprehensive enough to include searches for unpublished trials including those reported only in dissertation and theses (Egger et al 2003). The failure to search for unpublished trials, such as those in dissertation and thesis databases, may lead to biased results in some reviews (Ziai et al 2017). Dissertations and theses are not normally indexed in general bibliographic databases such as MEDLINE or Embase, but there are exceptions, such as CINAHL, which indexes nursing, physical therapy and occupational health dissertations and PsycINFO, which indexes dissertations in psychiatry and psychology.

To identify relevant studies published in dissertations or theses it is advisable to search specific dissertation sources:

own point-of-care tool Cochrane Clinical Answers. Although they are designed to be used in clinical practice, they offer evidence for diagnosis and treatment of specific conditions and are regularly updated with links to and reference lists to reports of relevant studies which can help in identifying studies, reviews, and overviews. Most evidence summaries for use in clinical practice are available via subscription to commercial vendors.

As noted above, it is mandatory, for authors of Cochrane Reviews of interventions, to check reference lists of included studies and any relevant systematic reviews identified (MECIR C30). Checking reference lists within eligible studies supplements other searching approaches and may reveal new studies, or confirm that the topic has been thoroughly searched (Greenhalgh and Peacock 2005, Horsley et al 2011). Examples of situations where checking reference lists might be particularly beneficial are:

- when the review is of a new technology;
- when there have been innovations to an existing technique or surgical approach;
- where the terminology for a condition or intervention has evolved over time; and
- where the intervention is one which crosses subject disciplines, for example, between health and other fields such as education, psychology or social work. Researchers may use different terminology to describe an intervention depending on their field (O'Mara-Eves et al 2014).

It is not possible to give overall guidance as to which of the above sources should be searched in the case of all reviews to identify other reviews, guidelines and reference lists as sources of studies. This will vary from review to review. Review authors should discuss this with their Cochrane Information Specialist or their medical/healthcare librarian or information specialist.

1.3.5 General web searching (including search engines/Google Scholar, etc.)

Searching the World Wide Web (hereafter, web) involves using resources which are not specifically designed to host and facilitate the identification of studies. This includes general search engines such as Google Search and the websites of organizations that are topically relevant for review topics, such as charities, research funders, manufacturers and medical societies. These resources often have basic search interfaces and host a wide range of content, which poses challenges when conducting systematic searching (Stansfield et al 2016). Despite these challenges web searching has the potential to identify studies that are eligible for inclusion in a review, including 'unique' studies that are not identified by other search methods (Eysenbach et al 2001, Ogilvie et al 2005, Stansfield et al 2014, Godin et al 2015, Bramer et al 2017a, Coleman et al 2020). It is good practice to carry out web searching for review topics where studies are published in journals that are not indexed in bibliographic databases or where grey literature is an important source of data (Ogilvie et al 2005, Stansfield et al 2014, Godin et al 2015). Grey literature is literature "which is produced on all levels of government,

academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers" (see Section 1.1.6) (Farace and Frantzen 1997, Farace and Frantzen 2004).

It is good practice to base the search terms used for web searching on the search terms used for searching bibliographic databases (Eysenbach et al 2001). A simplified approach, however, might be required due to the basic search interfaces of web resources. For example, web resources are unlikely to support multi-line search strategy development or nested use of Boolean operators, and single-line searching is often limited by a maximum number of alphanumeric characters. As such, it might be necessary to rewrite a search using fewer search terms or to conduct several searches of the same resource using different combinations of search terms (Eysenbach et al 2001, Stansfield et al 2016, Briscoe et al 2020b). In addition to using search terms, web searching involves following links to webpages and websites. This is less structured than searching using pre-specified search terms and the searcher will need to use their discretion to decide when to start and stop searching (Stansfield et al 2016). Wherever possible, a similar approach to searching should be used for different web resources to ensure consistency and searches should be documented in full and reported in the review (see Chapter 4, Section 4.5).

Web resources are unlikely to have a function for exporting results to reference management software, in which case the searcher may decide to screen the results 'on screen' while searching. Alternatively, screenshots can be taken and screened at a later time (Stansfield et al 2016). This process can be facilitated by software such as Evernote or OneNote. Because website content can be deleted or edited by the website editor at any time, a permanent record of any relevant studies should be retained.

Web searching should use a combination of search engines and websites to ensure a wide range of sources are identified and searched in depth.

Search engines

Due to the scale and diversity of content on the web, searching using a search engine is likely to retrieve an unmanageable number of results (Mahood et al 2014). Results are usually ranked according to relevance as determined by a search engine's algorithm, so it might be useful to limit the screening process to a pre-specified number of results, e.g. limits ranging from 100 to 500 results have been reported in recent Cochrane Reviews (Briscoe 2018). Alternatively, an ad hoc decision to stop screening can be made when the search results become less relevant (Stansfield et al 2016). It is good practice to use a more comprehensive approach when screening Google Scholar results, which are limited to 1000, to ensure that all relevant studies, including grey literature, are identified (Haddaway et al 2015). Some search engines allow the user to limit searches to a specified domain name or file type, or to web pages where the search terms appear in the title. These options might improve the precision of a search though they might also reduce its sensitivity. The reported number of results identified by a search engine is usually an estimate which varies over time, and the actual number of results might be much

lower than reported (Bramer 2016). Search engines often combine search terms using the 'AND' Boolean operator by default. Some search engines support additional search operators and features such as 'OR', 'NOT', wildcards and phrase searching using quotation marks.

There are many freely available search engines, each of which offers a different approach to searching the web. Because each search engine uses a different algorithm to retrieve and rank its results, the results will differ depending on the search engine that is used (Dogpile.com 2007). Thus it might be worth experimenting with or combining use of different search engines to retrieve a wider selection of results. There are freely available meta-search engines which search a combination of search engines, though they are often limited with regard to which search engines can be combined. Some search engines tailor the search results to a user's search history and location, so the search results might differ between users, thus limiting reproducibility (Cooper et al 2021). Clearing a web browser's cache and cookies before searching should, however, reduce the personalization of results (Curkovic and Kosec 2018).

A selection of freely available search engines and meta-search engines is shown in Box 1.a.These are examples of different types of search engine rather than a list of recommended search engines. No specific search engines are recommended for a Cochrane Review.

Box 1.a Search engines

Dogpile http://www.dogpile.com/

Dogpile is a meta-search engine which in a study from 2007 is reported to search Google Search, Yahoo!, Ask and Bing (Dogpile.com 2007). A more up to date list of search engines used by Dogpile has not been identified.

DuckDuckGo https://duckduckgo.com/

DuckDuckGo protects the privacy of its users by not recording their IP addresses and search histories. A potential advantage for systematic review authors is that DuckDuckGo does not use search histories to personalize its search results, which might make it better at ranking less frequently visited but useful pages higher in the results.

Google Scholar https://scholar.google.com/

Google Scholar is a specialized version of Google Search which limits results to scholarly literature, including published studies and grey literature. It cannot be used instead of searching bibliographic databases due to its basic search interface and a block on viewing more than 1000 records per search (Boeker et al 2013a, Bramer et al 2016a). It can, however, be a useful resource when used alongside bibliographic databases for identifying studies and grey literature not indexed in bibliographic databases or not retrieved by the bibliographic database search strategies (Haddaway et al 2015, Bramer et al 2017a). The option to search the full text of studies can contribute to the identification of unique studies

when using similar or the same search terms as used in bibliographic databases (Bramer et al 2017a). References can be exported to reference management software, though the number of references that can be exported at a time is limited to 20 (Bramer et al 2013). However, Google Scholar can be searched via the freely available Publish or Perish software, which also facilitates bulk exportation of results to reference management software (Harzing 2007).

Google Search https://www.google.com/

Google Search is the most widely used search engine worldwide. An advantage of its popularity is that there is an abundance of online material on how to make the most of its advanced search features. The Verbatim feature in the Google Search Tools menu can be used to ensure search results contain the precise search terms used (e.g. will not retrieve "nursing" if searching for "nurse") and to switch off the personalization of search results based on websites which the user has previously visited. Personalization can also be deactivated via the settings menu.

Not all content on websites is indexed by search engines, so it is important to consider accessing and searching any potentially useful websites which are identified in the search results (Devine and Egger-Sider 2013).

Websites

The selection of websites to search will be determined by the review topic. It is good practice to investigate whether the websites of relevant pharmaceutical companies and medical device manufacturers host trials registers which should be searched for studies. The websites of medicines regulatory bodies such as the US Food and Drug Administration (FDA) and the European Medicines Agency (EMA) should be searched for regulatory documentation (see Section 1.2 and subsections). It might also be useful to search the websites of professional societies, national and regional health departments, and health related non-governmental organizations and charities for studies not indexed in bibliographic databases and grey literature (Ogilvie et al 2005, Godin et al 2015, Briscoe et al 2020b).

Searching websites will usually yield a lower number of results than search engines, so it should be possible to screen all the results rather than a pre-specified number.

1.4 Summary points

- Cochrane Review authors should seek advice from their Cochrane Information Specialist on sources to search.

Chapter 6. Article 4

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REVIEW

The "realist search": A systematic scoping review of current practice and reporting

Andrew Booth[1] | **Simon Briscoe**[2] | **Judy M. Wright**[3]

[1]School of Health and Related Research (ScHARR), University of Sheffield, Sheffield, UK

[2]Exeter HS&DR Evidence Synthesis Centre, Institute of Health Research, College of Medicine and Health, University of Exeter, Exeter, UK

[3]Academic Unit of Health Economics, Leeds Institute of Health Science, University of Leeds, Leeds, UK

Correspondence
Andrew Booth, University of Sheffield, School of Health and Related Research (ScHARR), Regent Court, 30 Regent Street, Sheffield S1 4DA, UK.
Email: a.booth@sheffield.ac.uk

The requirement for literature searches that identify studies for inclusion in systematic reviews should be systematic, explicit, and reproducible extends, at least by implication, to other types of literature review. However, realist reviews commonly require literature searches that challenge systematic reporting; searches are iterative and involve multiple search strategies and approaches. Notwithstanding these challenges, reporting of the "realist search" can be structured to be transparent and to facilitate identification of innovative retrieval practices. Our six-component search framework consolidates and extends the structure advanced by Pawson, one of the originators of realist review: formulating the question, conducting the background search, searching for program theory, searching for empirical studies, searching to refine program theory and identifying relevant mid-range theory, and documenting and reporting the search process. This study reviews reports of search methods in 34 realist reviews published within the calendar year of 2016. Data from all eligible reviews were extracted from the search framework. Realist search reports poorly differentiate between the different search components. Review teams often conduct a single "big bang" multipurpose search to fulfill multiple functions within the review. However, it is acknowledged that realist searches are likely to be iterative and responsive to emergent data. Overall, the search for empirical studies appears most comprehensive in conduct and reporting detail. In contrast, searches to identify and refine program theory are poorly conducted, if at all, and poorly reported. Use of this framework offers greater transparency in conduct and reporting while preserving flexibility and methodological innovation.

KEYWORDS

literature searches, realist synthesis, reporting standards

ABBREVIATIONS: ASSIA, Applied Social Sciences Index & Abstracts; CINAHL, Cumulative Index to Nursing and Allied Health Literature; DARE, Database of Abstracts of Reviews of Effects; ERIC, Education Resources Information Center; MEDLINE, Medical Literature Analysis and Retrieval System Online; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RAMESES, Realist And MEta-narrative Evidence Syntheses: Evolving Standards; SCI, Science Citation Index; SSCI, Social Sciences Citation Index.

1 | INTRODUCTION

Realist synthesis has witnessed a dramatic and sustained rise in popularity since first being advanced in 2004.[1] A search in the Web of Science Core Collection (1900-2019) for publications with "realist synthesis" or "realist review" in the title revealed growth from two studies published in 2009 to a peak, so far, of 72 studies (2017), before falling slightly to 47 studies (2018) (see Figure 1).

This popularity may be attributed to the familiarity and accessibility of the mantra "what works for whom under what circumstances," successfully appropriated by realist synthesis advocates although equally a line of inquiry for other forms of evidence synthesis. Methods for systematic reviews of effectiveness hold limited capacity to gather and analyze evidence on why and when interventions are effective. Realist syntheses address this challenge. Realist synthesis has been further popularized through production of the RAMESES training materials and reporting standards,[2] by an active program of conferences and training events and, in July 2018, through the first edited collection on *Doing Realist Research.*[3] Uptake of realist approaches has been prolific within the UK National Institute of Health Research (NIHR) funding program, particularly within research programs that are characterized by complex questions associated with complex interventions being explored within complex adaptive systems.

As with other approaches to mixed methods synthesis, realist synthesis has faced challenges associated with the need to develop explicit and transparent methods. Early writings on realist synthesis were never intended as methodological guidebooks. While freedom to interpret existing methods, and thus to develop new responses, offers potential innovation, a lack of clarity persists around the key stages of the realist synthesis process.[4] Nowhere is this lack of clarity more apparent than in connection with the "realist search"; systematic review reporting guidelines cultivate an expectation for systematic, explicit, and reproducible search processes. By contrast, realist inquiry remains inherently intuitive and iterative, posing a challenge to sequential reporting. While this challenge is acknowledged and is being tackled for other evidence syntheses, such as systematic reviews of qualitative research, our collective experience suggests that realist reviews probably represent the most extreme position on this continuum.

The objective of this study is to examine current methodological practice as captured in a sample of realist reviews (ie, the outputs of realist synthesis) published in 2016 with respect to searches used to identify program theories and studies for inclusion.

Highlights

What is already known

Realist syntheses are becoming increasingly prevalent but methods for searching ("realist searches") are poorly specified.

What is new

Realist searches require iterative methods that use different search approaches to support different components of the realist synthesis process.

This audit of descriptions of search components from published realist syntheses for a single calendar year reveals examples of consensus on candidate approaches for retrieval and reporting as well as instances of genuine innovation.

Potential impact for RSM readers outside the authors' field

As realist syntheses start to populate subject fields where the systematic review convention has not previously gained traction it will be helpful for researchers in those fields to be exposed to information retrieval methods that can offer a systematic approach to study identification.

This paper offers a framework for planning, reporting and evaluating future realist searches from across multiple subject fields in an ongoing quest to improve standards of conduct and reporting.

2 | GLOSSARY FOR REALIST APPROACHES

Realist Review – a review presenting evidence from diverse sources, selected according to relevance and rigour, to explore how a complex intervention works, for whom and under what circumstances.

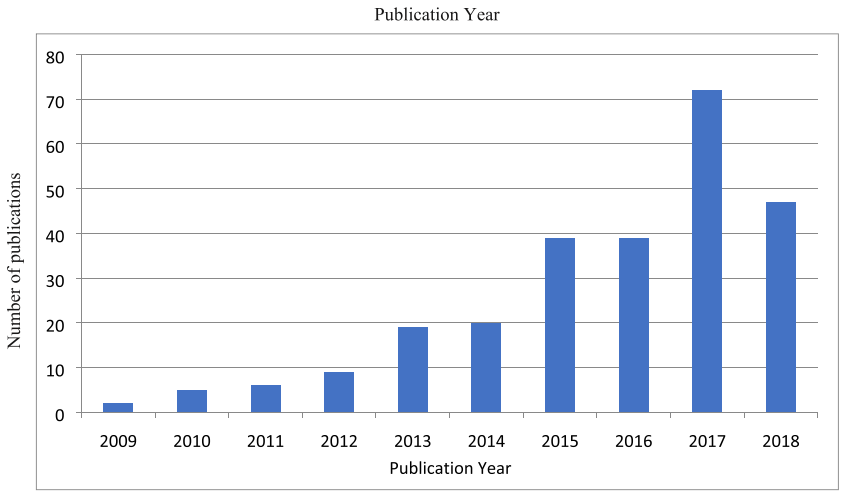

FIGURE 1 Number of realist synthesis publications in Web of Science Core Collection

[Colour figure can be viewed at wileyonlinelibrary.com]

"Realist Search" – a preferred label that describes all procedures used to identify documents for inclusion in a realist review, often as a counterpoint to a "Systematic Review Search". The search is not itself required to be 'realist'.

Realist Synthesis – term often used synonymously for realist review but also to refer to a synthesis method for studying complex interventions in response to perceived limitations of systematic review methodology. It involves identification of contexts, mechanisms and outcomes for interventions or programmes to explain the differences, intended or unintended, between them.

Context-Intervention-Mechanisms-Outcome (CIMO) – a way of structuring a realist review question, comparable to PICO for a systematic review, that formulates the question in terms of Where? By what? By what means? And with what effect?

Mechanism – an interaction of the reasoning and reactions of individuals/collective agent(s), activated by resources available in a given context, to achieve changes through implementation of an intervention.

Mid-range (or Middle-range) Theory – a theory that goes beyond the theory of change for a specific project or programme to explain how a group of similar interventions or programmes activate similar mechanisms in order to achieve change.

Programme Theory – explanations for how a specific intervention or programme is thought to work (also known as a "theory of change").

RAMESES (Realist And MEta-narrative Evidence Syntheses: Evolving Standards) – reporting standards for realist syntheses, comparable to PRISMA for systematic reviews and meta-analyses.

3 | BACKGROUND

3.1 | The six components of the realist search

As information specialists, collectively associated with diverse realist syntheses, we have documented different approaches to the realist search and have identified a need to map the search process to the realist synthesis template proposed by Pawson. We have previously specified six components of the realist search[5]:

1. Formulating the question[6];
2. conducting the background search[7];
3. searching for programme theories[7];
4. searching for empirical evidence[7];
5. searching to refine programme theories[8];
6. documenting the search process.[2]

Working within this six-component framework, we identified techniques and procedures to contribute to the specific objectives of each component. These included search methods for retrieving nonresearch materials,[5] for identifying "sibling" or associated papers around a particular index study,[9] and for identifying explicit mention of theory.[10] However, we anticipated that our proposed methods would be strengthened by considering innovative approaches used by our contemporaries. We therefore undertook an audit of realist search methods used within a sample of published realist reviews.

A previous audit of current practice in realist synthesis reviewed 54 realist reviews published between 2004 and January 2015.[4] The analysis, structured around the RAMESES reporting standards,[2] included

only three elements that relate to the realist search. Four reviews were excluded as they re-analyzed materials from a preexisting systematic review. Assessing the resultant sample against item 7 of the RAMESES Reporting Standards,[2] *Scoping the Literature*, the authors found that only 18 adequately described and justified the initial process of exploratory scoping of the literature. Forty-seven of the 50 eligible realist reviews performed well against item 8, *the Searching Process*, in that they both stated and provided a rationale for how the iterative searching was done, together with details on all the sources accessed for information in the review. Finally, item 17, *Comparison with existing literature*, which requires a comparison and contrast of findings with existing literature on the same topic was fulfilled in 19 reviews, not met in 27 reviews and partially met in a further eight.

While collectively welcoming inclusion of search methods in the previous audit,[4] we feel that further analysis is required if information specialists and review teams are to develop explicit and transparent methods for the realist search. In addition, the pace of rapid development of realist methods suggests that it is important to review a recent sample of published reports.

3.2 | Why this study is needed?

No published formal guidance exists on the conduct of literature searches to support the realist synthesis process. Three standards do exist for reporting of realist searches within the RAMESES reporting standards.[2] However, these standards do not distinguish between the different stages of a realist synthesis and typically lead to a single multipurpose search or to search stages that are indistinct and difficult to characterize. In a recent multi-authored work, we have outlined a six-component realist search process that we believe will assist review authors and information specialists to conduct systematic searches.[5] We deliberately present this as a framework, rather than a template (breaking with the Pawson convention), and as components (rather than stages) to emphasize the flexibility already present for both procedures and sequencing. Reviewing reports of realist searches enables us to assess the state of current practice and to make recommendations to improve practice if required. Doing this retrospectively in this first instance, while not seeking to impose standards post hoc, offers a potential benchmark against which future progress in reporting may subsequently be assessed.

4 | METHODS

This systematic scoping review is a selective update of a previous study.[4] We followed the recognized five stages of a scoping review,[11] as cited in the previous study,[4] to undertake our own systematic scoping review of the search methods reported in realist reviews published within the calendar year of 2016:

1. Identify the research question
2. Identify relevant studies
3. Select studies
4. Chart the data
5. Collate, summarize, and report the results.

4.1 | Inclusion and exclusion criteria

To be included in our systematic scoping review, a review had to meet the following criteria:

a. includes a realist component as part of the evidence synthesis methodology, ie, either as a standalone realist review or as a mixed-methods review that incorporates a realist synthesis;
b. describes the search to identify studies and/or other types of literature for inclusion in the review;
c. published in English;
d. published within the calendar year 2016, either in a journal issue, "early view" online only publication or academic thesis.

Non-English language realist reviews were excluded because of lack of translation resources. Monographs such as books and book chapters were excluded except for publications in the NIHR monograph series, a hybrid monograph/journal publication. Conference abstracts for realist or mixed methods reviews were also excluded being unlikely to contain a detailed report of the search methods. Having originally searched for realist and mixed methods reviews with a realist component published between 2015 and July 2017, we subsequently restricted our dataset to a sufficiently rich sample of articles published in 2016 to best manage and analyze the results of our search within the available time and resources (see Appendix C for excluded studies).

4.2 | Search to identify relevant realist and mixed methods reviews

We (A.B., S.B., and J.W.) updated the bibliographic database searches from the previous audit[4] in July 2017,

replicating both search terms and databases reported. One minor variation was that we searched MEDLINE via PubMed rather than via the Ovid platform. Berg and Nanavati (2016) selected search terms empirically derived from realist reviews known to them at the outset of the review and tested the resulting search strategy to ensure that all known reviews were retrieved.[4] Bibliographic databases searched include: CINAHL (via EBSCO); the Cochrane Database of Systematic reviews (via the Cochrane Library); DARE (via the Centre for Reviews and Dissemination); Embase (via Ovid); ERIC (via EBSCO); MEDLINE (via PubMed); ProQuest Dissertations and Theses; PsycINFO (via Ovid); Social Services Abstracts (via ProQuest); Sociological Abstracts (via ProQuest); and Web of Science Core Collection (via Clarivate Analytics). Search results were limited to the calendar year of 2016 to provide a standardized unit for analysis, although studies published during this period could have been conducted over different time intervals. All search results were exported to EndNote X7 (Clarivate Analytics) and deduplicated. Search strategies for each database and the number of hits retrieved are reported in Appendix A.

Also following the previous audit,[4] forward citation searching was undertaken using Google Scholar, accessed via the Publish or Perish software, using key realist methodological texts as source studies.[1,2,10-12] Results were exported to EndNote X7 and deduplicated against the bibliographic database search results.

4.3 | Selection of relevant reviews

A.B. screened the titles and abstracts of all search results to identify relevant realist and mixed methods reviews including a realist component. Following post hoc application of the 2016 date limit (see above), we (A.B., S.B., and J.W.) retrieved full-text copies of all relevant reviews published in 2016. Full text screening to assess eligibility of reviews for inclusion in our review was undertaken once reviews had been assigned to reviewers (A.B., S.B., and J.W.) for data extraction.

4.4 | Data extraction

A.B. designed the data extraction form using Google Forms and all three authors piloted it. Reviews meeting our inclusion criteria at title and abstract were divided equally between the three authors. The data extraction form was structured around our previously presented six-component framework for the realist search.[5] This includes four separate search components, including "background searches," "searches to identify programme theory," "searches to identify empirical evidence," and "searches to refine the programme theory," prefaced by "focusing the question" and followed by "search documentation."[5] The data extraction form captured data on the overall approach for each stage together with specific detail on the bibliographic databases searched, any non-bibliographic database search methods, the sampling strategy, and the type of studies included. The data extraction form is reproduced in Appendix B.

Where the description of the search methods could not be mapped to the four components on the data extraction form,[3] data were copied and pasted into the most appropriate free-text boxes to avoid loss of data about search methods.

4.5 | Data analysis

Data extraction form responses were collated in a table (spreadsheet) where each row contained data for a study and data extraction items were organized in columns. Analysis was divided between all authors, each summarizing data for multiple data items. Categorical data such as responses for "tick box" questions were summed to give an overall numerical result, eg, the number of studies reporting a "background search." Free text responses were collated and summarized thematically where possible.

5 | RESULTS

We initially identified 187 records of realist syntheses published between 2015 and 2017 from the formal search strategy and Google Scholar citation searches (Figure 2). Realist review protocols were subsequently excluded as they represented planned, not actual practice. We subsequently applied strict date criteria relating to print and electronic publication of articles to restrict our data set to studies first published in 2016.

5.1 | Overview of the included studies

We included a total of 35 studies in our sample.[13-47] Most papers reported a single realist review (27 of 35). Fewer papers reported a multicomponent review that include a realist review component (n = 5)[16,22,34,39,45] or a rapid realist review (n = 3).[24,40,42] We identified different models of searching from examining the overall purpose and scope of the reported searches (Table 1). The most common model (n = 25) was where realist reviews

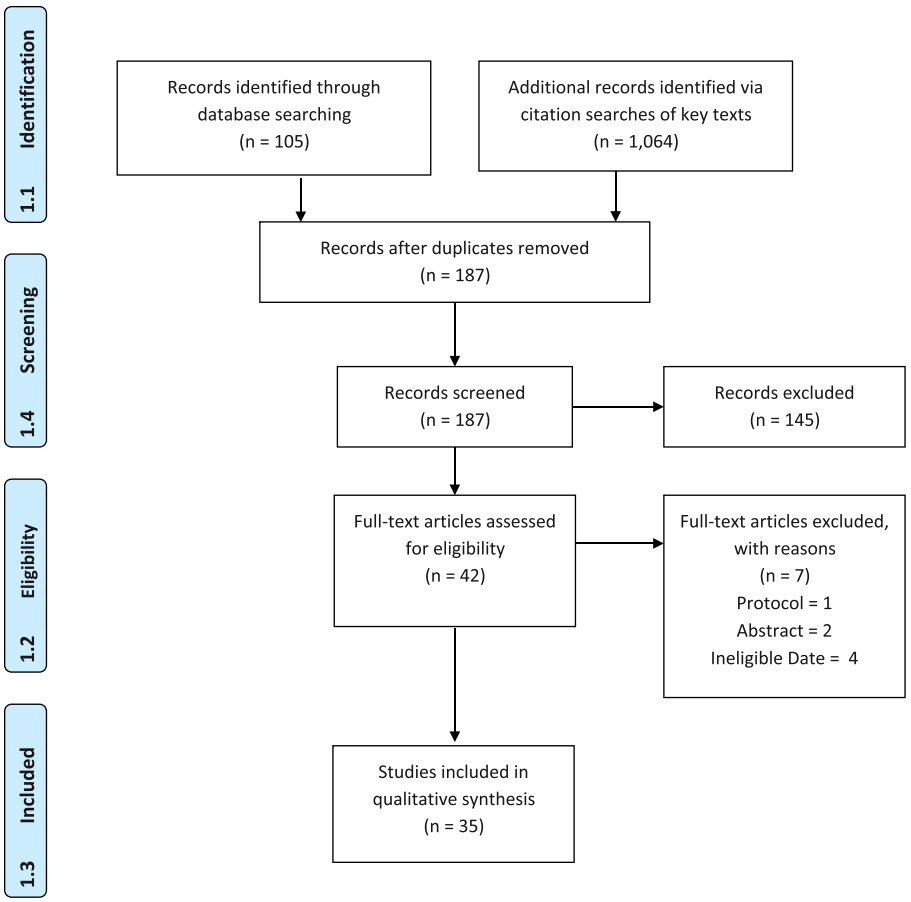

FIGURE 2 PRISMA flow diagram [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Realist search approaches

Search Model	Number of Reviews
Exclusive (realist-only) searches • Search conducted exclusively to inform the realist synthesis	25
Mushroom/staged searches • A generic topic-based multipurpose search (cap) followed by a targeted search (es) (stalk) exclusively to inform the realist synthesis	4
Pick and place approach • Single comprehensive multidomain search from which different studies are picked for different components (eg, effectiveness, cost effectiveness, and acceptability) of a review (including for the realist synthesis) and placed in results sets for subsequent processing.	6

reported the realist search as the exclusive search, ie, all the searches reported had the sole purpose of gathering evidence for the realist synthesis. Four adopted what we label a "mushroom" approach, whereby a general search was conducted first (mushroom cap) and then a separate realist search (or searches) (mushroom stalk) was undertaken,[24,25,27,41] eg, one realist review drew from studies previously included and excluded from a linked systematic review and conducted citation chaining to identify further studies to support the realist analysis.[27] In this example, results found for the earlier systematic review represent the mushroom cap and later citation chaining searches to support the realist analysis constitute the mushroom stalk. A third "pick and place" model (from the analogy of an assembly line) emerged in six reviews,[16,18,34,39,45,47] where a search produced a large set of results from which the research team "picked" different study types and then "placed" them for inclusion within different aspects of a review. In this model, a separate realist search was not reported and the reviewers gathered studies to inform the realist synthesis from the large, multipurpose search. A health technology assessment report[39] illustrates how a single search, designed to retrieve studies for an evidence mapping exercise, "picked" studies to be "placed" in a systematic review of costs and effectiveness or in the realist synthesis. Studies for this realist synthesis were picked from this large set of search results without undertaking a separate search.

5.2 | Structure of the review team and number of authors

Four of 35 reviews in our sample were conducted by one author; 15 reviews were carried out by two to five authors; 11 reviews by six to nine authors; and five reviews by 10 or more authors. These results appear similar to a seminal epidemiological study of systematic reviews, which identified a median of five authors (IQR 4-6) per review in a cross-sectional sample of 300 systematic reviews.[48] However, we are unable to compare our data directly with the range of values captured in this previous study. Most reviews (n = 25) described the roles and responsibilities of review team members, variously reported as listings of professional titles through to crediting team members with particular tasks. The remaining 10 reviews provided selected team member roles or no details about team member roles. Four of these reviews involved only one author, whom we assume undertook all tasks.

5.3 | Information specialist involvement

Three reviews explicitly credited an information specialist with authorship.[26 36 45] In one review, the information specialist was credited with carrying out the searches[24]; and in one review, the information specialist provided advice on carrying out the searches.[45] No information was given about the involvement of the information specialist in the third review.[34] A further 12 reviews mentioned an information specialist in either the main text or in the acknowledgements section but not as an author. In these examples, the input of the information specialist was not significantly different to where they were explicitly credited with authorship: information specialist input ranged from providing advice on searching through to designing and carrying out the search. The remaining 20 reviews did not explicitly credit an information specialist as an author or acknowledge them elsewhere in the text. However, this may reflect nonreporting rather than non-involvement.

5.4 | Sampling approaches

The persistence of the comprehensive sampling approach was clearly evidenced in the study sample. Twenty-six of the included reviews described using a comprehensive search, either as the main search strategy or as a principal component alongside other sampling approaches. This finding was not unexpected, particularly with respect to the search for empirical evidence, the realist search component that most closely conforms to the typical systematic review search template. Even purposive sampling approaches may require construction of an initial comprehensive sampling frame before pursuing strategies informed by this "map" of an overall research area. Realist searches for the remaining reviews in the sample displayed diverse sampling strategies, including the following:

Convenience sample.

- Realist synthesis methods are occasionally used to add enhanced analysis to a dataset of previously identified studies. So, a realist review of pharmacist-led smoking cessation support describes using pre-existing empirical evidence to populate the review.[27]

Maximum variation sample

- Specifically, at the stage of theory testing, a review team may seek a maximum variation (or maximum variety) sample to identify features associated with a successful or unsuccessful program. In practical terms, however, this may involve undertaking a comprehensive search and then mapping retrieved studies against variables to identify maximum variation. So, a realist review of music therapy for palliative care describes undertaking "comprehensive purposive searching to arrive at a 'maximum variety sample' that could sufficiently test our theories."[33]

Snowball sample.

- Six of the reviews in our sample described use of snowball sampling. Snowball sampling can be achieved by following up the citations of a highly relevant study forwards to find subsequently published relevant studies, and then following up the citations of those newly found relevant studies, and so on. Within realist syntheses, snowball sampling has two particular uses—first, for poorly defined concepts with disparate keywords, it offers an additional access point to the literature as an alternative to subject-based searching. Second, snowball sampling can help in identifying chains or clusters of related references associated with a single project.[9] Whitaker and colleagues describe seeking "evidence clusters" associated with the implementation or acceptability of interventions related to key randomized controlled trials.[45] However, the success of this strategy was limited by a shortage of UK-based index studies from which to grow the evidence clusters.

Purposive and theoretical sampling.

- Purposive approaches to sampling focus on the precision of the search to yield literature with a high degree of relevance to the research question. Eight reviews in our sample reported such an approach

purposively selecting key (as defined by the review teams) relevant documents as starting points for identifying further documents of interest via citation searching. Berge reported carrying out three separate searches in an iterative attempt to gradually refine their literature base to match the focus of the research question.[15] Berge's approach combined elements of comprehensive sampling, with respect to the number of sources searched, with a subsequent purposive stage when refining the literature base.

Theoretical sample.

TABLE 2 Reporting of realist search cxomponents

Study ID	Formulating the Question	Background Search	Programme Theory Search	Search for Empirical Evidence	Refining Programme Theories
Apollonio et al[13]	No	No	No	Yes	No
Baker et al[14]	No	Yes	Yes	Yes	No
Berge[15]	No	No	Yes	Yes	Yes
Brown et al[16]	No	No	No	No	No
Camprubi et al[17]	No	No	Yes	Yes	No
Charles et al[18]	No	Yes	No	Multipurpose	No
Cunningham[19]	No	Yes	No	Yes	Yes
De Souza[20]	No	No	No	Multipurpose	No
Elliott et al[21]	No	Yes	No	Yes	No
Ellwood et al[22]	CIMO	No	No	Yes	No
Ford et al[23]	No	Yes	Yes	Multipurpose	No
Gee et al[24]	No	No	Yes	Multipurpose	No
Gilmer et al[25]	No	Yes	Yes	Multipurpose	No
Goodman et al[26]	No	Yes	Yes	Yes	No
Greenhalgh et al[27]	No	Yes	Yes	Multipurpose	Yes
Kehoe et al[28]	No	No	Yes	Yes	Yes
Kornelson et al[29]	No	No	No	Yes	No
Kornelson et al[30]	No	No	No	Yes	No
Lindsey and Bacon[31]	No	No	Yes	Yes	No
Lodenstein et al[32]	No	Yes	No	Yes	No
McConnell and Porter[33]	No	No	Yes	Multipurpose	Yes
McLean et al[34]	No	No	No	Multipurpose	No
McNeil et al[35]	No	Yes	Yes	Yes	No
McVeigh et al[36]	No	Yes	No	Yes	No
Mogre et al[37]	No	No	Yes	Multipurpose	No
Nilsson et al[38]	No	Yes	Yes	Multipurpose	No
Nyssen et al[39]	PICO	No	Yes	Multipurpose	No
Parkinson et al[40]	No	Yes	Yes	Multipurpose	No
Smylie et al[41]	No	No	Yes	Multipurpose	Yes
Tsang et al[42]	No	No	No	No	No
van Hooft et al[43]	No	No	No	Yes	No
Watkins[44]	No	Unclear	No	Yes	Yes
Whitaker et al[45]	PICO	Yes	Yes	Multipurpose	No
Williams et al[46]	No	Yes	Yes	Yes	Yes
Willis et al[47]	Concepts only	Yes	Yes	Multipurpose	No

- One realist review cites theoretical sampling, stating that the team achieved "theoretical saturation" from their initial comprehensive search.[21] Theoretical sampling in synthesis shares with primary qualitative data collection challenges in how authors define "saturation" and in how to demonstrate achievement of this state.

Overall, the descriptions of sampling strategies revealed a lack of clarity. This was a natural consequence of the failure by most realist review reports to differentiate between the four principal realist search components. We contend that specifying the four search components separately, together with the sampling strategy associated with each particular component, would provide a clear and consistent description of methods.

We next examined how the individual realist reviews performed against the first five components of a realist search (Table 2). The sixth component, reporting and documentation, is discussed narratively in a subsequent section of this article.

5.5 | Formulating the question

Systematic review conventions in health care, management, and many other fields, assert the importance of formulating a question both to specify the scope of the topic being explored and to inform subsequent inclusion and exclusion criteria and data extraction. Question formulation also helps the searcher to identify suitable components for use in the bibliographic database search strategy. Within health care, the Population-Intervention-Comparison-Outcome (PICO) formulation holds ascendancy, particularly for intervention-based questions. Other question formulations, such as context-intervention-mechanism(s)-outcome (CIMO), have been proposed as more suited to realist review questions.[5]

We found little evidence of structured question formulation within the sample of realist reviews. Thirty-two of the included reviews had no specific question formulation. Only two reviews used the PICO formulation,[39,45] although this information may be contained elsewhere in a published protocol document. One review used the principles of question formulation, specifying concept 1, concept 2, concept 3, etc, without invoking a specific formulation.[47] The final example[22] used the CIMO formulation,[6] which, ostensibly, offers the closest match to the terminology of realist synthesis. The RAMESES reporting standards include a criterion related to the development of an appropriate research question,[2] suggesting that the familiar "for whom, in what contexts...etc" should be used to structure research questions. This may represent an appropriate standard to apply to reviews in our sample.

5.6 | Conducting the background search

A background search is considered an important component of the exploratory realist process and serves to sensitize the review team to the available literature. This search was variously labeled a "background search,"[46,47] which suggests sensitisation to the literature, or a "scoping search,"[36,40,44] which conveys a logistic function. However, we could not detect any consistency in the differential use of these terms with both purposes being important at this stage of the search process:

> "The purpose of this initial search was twofold; to ascertain that there was sufficient breadth and depth of available evidence ... on which to base the review, and to begin to identify papers which could firm up the nascent theories about what the mechanisms of the programme might be."[19]

Seventeen of the included reviews did not report any process for a background search. Numerous diverse strategies were reported within the remaining papers:

- starting from existing review or primary literature[45];
- preliminary broad concept search of one or more targeted databases for reviews[47];
- web search using Google Scholar[40];
- search for policy documents or other gray literature[23];
- searches for recurrent authors[38];
- website searches of relevant organisations.[23]

In other cases, review teams engaged with stakeholders,[30] requesting relevant documents, either as an alternative or to supplement a broad literature search.

5.7 | Searching for programme theories

The formal search for programme theory is only one of several possible routes for identifying programme theories, alongside such methods as consultation with stakeholders and review of unpublished programme descriptions. Nevertheless, assuming a review team decides that they will undertake a formal search, this need not automatically assume a subordinate role in the development of programme theories.

Results from the "scoping" or "background" searches, including both academic and gray literature, may serve a

dual purpose in contributing to emerging programme theory. This publicly available data, alongside input from external experts may contribute to the initial program theory.[32] Other sources include policy documents while the research team themselves are often involved in generating the initial program theory. Typically, creation of the initial program theory leads to subsequent searches for specific aspects of the program theory, broken down into main concepts.[5]

Given that realist synthesis and realist evaluation are increasingly being harnessed, in conjunction, it is unsurprising to see evidence strands from literature, policy documents and stakeholders being increasingly interwoven. Pawson attests to the value of comparing "official expectations with actual practice."[49] Some realist projects sought to identify all relevant literature a priori and then to identify program theory from a conceptually rich subset of the total literature set.[45]

Few review teams reported systematic approaches to searching for theory.[27,47] More typically, theory was identified serendipitously from the background/scoping searches or from a comprehensive search for empirical evidence. One team found that items excluded from a review of quantitative findings were particularly relevant for theory building as well as supplying important contextual detail.[27] They describe using "citation-based search methods" to identify key papers and reviews. These methods included citation chaining (backwards inspection of reference lists and Google Scholar forward tracking) and the "related citations" function on PubMed for titles of studies matched to an index paper using the database algorithm.

A notable exception to the serendipitous approach involved using the strategy "framework/model/theory/concept" with terms used to indicate large-scale organizational change.[47] The strategy does not acknowledge published methods for searching for theory but, nevertheless corresponds to these suggestions.[10] In fact, the same review was the only one to include an Appendix entitled: Search strategy for dseveloping the programme theory.[47]

5.8 | Search for empirical evidence

The search methods used for finding empirical evidence were described in more detail than other elements of the realist search. Searches were reported similarly to conventional systematic review searches with (for most reviews) details about the database searched, search terms used, and date of search. The empirical evidence search has largely the same aim as a conventional systematic review search to identify evidence that tests either a theory or an intervention, differing in that a comprehensive search is not a prerequisite of a realist review. This similarity probably reflects review team familiarity with well-established search methods and reporting requirements for empirical evidence in conventional systematic reviews as well as shared expectations cultivated by the content of the RAMESES reporting standards.[2]

5.8.1 | Total number of databases searched

The number of databases searched for a review is influenced by the databases available to the review team, the discipline(s) covered by the review question, the study and publication types under review, and the time and experience of the searcher. We would expect more than one database to be searched for a systematic review or realist synthesis to minimize publication bias. It is difficult to determine any pattern from our results since the realist syntheses we evaluated spanned diverse disciplines and searched for different publication types. The results indicate a broadly similar number of databases searched across the realist reviews, when compared with a conventional systematic review. An analysis of 300 systematic reviews reported a median of 4 (IQR 3-5) databases searched for systematic reviews,[48] and as Figure 3 reveals, searches of either two to seven or over 10 databases were most common for our realist review sample. We were unable to distinguish any differences in database numbers for rapid realist reviews or realist review-only types of paper. Of three rapid reviews assessed,[24,40,42] one searched two to four, one searched five to seven, and the other eight to 10 databases. Fifteen of the 27 realist review-only papers searched two to seven databases. Four of the five multicomponent reviews searched over 10 databases, though the remaining one searched two to four databases. Multicomponent reviews could be expected to search a large number of databases

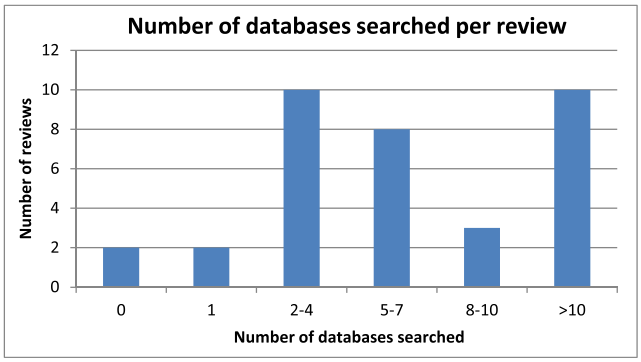

FIGURE 3 Number of databases searched per review [Colour figure can be viewed at wileyonlinelibrary.com]

if the aim was to identify evidence relevant for several review components covering different types of evidence or data. For example, clinical trials, guidelines, theses, trade articles, and research articles are accessible from different databases including ClinicalTrials.gov, HMIC, SCIE, ProQuest Dissertations and Theses, ABI/INFORM, and Web of Science. Furthermore, we would expect a higher number of databases to be searched where the review question straddles several disciplines—a question on the implementation and use of electronic health records could draw on health, computer science, management science, and psychology literatures.

For two reviews, it was impossible for us to determine from the reports if any databases were searched. One reported sourcing reports from a University digital repository[20] while the other sourced reports from websites, personal knowledge, and reference tracking.[31] It is unclear if these activities involved browsing, retrieving known items, or conducting a structured search. Two reviews reported searching only one database,[17,27] although one of these indicated that a larger set of seven databases was searched for a separate review component reported elsewhere but which subsequently contributed data to the realist review.[27]

5.8.2 | Main databases searched

No specific databases figured prominently across all reviews although, as Table 3 indicates, the health databases were most frequently utilized. This dominance of health databases was expected since 31 of the 35 reviews covered health-related questions. The majority of health-related reviews had searched MEDLINE (n = 27), followed by EMBASE (n = 19) and CINAHL (n = 18). Of the four nonhealth reviews, two searched general databases and nonhealth discipline-specific databases,[22,38] and two did not report searching databases.[20,31]

TABLE 3 Number of reviews searching specific and grouped database

Database	No. of Reviews Searching the Database(s)
MEDLINE	27
EMBASE	19
CINAHL	18
PsycINFO	15
Cochrane Library	13
Web of Knowledge SSCI SCI	13 2 1
SCOPUS	12
Other non-health discipline specific databases	21
Other medicine/health databases	10
Other general database	8
Other	0

Realist reviews sometimes "borrow" evidence from other disciplines to support or refute a programme theory. Searching information resources for evidence from related disciplines is evidenced with most of our sample searching diverse discipline-specific and multidisciplinary databases. Twenty-six of the 31 health reviews reported searching nonhealth discipline-specific databases (n = 5) such as ASSIA, Engineering Village, and ERIC; multidisciplinary databases (n = 7) such as Web of Knowledge, or both (n = 14). Three health reviews did not search any health discipline databases,[15,17,40] but relied on multidisciplinary databases for health studies and, presumably, relevant studies from other disciplines. Five health reviews searched only health databases.[14,23,27,33,42]

Health databases that fell under our data category "Other medicine/health databases" included global health, ongoing research, health care condition, and health care professional specific databases, chosen for relevance to the review question. For example, a review of rehabilitation included database searches of Rehabdata and the CIRRIE Database of International Rehabilitation Research.[36]

Twenty-two reviews searched at least one multidisciplinary database (Scopus, Web of Knowledge, Social Science Citation Index and Science Citation Index). Six reviews named various sources classed as "Other general/multidisciplinary sources" including a university research articles database, grey literature, eg, OpenGrey, dissertation abstracts, inside conferences, and journal articles, eg, ScienceDirect.

Thirteen reviews reported searching within a search engine, including eight reviews that reported a Google search, two reviews that reported a Google Scholar search and three that reported searching both Google and Google Scholar.

5.8.3 | Date coverage

Twenty-one reviews reported either a start date, an end date, or both to describe the date coverage of the searches. Just over a third (13 reviews) gave justifications for their start dates or end dates or both. Justifications included identifying publications after landmark policies or guidelines were introduced, rapid review considerations, an aim to focus on recent publications, and

starting from a date when relevant publications gained prominence in the literature. One review selected a start date for their final search by identifying when a trend of increased relevant publications began from initial search results.[36]

5.8.4 | Limits

Although reporting the use of limits (other than date limits) within a search is not required by RAMESES publication standards[2] we included it in our data extraction to identify the types of limits used and justifications for using them in the context of realist reviews. Twenty-one reviews did not report using limits (other than date limits). A single limit was reported in 12 reviews, and two reviews reported multiple limits.[13,15] English language was the search limit used most frequently (n = 12). Other limits included geographic search filters and limiting to peer-reviewed publications. Some reviews reported using a limit for searches for one component, eg, background search but not another. Geographic searches were used to limit search results to studies from particular entities, eg, low-income countries. However, in a review that focussed on less resourced settings,[36] studies from high income countries were identified where findings could be adapted to low-income countries. Geographic filters may be appropriate but should be used with caution within realist reviews where studies based in different geographic contexts may offer valuable insights.

5.9 | Searching to refine programme theories

A notable omission from the majority of realist search descriptions were details of specific searches to refine program theories. This may reflect that the search to refine program theories is pervasive throughout the course of the review or, more simply, that it is particularly challenging to document this fact. Most included reviews indicated some additional activity but typically described in general terms and in the perfunctory detail of a couple of sentences of description. Others used the results of an earlier search, the background search, or the search for empirical evidence as a source to refine program theories. Many review teams chose to describe the dual process of developing an initial program theory and subsequent refinement as continuous, rather than as two discrete stages. This is confirmed by an emphasis on searches conducted "throughout the project"—suggesting follow up of theory leads. One realist review describes how this iterative process would work "as new elements of theory were developed from the data, secondary searches for evidence to support and refine those elements were required."[28]

This review also described the creation of case studies as a way of exploring theory refinement (describing this as a "reality check"). Key to this stage of the process is the need to look for the disconfirming case[50]—indeed one review described the need to revisit previously excluded studies specifically for this purpose.[27]

5.9.1 | Searching for midrange theories

We observed a comparable lack of description of how searches had been used in connection with identification of midrange theories. In some cases, the review team seems to have centered on a specific theory early in the process and then to use this as a "lens" through which to explore the collected data.[15,23] In other cases, the review team gathered together a host of frameworks, from different disciplines and contexts, and explored the utility of each.[21] Some programmes were explicitly based on underpinning theoretical frameworks in which case the review team could establish a strong link between the programme theory and midrange theory. However, notwithstanding this apparent richness of explicit theorizing, the same team observed that a large proportion of the remaining programmes "appeared to be atheoretical or chose not to discuss their theoretical underpinnings."[25]

The process which we expected to see, based on realist methods texts,[8] was most closely approximated in a review of care homes for older people.[26] After producing a set of potential context, mechanism, and outcome configurations, the team conducted more detailed searches of the literature that revisited and expanded the searches from stage 1. Subsequently, they "considered interventions that drew on theories that focused on: the assessment of frail older people in the last years of life; system-driven quality improvement schemes in primary care; and theories of integrated working."[26] Even here, however, the team does not explain how they identified, and then selected, the candidate theories that they subsequently pursued.

Once midrange theories are identified, the review team undertakes a process by which they question the integrity of each theory, consider the competing theories as explanations to why certain outcomes are achieved in similar and different settings and compare the stated theory with observed practice.[51]

5.10 | Documenting and reporting the search process

Detailed documentation and reporting of searches is essential for ensuring that the searches can be critiqued by peer reviewers and interested readers. As a general guide, the standard of reporting should be sufficient for a reader to reproduce the search methods. As well as ensuring transparency of method, this level of reporting facilitates maintenance and update of subsequent reviews. The RAMESES publication standards for realist syntheses stipulate reporting: the sources searched, including bibliographic databases and any other sources; all search terms used (optimally including how the search terms were combined into a search strategy); the most recent date that searches were carried out; and dates of coverage.[2] These requirements are common to other types of systematic review reporting guidance, eg, the *Cochrane Handbook for Systematic Reviews of Interventions*,[52] the *Collaboration for Environmental Evidence's Guidelines for Systematic Reviews in Environmental Management*,[53] and the *Centre for Reviews and Dissemination's Guidance for Undertaking Reviews in Health Care*.[54] Further to the above, RAMESES stipulates that review authors should state and provide a rationale for any iterative searching, eg, when testing and refining program theories.[2]

5.10.1 | Use of reporting standards

Twenty-five of the 35 reviews in our sample cited the RAMESES publication standards for realist syntheses.[2] A further two reviews cited the RAMESES publication standards for meta-narrative reviews[55] and one review cited the RAMESES protocol.[56] The remaining seven reviews[13,19,20,22,31,33,36] did not reference RAMESES or any other reporting standard, eg, PRISMA.[57] Twenty-two reviews reported a PRISMA flow diagram or adapted a PRISMA flow diagram but did not always attribute the PRISMA Statement to the diagram.[57]

Reporting of searching bibliographic databases

Searching bibliographic databases was the most frequently reported search method in our sample of realist reviews (n = 33). The majority of such reports were broadly compliant with RAMESES.[2] At least one database was reported in all 33 reviews, although we cannot be certain that every database searched was reported in every case (see Table 3). Of these, 24 reviews reported search terms, either as a sample search strategy (n = 12) or as illustrative search terms in tabular or list form (n = 12). Four reviews went further and reported the bibliographic database search strategies for all databases searched.[15 17 41 47] Although this constitutes an exemplary approach, we acknowledge that this level of reporting may be constrained by publication word limits or reporting preferences of journal editors. (RAMESES guidance recognizes that review authors should consider [the] specific requirements of the journal or other publication outlet).[2] Notably, two of these four reviews are UK Health Technology Assessment reports published in the NIHR journals monograph series,[39,45] with higher word count limits and greater scope for detail than standard journal publications.

The remaining five reviews which reported searching one or more bibliographic database did not report any details of the search terms. However, in some cases, the reader was directed to a sibling study with additional detail about the searches.[26,58] This necessarily acknowledges the word count limitations of some journals although transparency might require that sibling studies with essential detail are available via open access, either through the journal site or through an open access institutional data repository.

The reporting of database coverage dates and justification for the date coverage chosen was variable across the reviews. RAMESES publication standards for realist syntheses require dates of coverage and dates last searched.[2] Ten reviews did not report the dates of coverage, six reported start dates only (ie, the historical cut-off date), four reported end dates only, and fifteen reported both start and end dates in line with RAMESES standards.[2]

Limits to searches such as date or language limits can be described in the search methods section of the manuscript, and also clearly identified as search lines within a full database search strategy. In some reviews with multiple searches or search iterations, it was unclear if a limit was applied to all searches throughout the review or only to selected searches.[25] Some papers indicated that limits had been applied in some, but not all, databases,[40] whereas others did not contain detailed search data, implying that a stated limit was applied to all databases. To avoid misrepresenting searches, careful attention should be paid when describing which search limits were used, to which stages of the search and for which database.

Reporting of nonbibliographic database searching

Several forms of nonbibliographic database searching were reported. Reporting was less detailed than for bibliographic database searching—in general, narrative detail of the overall approach was provided in the main text, but did not always include the step-by-step detail required for full transparency. In part, this may reflect a focus of the RAMESES publication standards on

reporting relevant to bibliographic databases, eg, search terms and limits.[2] However, this may mirror a broader trend in the reporting of what is typically described as "supplementary searching" for other types of reviews—a comparable lack of detail when reporting non-bibliographic database searching has been observed in Cochrane reviews.[59]

Constraints of time and resources available for our review prevent describing and comparing in detail the reporting of each supplementary search method across all 35 reviews in our sample. Whitaker provided the most detailed report of supplementary searching,[45] which included step-by-step detail on:

- how lead authors were approached for details of associated reports;
- how sibling papers were identified using the PubMed related articles feature;
- resource names, search dates, and numbers of results retrieved for searches for gray literature;
- google search terms, dates, and numbers of results;
- search dates and numbers of results for citation searches;
- journals in which hand-searching was conducted.

This approach could be considered exemplary reporting. However, as noted above, this realist review is published within the NIHR journals monograph series with higher word count limits and more scope for reporting detail than a standard journal publication.[45] Reporting of nonbibliographic database searching in standard journals typically included lists of methods and/or sources searched rather than the full process undertaken, eg, "we searched for gray literature via websites, national guidance, and professional publications" not identifying particular sources or how they were searched. However, we note room for improvement in such reporting, even given space limitations in print journals, as names of sources would be useful, and not prohibitively lengthy, even if step-by-step descriptive detail cannot be accommodated within the journal format.

For realist reviews, all available search methods can be used throughout the review within an iterative search process,[5] contrasting with the classic systematic review model where bibliographic database searches are conducted at the start of the review supplemented by other nonbibliographic database search approaches. We identified explicit mention of iterative searching in 10 reviews. Typically, this comprised a general statement that an iterative approach to searching was used to test and refine program theories.[14,23,28,31,33,46] Gilmer reported including an advisory group of experts in an iterative search process by asking for feedback on the results of each stage of searching, which led to suggestions for additional searches.[25] Our personal experience confirms what we observed within reviews in our sample, namely, that iterative searching is difficult to document and report in full, with implications for the transparency of realist reviews.[42] However, we contend that—although more labor-intensive and demanding of limited journal space—transparent reporting of iterative searching—for the most part—remains possible.[45] In reporting, a non-iterative approach to searching, Elliott (2016) reported that all items in RAMESES were followed *except* for iterative searching, as the initial searches "obtained a large sample of literature ... which we felt [provided] sufficient data."[21] Although not an iterative search method per se, repeated mining of a large and broadly inclusive data-set offers iterative theory or evidence identification, as a valid alternative to repeated searches for new theories or studies.

6 | DISCUSSION

6.1 | Summary of findings

Across the sample of 35 realist reviews, published within both health and nonhealth, we detected considerable variation in search methods and reporting. Diverse methods reflect the still-experimental nature of the realist synthesis approach, justifying our quest to identify alternative search methods beyond our own. Furthermore, this reflects the lack of explicit realist synthesis methods handbooks, with realist commentators focusing on an overall direction of travel rather than on specific detail. It could also reflect an inherent flexibility of approach to realist synthesis where standardization is likely to be both unlikely and undesirable. The flexibility of the realist approach when carrying out literature searches is illustrated in a worked example in this journal.[60]

Similarities and differences between the "realist search" and the "systematic review search" were revealed at all levels of the sample, from the overall search process down to specific stages or techniques. In many cases, the realist search process could be characterized as essentially iterative, either stated explicitly or indicated implicitly within the narrative description of methods or accompanying search diagrams. Several reviews mirrored the "big-bang" search process that characterizes systematic reviews, where relevant information is identified through a single upfront search, either within wider review objectives or for a specific realist component, and other features typical to systematic review methods were both used and documented.

6.2 | Current practice of search methods

Searching for program theories revealed perhaps the greatest variation in methods. Indeed, some reviews did not even include this as a formal search stage with program theories being generated internally by the team or from serendipitously identified documents. The well-documented split within most fields of study between conceptual and empirical literature suggests the potential value of specific additional searches although methods for identification of program theory need further development.

We found it particularly challenging to identify formal processes for searching to refine programme theories. Partly, this may be attributable to the fact that this might be considered and described as an extension of the earlier search for program theories. It might also reflect the fact that the review team iteratively returns to data previously identified from background or empirical searches rather than initiating further searches.

In contrast, the search for empirical evidence most closely resembles the familiar search for studies modeled by the conventional systematic review. The number and types of sources used, search terms selected, and methods harnessed when searching bibliographic databases differed little from corresponding searches for systematic reviews. Perhaps an exception lies with nonbibliographic database search techniques and the use of gray literature sources which are extensively used within realist syntheses, largely because of a need to identify more extensive evaluative literature, a wider range of study and publication types, and examples of programmes currently in progress. Whether the configurative (interpretive) nature of realist syntheses opens up the possibility of more theoretical, purposive methods of sampling was ambivalent within the sample with a large proportion mirroring the comprehensive sampling of the conventional systematic review. We contend that even purposive approaches to sampling may require an underlying comprehensive search approach so that the sampling frame, from which included "cases" are selected, reflects the true diversity and richness of relevant studies. Furthermore, we detected realist syntheses that did not fully engage with the systematic review tradition evidenced in a more discursive, less complete, and less structured approach to description of methods.

6.3 | Reporting of search strategies

In comparison with limited available guidance material on specification of methods, reporting is well-catered for by the RAMESES reporting standards. However, even the three specific RAMESES reporting standards relating to the realist search do not acknowledge the full extent or variation of the multicomponent searches as documented in our six-stage process. Furthermore, documentation of the search process did not always comply with the RAMESES reporting standards.[2] Seven of our sample of reviews did not reference RAMESES at all. Our sample shared the inadequacies of many systematic reviews in omitting important details of decisions made regarding limits, date cut-offs, and types of included studies. The sample showed substantive variation in reporting of search strategies ranging from no detail, reporting of indicative key terms, documenting a single search strategy from one database or reproducing multiple search strategies. We contend that a search strategy should extend beyond the minimum requirements of RAMESES; not only including indicative terms used but routinely going beyond this to indicate the syntax and relationships between search terms. Furthermore, we highlight the enduring value of a PRISMA-type flow diagram in ensuring the transparency of the search process.[57]

In making a plea for more complete reporting of search strategies and approaches, we acknowledge that multiple alternatives exist to achieve this including the provision of supplementary appendices or links to associated publications, protocols, or full reports. Above all, we affirm a tension previously identified within qualitative evidence syntheses[61] namely that better synthesis science may require iterative and responsive search strategies. Accommodating iterative search strategies with fidelity may aggravate the challenge already posed by the need to document strategies with both transparency and clarity.[42] Developing and sharing good practice for efficiently documenting iterative searches during the review's lifecycle is encouraged.

6.4 | Strengths and limitations of this study

This study was conducted by three experienced information professionals with extensive collective experience of supporting diverse realist syntheses as well as having documented diverse review types. The six-component realist search framework used for data extraction extended an early version from the originator of realist synthesis, supplemented by formulating the question and documenting and reporting the search process. Nevertheless, it was challenging to compartmentalize published written accounts of the search process within the framework; authors did not clearly delineate the different

components nor did they use consistent labels when describing the search process. It was also challenging to decide on the eligibility of included reviews, both in the degree to which they represented a full report of a realist search and in how to interpret publication within a single calendar year.

We sought to replicate as closely as possible, the search methods used in the original study by Berg and Nanavati.[4] As experienced information professionals, we acknowledge the potential to improve on the original authors' published search strategies for identifying a test set of realist reviews. Our study required as unequivocal a sample of realist reviews as possible and so we relied on distinctive labels (eg, realist review and realist synthesis) for positive identification. Even choosing this conservative strategy required subsequent exclusion of protocols and realist evaluations with a synthesis element. We further acknowledge that, given additional time and resources, we could have described and compared supplementary search methods across our sample. Future reviews and updates could make practice and innovation in supplementary search methods a focus for exploration.

Fulfillment of reporting requirements is a question of degree and is not easily reduced to binary judgements. We have not attempted to evaluate the quality or appropriateness of the search techniques used, focusing only on describing the procedures used. Interpretations of the written reports were achieved through consensus.

7 | CONCLUSIONS

In assessing a sample of 35 realist reviews published within a single calendar year, we have identified considerable variation and yet some areas of consensus. Sampling strategies were diffuse yet the comprehensive sampling strategy was also clearly detected in the majority of included reviews. The search for empirical evidence was the most systematically conducted and transparently reported searching stage, while searches for program theory were conducted alongside or as part of more vaguely reported "background" or "scoping" searches, or coterminous with the search for empirical evidence. Reporting of searches to refine programme theories was even more sparse. We have suggested that it would be useful to differentiate between these search stages clearly when conducting and reporting searches for realist reviews. This might involve clearly describing the way in which the results of a single search were sifted for different stages of the review, rather than necessarily running multiple searches—although we do advocate that the latter approach offers unique benefits by harnessing diverse search approaches beyond the bibliographic database-led systematic review search for evidence.

Suggestions for practice

Conduct

- Consider conducting searches for programme theory separately to searches for evidence.
- Iterative approaches to mining reference libraries could be used in place of multiple searches.
- Gray literature sources might be particularly useful for programme theory development in addition to published sources.
- A comprehensive approach to searching for empirical evidence should not necessarily be rejected in favor of narrow sampling techniques, as this can provide rich data to draw from.
- Supplementary search methods should be considered at all stages of the review.

Reporting

- Searches to inform and refine the initial programme theory should be reported alongside searches for empirical evidence.
- Supplementary searches should be transparently reported alongside bibliographic database searches.
- Consistent approaches to reporting the "realist search" could improve the readability and clarity of the reviews: this could be achieved using the featured six-part structure.

Operating outside prescribed standards for searching allows researchers to innovate and yet, at the same time, generates considerable uncertainty. In demonstrating a previously proposed six-component structure within which to frame the "realist search," we seek to accommodate innovation while encouraging searchers to conduct and document essential ingredients of the realist method, as captured within Pawson's original template.[7] We look forward to the development and evaluation of advanced methods of study identification in support of realist synthesis.

In common with other types of literature review, reporting of searches was better for bibliographic database searches than for other search methods. The RAMESES reporting standards[2] do not currently distinguish between the different components of the realist search. As a consequence, a realist review team, supported by an information specialist unfamiliar with realist synthesis, may find it confusing to differentiate contrasting expectations of comprehensive searching for empirical studies from more purposive and intuitive approaches in search

for program theory or midrange theory. Structured reporting of the realist search process, according to the six-component framework that we recommend, holds the potential to ensure that the next literature survey of realist syntheses documents a clearer, more coherent and structurally consistent approach than was revealed by our survey. Potentially, improved reporting will improve the readability of realist synthesis reports and the clarity of review methods, further enhancing the credibility of the realist synthesis methodology.

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CONFLICT OF INTEREST

The author reported no conflict of interest.

ORCID

Andrew Booth https://orcid.org/0000-0003-4808-3880
Simon Briscoe https://orcid.org/0000-0002-6982-4521
Judy M. Wright https://orcid.org/0000-0002-5239-0173

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APPENDIX A: | SEARCH STRATEGIES FOR EACH DATABASE AND NUMBER OF HITS RETRIEVED

Database: Cochrane Database of Systematic Reviews (CDSR)
Host: Cochrane Library
Data Parameters: Issue 7 of 12, July 2017
Date Searched: 12/7/2017
Searcher: SB
Hits: 0
Strategy:

1. ("realist systematic review*" or "realist review*" or "realist synthes*"):ti or ("realist systematic review*" or "realist review*" or "realist synthes*"):ab Publication Year from 2015 to 2017

Database: CINAHL
Host: EBSCO
Data Parameters: n/a
Date Searched: 12/7/2017
Searcher: SB
Hits: 85
Strategy:

1. TI ("realist systematic review*" or "realist review*" or "realist synthes*") OR AB ("realist systematic review*" or "realist review*" or "realist synthes*")

Notes: Date limited 2015 to current.
Database: DARE
Host: Centre for Reviews and Dissemination
Data Parameters: n/a
Date Searched: 12/7/2017
Searcher: SB
Hits: 0
Strategy:

1. (realist systematic review* or realist review* or realist synthes*) IN DARE FROM 2015 TO 2017

Notes: DARE was discontinued in March 2015 but is still searchable as an archive.
Database: Embase
Host: Ovid
Data Parameters: 1974 to 2017 July 11
Date Searched: 12/7/2017
Searcher: SB
Hits: 165
Strategy:

1. ("realist systematic review*" or "realist review*" or "realist synthes*").tw
2. limit 1 to yr = "2015 -Current"

Database: ERIC
Host: EBSCO
Data Parameters: n/a
Date Searched: 12/7/2017
Searcher: SB
Hits: 4
Strategy:

1. TI ("realist systematic review*" or "realist review*" or "realist synthes*") OR AB ("realist systematic review*" or "realist review*" or "realist synthes*")

Notes: Date limited 2015 to current.
Database: PsycINFO
Host: Ovid
Data Parameters: 1806 to July Week 1 2017
Date Searched: 12/7/2017
Searcher: SB
Hits: 54
Strategy:

1. ("realist systematic review*" or "realist review*" or "realist synthes*").tw
2. limit 1 to yr = "2015 -Current"

Database: ProQuest Dissertations & Theses A&I
Host: ProQuest
Data Parameters: After December 31 2014
Date Searched: 12/7/2017
Searcher: JW
Hits: 17
Strategy:

1. ti("realist systematic review*" OR "realist review*" OR "realist synthes*") OR ab("realist systematic review*" OR "realist review*" OR "realist synthes*")

Database: PubMed
Host: NLM
Data Parameters: 1966 to 2017 July 12
Date Searched: 12/7/2017
Searcher: AB
Hits: 187
Strategy:

1. "realist systematic review*" or "realist review*" or "realist synthes*"
2. limit 1 from 2015/01/01 to 2017/12/31

Database: Sociological Abstracts (1952 - current)
Host: ProQuest
Data Parameters: After December 31 2014
Date Searched: 12/7/2017
Searcher: JW
Hits: 7
Strategy

1. ti("realist systematic review*" OR "realist review*" OR "realist synthes*") OR ab("realist systematic review*" OR "realist review*" OR "realist synthes*")

Database: Social Services Abstracts (1979 - current) Host: ProQuestData Parameters: After December 31 2014Date Searched: 12/7/2017Searcher: JWHits: 9Strategy

1. ti("realist systematic review*" OR "realist review*" OR "realist synthes*") OR ab("realist systematic review*" OR "realist review*" OR "realist synthes*")

Database: Web of Science Core Collection
Host: Clarivate Analytics
Data Parameters: 2015-2017
Date Searched: 12/7/2017
Searcher: JW
Hits: 145**
Strategy

1. ("realist systematic review*" OR "realist review*" OR "realist synthes*") TOPIC search

Notes: Web of Science Core Collection search includes:

- Science Citation Index Expanded (SCI-EXPANDED) --1900-present
- Social Sciences Citation Index (SSCI) --1900-present
- Arts & Humanities Citation Index (A&HCI) --1975-present
- Conference Proceedings Citation Index- Science (CPCI-S) --1990-present
- Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) --1990-present
- Emerging Sources Citation Index (ESCI) --2015-present

Numbers found per database are:
SCI = 114, SSCI = 121, A&H = 0, CPCI-S = 2, CPCI-SSH = 0, ESCI = 4

TABLE A1 Number of results per database and in total

Database	Results	Google Scholar
CDSR	0	
CINAHL	85	
DARE	0	
Embase	165	
ERIC	4	
PsycINFO	54	
ProQuest Dissertations & Theses	17	
PubMed	187	
Sociological Abstracts	7	
Web of Science Core Collection	145	
Total results	664	1,064
Duplicate results	559	982
Unique results	105	82
Total Records Screened		187*

[a]See Figure 2.

Reference	Reason
Booth V, Harwood R, Hood V, Masud T, Logan P. Understanding the theoretical underpinning of the exercise component in a fall prevention programme for older adults with mild dementia: a realist review protocol. Systematic Reviews. 2016 Dec;5(1):119.	Protocol
Ellaway RH, O'Gorman L, Strasser R, et al. A critical hybrid realist-outcomes systematic review of relationships between medical education programmes and communities: BEME Guide No. 35. Medical Teacher. 2016 Mar 3;38(3):229-45.	Published online: 08 Dec 2015
Lhussier M, Carr SM, Forster N. A realist synthesis of the evidence on outreach programmes for health improvement of Traveller Communities. Journal of Public Health. 2015 Jul 30;38(2):e125-32.	Published online 2015 Jul 30.
Mitchell S, Bennett K, Morris A, Dale J. Palliative care services for children and young people: Realist review of the literature. Archives of Disease in Childhood. 2016;101:A305-A6.	Abstract
Pearson M, Brand SL, Quinn C, et al. Using realist review to inform intervention development: methodological illustration and conceptual platform for collaborative care in offender mental health. Implementation Science. 2015;10(1):1-12.	Published Online Sept 28th 2015
Pearson M, Chilton R, Wyatt K, et al. Implementing health promotion programmes in schools: a realist systematic review of research and experience in the United Kingdom. Implementation Science. 2015;10:1-20.	Published Online October 28th 2015
Yalamanchili S, Skordis-Worrall J, Blanchet K. Barriers to Initial Management of Major Trauma in Low & Middle Income Countries: A Realist Synthesis. British Journal of Surgery. 2016 Aug;103:208-.	Abstract

APPENDIX B: | DATA EXTRACTION FORM

Study ID
- Question Formulation
- Background Search
- Search Approach
- Search to develop programme theories
- Overall description of Search Strategy
- Search to refine programme theories
- Search for Mid-Range Theories
- Inclusion Criteria
- Terms Used
- Reported Limitations of Search Methods Used
- Documentation provided
- List all supplementary search documentation (other than above)
- Use of Reporting Standards
- Reviewer Comments
- Follow up Methodology References

APPENDIX C: | EXCLUDED STUDIES

Chapter 7. Article 5

Briscoe S, Bethel A, Rogers M. Conduct and reporting of citation searching in Cochrane systematic reviews: A cross-sectional study. Res Synth Methods. 2020 Mar;11(2):169-180. doi: 10.1002/jrsm.1355.

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RESEARCH ARTICLE

WILEY Research Synthesis Methods

Conduct and reporting of citation searching in Cochrane systematic reviews: A cross-sectional study

Simon Briscoe[1] | Alison Bethel[2] | Morwenna Rogers[2]

[1]Exeter HS&DR Evidence Synthesis Centre, College of Medicine and Health, University of Exeter, Exeter, UK

[2]Evidence Synthesis Team, NIHR CLAHRC South West Peninsula, College of Medicine and Health, University of Exeter, Exeter, UK

Correspondence
Simon Briscoe, Exeter HS&DR Evidence Synthesis Centre, College of Medicine and Health, University of Exeter, South Cloisters, St Luke's Campus, Exeter, EX1 2LU, Exeter, UK.
Email: s.briscoe@exeter.ac.uk

Background: The search for studies for a systematic review should be conducted systematically and reported transparently to facilitate reproduction. This study aimed to report on the conduct and reporting of backward citation searching (ie, checking reference lists) and forward citation searching in a cross section of Cochrane reviews. Citation searching uses the citation network surrounding a source study to identify additional studies.

Methods: Cochrane reviews were identified by searching the Cochrane Database of Systematic Reviews using the wildcard symbol and date limiting to the 3-month period November 2016 to January 2017. Cochrane reviews thus identified were screened for mention of citation searching. Descriptive detail on the conduct and reporting of citation searching was captured in data extraction forms and described and evaluated.

Results: Two hundred fifteen Cochrane reviews were identified. One hundred seventy-two reviews reported backward citation searching, and 18 reviews reported forward citation searching. Web of Science was the most frequently reported citation index. The studies used for backward citation searching consisted mainly of studies meeting the inclusion criteria. One-third of reviews that reported forward citation searching used selected studies of importance. Reporting of citation searching was compliant with the Methodological Expectations of Cochrane Intervention Reviews (MECIR) standards, but full transparency requires additional detail that only a minority of reviews reported.

Conclusion: The conduct of backward citation searching was more uniform than forward citation searching. This might be due to lack of MECIR guidance for forward citation searching. Reporting was generally compliant with MECIR, but this is not always sufficient to ensure full transparency.

KEYWORDS
checking references, citation searching, Cochrane reviews, literature searching

1 | INTRODUCTION

Systematic reviews aim to answer research questions by identifying, appraising, and synthesizing all the relevant evidence.[1] An important component of a systematic review is the search for studies, which aims to identify all studies that answer the research question. In conformity with the overall methodology for a systematic review, the search for studies should be conducted using systematic and reproducible methods and documented such that it can be reported transparently.[2] This study reviews how two similar search methods, backward and forward citation searching (hereafter, citation searching, unless one or the other is explicitly stated), were conducted and reported in a cross section of Cochrane systematic reviews (hereafter, Cochrane reviews) published in a 3-month period.

1.1 | What is and why conduct citation searching?

Citation searching uses the citation network surrounding a source study to identify similar studies. A citation network consists of the studies that are cited by a source study (ie, the reference list) and the studies that cite a source study. Citation searching in the context of a systematic review usually starts with one or more studies that meet, or that have similar content to, the inclusion criteria. We use the term *study* herein synonymously with *article* to refer to a document that describes the methods and results of primary or secondary research. Potential candidate studies for citation searching include the following:

- Selected key studies of particular importance;
- All studies eligible for inclusion in a review;
- Potentially relevant studies, such as studies included at title and abstract screening for full-text screening.[3]

On the assumption that studies that cite or are cited by a source study are likely to have similar content, the citation network is searched backward and/or forward: *Backward citation searching* involves inspecting the references that are cited in the source study (hence often called *checking reference lists*), and *forward citation searching* involves using a citation index to identify studies that cite a source study.[2,4]

Citation indexes are bibliographic databases that index citations of studies in addition to the standard bibliographic content. They include Scopus (Elsevier, USA) and Web of Science (Clarivate Analytics, USA), which are both subscription-based, and the freely available Google Scholar. Web of Science is composed of several subject specialist databases, access to which varies depending on the user's subscription. The Web of Science Core Collection includes the Science Citation Index, the Social Sciences Citation Index, the Arts & Humanities Citation Index, and conference proceedings.[5] Google Scholar, Scopus, and Web of Science have similar but not identical journal coverage, which can result in variation in the number of citations identified for the same source study.[6] For example, a forward citation search of Whear et al[7] identifies 29 citations in Web of Science, 37 citations in Scopus, and 65 citations in Google Scholar (search conducted by S.B. on 1 November 2018). This phenomenon has raised the question, still to be resolved conclusively, of whether searching multiple citation indexes is preferable to one citation index[8]; reasons against this approach include time and resource implications. Backward citation searching can be conducted manually by inspecting the reference list of the source study or via Scopus or Web of Science, which both index reference lists of studies as well as citations of studies.

Citation searching typically supplements searching bibliographic databases when searching to identify studies for a systematic review.[9] A cross-sectional study of 300 systematic reviews found that 81% reported backward citation searching and 12% reported forward citation searching as an adjunct to searching one or more bibliographic database.[10] The aim of citation searching is to identify studies missed by text-based searches in the title, abstract, or controlled vocabulary fields of bibliographic records.[9] Studies that compare the effectiveness of citation searching with searching bibliographic databases show that citation searching is particularly effective at retrieving studies for systematic reviews where core concepts are difficult to capture using keywords, eg, where core concepts are described inconsistently due to systemic reporting deficiencies, or due to historical development of terminology in a subject area or research methodology.[9,11-15] Iterative citation searching using studies identified by citation searching, or *citation snowballing*, might be useful for systematic reviews of hard-to-find studies, such as those included in qualitative evidence synthesis.[16] In these types of review, citation searching can be considered a complementary or even primary search method rather than as supplementary to searching bibliographic databases.[15,17] Citation searching yields fewer unique studies where the search query can be successfully represented by a text-based search.[18] However, it can still be useful for identifying studies not indexed in the bibliographic databases searched, or identifying studies before they are indexed in a bibliographic database.[18]

1.2 | Cochrane guidance on citation searching: summary and commentary

Guidance and methodological standards on searching for studies for Cochrane reviews are found in the "Searching

for Studies" chapter of the Cochrane Handbook for Systematic Reviews of Interventions (hereafter, Cochrane Handbook)[2] and the Methodological Expectations of Cochrane Intervention Reviews (hereafter, MECIR standards).[19,20] The Cochrane Handbook[2] provides detailed guidance on searching for studies, and the MECIR standards describe the mandatory and desirable standards of conduct[20] and reporting.[19] At the time of writing, the Cochrane Handbook is undergoing revision in preparation for a new edition (version 6). The summary and commentary below on citation searching guidance refer to the currently available version (5.1), which is the version that the authors of the Cochrane reviews in our cross section have used to inform their search methods.[2]

The MECIR standards for *conducting* Cochrane reviews stipulate that backward citation searching is mandatory (C30)* alongside searching a core set of bibliographic databases (C24).[20] In particular, review authors should use *included studies* and *any relevant systematic reviews* when conducting backward citation searching.[20] There is no guidance in the MECIR standards[20] or Cochrane Handbook[2] on whether to use a manual or citation index-assisted approach, leaving it open to the searcher to determine the most appropriate method. Although forward citation searching is not mentioned in the MECIR standards, the Cochrane Handbook recommends it as an important adjunct to searching bibliographic databases.[2] Also in the Cochrane Handbook[2] is the suggestion that an important relevant article might be a good starting point for forward citation searching, implying that a more focused approach may be taken than for backward citation searching (cf C30).[20] No specific single or combination of citation indexes is recommended in the MECIR standards[20] or Cochrane Handbook,[2] leaving it open to the searcher to determine the most appropriate tool or tools. There is a warning in the Cochrane Handbook that, because citations are susceptible to biases such as selective citation of studies with positive results, citation searching is not an objective search method and the results should be used with caution.[2]

The MECIR standards for the *reporting* of search methods in Cochrane reviews stipulate that review authors should "[l]ist all sources searched, including ... whether reference lists were searched" (R33).[19] Although forward citation searching is not explicitly mentioned, any citation indexes used should be included in the list of sources searched. This also applies to backward citation searching in reviews where a citation index is used for this purpose.

*Numbers in parentheses in this section refer to the relevant MECIR standard item on either conduct (eg, C30) or reporting (eg, R33).

This is the full extent of detail required by the MECIR standards to report about citation searching.[19] In addition, we suggest that it is useful to report the set of studies used for citation searching. In particular, if the set of studies used is a narrower or broader set than the studies included in the review, then the specific studies should be listed, eg, key studies of interest or studies not included in the review. This allows the scope of the search to be assessed and facilitates reproduction. Furthermore, we suggest explicitly stating that a citation index was used for citation searching as citation indexes can also be searched using keywords. Finally, reporting the date of forward citation searching allows the timeliness of the search to be assessed. The date of the search is not relevant for backward citation searching as reference lists remain the same over time.

A summary of key methodological decisions required when conducting citation searching is presented in Table 1. The only mandatory requirement in the MECIR

TABLE 1 Key methodological decisions when conducting citation searching

	Methodological decision	Commentary
1	What set of studies to use	The minimum standard for BCS for Cochrane reviews is included studies and any relevant systematic reviews. A more selective approach can be used for FCS if appropriate.
2	What citation index to use and whether to use more than one citation index	The main options are Google Scholar, Scopus and Web of Science. Coverage varies between citation indexes.
3	Whether to use a manual or citation index-assisted approach for BCS	A manual approach is perhaps the best way of ensuring all citations are checked as there is a risk that a citation index fails to index all cited studies. A benefit of using a citation index is the option to export and de-duplicate the results of a large set of citations from multiple studies to avoid the potential for screening the same cited study or studies multiple times.
4	Whether to use a non-standard approach	For example, citation snowballing. Can be particularly useful for identifying hard-to-find literature, such as qualitative studies.

Abbreviations: BCS, backward citation searching; FCS, forward citation searching.

standards on conducting citation searching is that included studies are used for backward citation searching. A summary of the reporting guidance in the MECIR standards combined with our suggestions and commentary is described in Table 2.

1.3 | Rationale, aims, and objectives

We conducted this study because we wanted to better understand variations in the conduct and reporting of citation searching in systematic reviews. To date, reviews on the conduct and reporting of search methods in systematic reviews have reported findings on citation searching relatively briefly—typically, the prevalence of the search method.[10,21] There are several published case studies of citation searching[11-14,18] and reviews of such studies,[3,9] but their focus is the effectiveness of the search method compared with other search methods (usually in a single case study) rather than a cross-sectional analysis of conduct and reporting. We chose to examine Cochrane reviews in particular because they are a more consistently high standard of systematic review than other types of systematic review.[22]

We had two main aims. First, we aimed to describe how citation searching was conducted in a cross section of Cochrane reviews. This included five specific objectives on the conduct of citation searching derived from our experience as information specialists and the relevant literature (summarized in Table 1), namely, to describe the following:

1. The different sets of studies that were used for citation searching and how frequently;
2. The citation indexes that were used and how frequently;
3. The frequency of a manual approach for backward citation searching versus a citation index assisted approach;
4. The frequency of using more than one citation index for citation searching;
5. The frequency of citation snowballing and/or detection of other nonstandard approaches to citation searching.

Secondly, we aimed to assess whether the reporting of how citation searching was conducted was transparent and reproducible, in fulfilment of the minimum reporting standard required for a Cochrane review.[1] This included the three items in Table 2 (ie, name of citation index, set of studies used, and the date of the search) and also where in the systematic review citation searching was reported.

2 | METHODS

2.1 | Eligibility criteria

We included Cochrane reviews (including both new and update reviews) if they used backward or forward citation searching to identify studies. It was not sufficient for inclusion that a review listed a citation index in the list of databases searched, as this could mean that the citation index was searched using a text-based search strategy. Instead, we looked for explicit description that citation searching was conducted.

The publication date of included reviews was limited to the 3-month period November 2016 to January 2017. This was due to practical constraints of time and resources that prevented looking at a larger cross section; and it was a convenience sample from an earlier review on the reporting of web searching in Cochrane reviews by S.B.[23]

Cochrane reviews that reported identifying no studies that met their inclusion criteria were excluded because these reviews had no or limited opportunity to conduct citation searching. Some such reviews reported an

TABLE 2 MECIR standards and suggested checklist for the reporting of citation searching

		MECIR		
	Detail	**BCS**	**FCS**	**Commentary**
1	Name of citation index(es) or manual approach	Yes if citation index is used (R33)	Yes (R33)	Provides the reader with important detail on what was done. This should include a statement that the citation index was used for citation searching in particular, as citation indexes can also be searched using keywords.
2	Set of studies used	No	No	To ensure transparency, wherever possible the specific studies used should be listed if other than all included studies.
3	Date of search	-	No	Useful for FCS. Not required for BCS as the results do not change over time.

Abbreviations: BCS, backward citation searching; FCS, forward citation searching.

intention to conduct citation searching, but because we were interested in actual practice of citation searching, we did not include these reviews in our analysis. Cochrane reviews that were withdrawn from publication were also excluded due to potential shortcomings in the search methods that would not reflect acceptable practice when searching for studies for Cochrane reviews.

2.2 | Identification of Cochrane reviews

Cochrane reviews from the 3-month period November 2016 to January 2017 were identified by searching the Cochrane Database of Systematic Reviews via the Cochrane Library using the asterisk (ie, wildcard) symbol in the Search All Text search field and date-limiting using the Online Publication Date feature. The results were then exported to Endnote X7 (Thomson Reuters, New Mexico, USA). This process was undertaken in February 2017 by S.B. as part of an earlier study on the reporting of web searching in Cochrane reviews.[23] All Cochrane reviews in the Endnote library were downloaded and inspected for detail about citation searching by S.B. This involved manual inspection of the abstract, methods, and appendices of reviews for any mention of citation searching and using the Control-F search feature to search for keywords and phrases such as *backward*, *forward*, *citation*, *reference list*, *Web of Science*, *Scopus*, and *Google*.

2.3 | Data-extraction and categorization

We developed a data-extraction form to capture details about how citation searching was conducted and reported. The form was developed with reference to the MECIR standards[19,20] and our wider background reading and recommendations for good practice (see Tables 1 and 2). After a pilot run by all authors on a sub-set of the sample, S.B. inspected all the included Cochrane reviews in the sample and data-extracted key details relating to our five specific aims, including whether backward or forward citation searching was reported; what citation index was reported (or manual approach); the set of studies used to conduct citation searching; any additional details reported about citation searching; and where detail about citation searching was reported. M.R. data-extracted a 10% subset of the sample that were cross-checked with S.B.'s data-extraction forms for consistency. Discrepancies were resolved through discussion after the data-extraction process was complete.

We coded reviews that did not explicitly state whether a manual or citation index-assisted approach was used for backward citation searching as *manual*. In our extensive collective experience of searching for studies for systematic reviews within several UK research institutions, researchers have almost always opted to conduct backward citation searching manually—hence, we considered this a reasonable assumption. However, we also acknowledge that this was only an assumption and kept a separate record of the number of reviews that explicitly reported using a manual approach.

We applied categories to describe the different sets of studies used for citation searching that we identified. These included the following: *key studies* (ie, studies selected as of outstanding importance for the review); *included studies* (ie, studies that met the inclusion criteria for the review, variously described in our sample as *included*, *eligible*, and *relevant* studies); and *identified studies* (ie, studies identified by other search methods that may or may not be relevant to the review, variously described in our sample as *identified*, *retrieved*, and *potentially relevant* studies). These categories are all mutually exclusive. However, we acknowledge that the intended meaning of *identified* is ambiguous and might have been used synonymously with *included* in some cases. As such, the distinction made by our categorization might in some cases be semantic rather than procedural.

We also had a category for *systematic reviews* that is not mutually exclusive, as review authors can conduct citation searching on both primary studies and systematic reviews.

3 | RESULTS

3.1 | Selection of Cochrane reviews

We identified 215 Cochrane reviews with online publication dates from November 2016 to January 2017. We excluded 17 reviews from all subsequent analysis, including seven reviews that were withdrawn from publication and 10 reviews that failed to identify any source studies for citation searching via the bibliographic database searches, ie, no studies that met the inclusion criteria for the review. Of the remaining 198 reviews, 172 (87%) reported backward citation searching, and 18 reviews (9%) reported forward citation searching. The 18 reviews that reported forward citation searching were published by 14 different Cochrane review groups (Airways[24]; Anesthesia[25]; Common Mental Disorders[26]; Developmental, Psychosocial, and Learning Problems[27]; Dementia and Cognitive Improvement[28,29]; Effective Practice and Organization of Care[30,31]; Eyes and Vision[32]; Heart[33,34]; Injuries[35]; Musculoskeletal[36]; Neonatal[37,38]; Stroke[39]; Vascular[40]; and Wounds[41]). No reviews reported forward citation searching without also reporting backward citation searching.

3.2 | Conduct of citation searching

Here, we present our findings on how citation searching was conducted in the sample. Table 3 presents overall findings for each of our five objectives regarding the conduct of citation searching.

TABLE 3 Conduct of citation searching in cross-section of Cochrane reviews (n = 198)

	Item of Conduct	Descriptive Detail	BCS n = 172	FCS n = 18
1	Set of studies used[a]	**Named set of studies**	**159 (92)**	**15 (83)**
		Key studies	3 (2)	5 (33)
		Key studies (reported)	*0 (0)*	*2 (13)*
		Key studies (not reported)	*3 (2)*	*3 (20)*
		Included studies	94 (59)	8 (53)
		Identified studies	62 (39)	2 (13)
		Identified studies (reported)	*0 (0)*	*0 (0)*
		Identified studies (not reported)	*62 (39)*	*2 (13)*
		Systematic reviews	65 (41)	1 (7)
2	Citation index used	**Named citation index**	**0 (0)**	**15 (83)**[b]
		Google Scholar	-	1 (7)
		Scopus	-	2 (13)
		Web of Science	-	13 (87)
		Science Citation Index	-	*7 (47)*
		Core Collection	-	*1 (7)*
3	Citation index/ manual for BCS	**Citation index**	**0 (0)**	-
		Manual	**172 (100)**	-
		Manual (reported)	3 (2)	-
		Manual (assumed)	169 (98)	-
4	Citation indexes per review	1 citation index	-	14 (93)
		2 citation indexes	-	1 (7)
5	Non-standard approaches	Snowballing	0 (0)	0 (0)
		Other	0 (0)	0 (0)

Note. Numbers outside parentheses are totals, and numbers inside parentheses are percentages. Percentages in bold are of the overall set of included reviews for backward (n = 172) and forward (n = 18) citation searching; all other percentages are of the subset of reviews for the relevant item of conduct; eg, 83% of reviews that reported forward citation searching reported the set of studies used, and 5% of this subset of reviews reported using key studies.

Abbreviations: BCS, backward citation searching; FCS, forward citation searching.

[a]Sets of studies (ie, key, included, and identified) are mutually exclusive except for systematic reviews.

[b]The total number of reviews that named a citation index for forward citation searching is less than the sum total of named citation indexes because a proportion of reviews named more than one citation index (see item of conduct 4).

3.2.1 | What sets of studies are used and how frequently?

Of the 172 Cochrane reviews that reported backward citation searching, 159 (92%) reported the set of studies that were used. Of the 18 reviews that reported forward citation searching, 15 (83%) reported the set of studies used.

Key studies were used for backward citation searching in three of 159 (2%) reviews that reported a set of studies and forward citation searching in five of 15 (33%) reviews that reported a set of studies. The specific studies on which citation searching was conducted were reported in two reviews, including Ng et al,[38] who reported a forward citation search of the earliest identified included study, and Kirkland et al,[24] who reported a forward citation search of a "sentinel paper". Other reviews in this category did not report the specific studies that were used, including three that reported backward citation searching[42-44] and three that reported forward citation searching.[28,29,39]

Included studies were used for backward citation searching in 94 of 159 (59%) reviews and forward citation searching in eight of 15 (53%) reviews that reported the set of studies used. Included studies are by convention listed in full in a Cochrane review.[19]

What we have labelled as *identified studies* were used for backward citation searching in 62 of 159 (39%) reviews that reported a set of studies and forward citation searching in two of 15 (13%) reviews that reported a set of studies. In seven reviews, our definition of identified was clearly apparent; ie, citation searching was conducted using studies excluded from the review (as well as included), or prior to agreeing inclusion/exclusion of studies.[45-51] Dietrich et al[45] and Huf et al[47] reported conducting backward citation searching using included and excluded studies; MacDonald et al,[48] Romano et al,[49] and Wiysonge et al[51] reported conducting backward citation using potentially eligible studies; and Howcroft et al[46] and Walters et al[50] reported conducting backward citation searching using studies retrieved for full-text screening.

The majority of reviews in this category (n = 57) reported only that identified or retrieved studies were used for citation searching. For example, Di et al[52] reported that "review authors searched the reference lists of identified studies," Gregorio et al[53] reported that they "checked the reference lists of all studies identified by the ... [search] methods," and Watson et al[54] reported that the "reference lists of articles retrieved by electronic searches were searched for additional citations." These examples imply that citation searching was conducted using every individual study identified. However, unless

the number of studies identified overall was very low, this seems unlikely, and it may be more plausible that the review authors are using the term identified synonymously with included.

Systematic reviews were reported as used for backward citation searching in 65 of 159 (41%) reviews that reported a set of studies and forward citation searching in one of 15 (7%) reviews that reported a set of studies.

3.2.2 | What citation indexes are used and how frequently?

Of the 18 Cochrane reviews that reported using a citation index to conduct citation searching, 15 (83%) reported the name of the citation index(es) used. Google Scholar was reported in one review[55]; Scopus was reported in two reviews[24,29]; and Web of Science was reported in 13 reviews,[26-29,31,32,34-40] including seven reviews[26-29,32,34,39] that reported searching the Science Citation Index (a subset of the Web of Science) in particular and one review[35] that reported searching the Core Collection (which includes the Social Sciences Citation Index and Arts & Humanities Citation Index) in particular.

Van Mens et al[40] reported conducting forward citation searching using PubMed (in addition to Web of Science), which probably refers to a Similar Articles search as PubMed does not facilitate citation searching. A Similar Articles search uses an algorithm to detect similar articles to a source study rather than identifying citing or cited articles.[56] In addition to Van Mens et al,[40] we serendipitously identified a small number of reviews that reported using Similar Articles search or equivalent searches in other databases.[29,57] However, because we were not systematically searching for this search method, it may have been reported more widely in the sample.

3.2.3 | The frequency of using a citation index to conduct backward citation searching

None of the reviews that reported backward citation searching reported using a citation index for this purpose. We have assumed that no mention of a citation index implied that backward citation searching was conducted manually. However, only three reviews explicitly reported using a manual approach, and in some of the remaining 169 reviews, authors might have failed to report the use of a citation index. In confirmation that the practice does exist, we identified one review that reported using Web of Science for backward citation searching in a previous iteration of the review; however, this was not repeated for the update review captured in our 3-month cross section.[58]

3.2.4 | The frequency of using more than one citation index

Of the 15 reviews that reported the name of a citation index, one review (7%) reported using multiple citation indexes for forward citation searching, namely, Scopus and Web of Science.[29] All other reviews that reported the use of a named citation index reported one citation index.

3.2.5 | Nonstandard approaches to citation searching, eg, snowballing

None of the reviews reported snowball searching nor did we detect any other nonstandard approaches other than the aforementioned Similar Articles search in PubMed.

3.3 | Reporting of citation searching

Here, we present our findings on how citation searching was reported in the sample. Table 4 shows the number of Cochrane reviews that reported our proposed combination of MECIR standards and suggested details to report about backward and forward citation searching respectively and the detail required by the MECIR standards alone.[19]

TABLE 4 Detail reported about citation searching in cross section of Cochrane reviews

	Detail	BCS n = 172	FCS n = 18
1	Name of citation index(es)/manual approach		
	Citation index(es)	0 (0)	16 (89)
	Manual (transparently reported)	3 (2)	-
	Manual (assumed[a])	169 (98)	-
2	Set of studies (transparently reported[b])	94 (55)	10 (56)
3	Date searched	-	2 (11)
	All suggested details reported	**1 (<1)**	**1 (6)**
	All MECIR details reported	**169 (98)**	**16 (89)**

Note. Numbers outside parentheses are totals, and numbers inside parentheses are percentages. All figures are calculated according to the total number of included reviews for backward (n = 172) and forward (n = 18) citation searching, respectively.

Bold = Sum Total.

Abbreviations: BCS, backward citation searching; FCS, forward citation searching.

[a]Manual approach assumed in absence of mention of citation index.

[b]Reviews that reported using included studies (which are listed in full in the review by convention) and studies that reported using key or other studies and have reported the specific studies.

Only two reviews reported all relevant details in our suggested checklist: one (less than 1% of total)[59] for backward citation searching and one (6% of total)[34] for forward citation searching. The number of reviews that fulfilled the requirements for the MECIR standards alone (ie, not including our suggested details to report) for both backward and forward citation searching was much higher (98% and 89%, respectively).[19]

Although no reviews reported using a citation index for backward citation searching, only three reviews (2%) explicitly stated that a manual approach was used.[38,48,59] Reports of citation searching in some reviews used phrases suggestive of manual checking rather than a citation index, such as "we scanned the reference lists of relevant studies," but we felt this was still not fully transparent. Hence, these are recorded as *manual (assumed)* in Table 4. Because there is no requirement to report how backward citation searching was conducted in the MECIR standards, these reviews are still fully MECIR compliant in terms of reporting.[19] Only one review used the specific phrase *backward citation searching* to describe the search method,[25] and all other reviews described this search method as *checking reference lists* or used similar phrases such as *inspecting references lists* or *examining reference lists*.

Just over half of reports of both backward (55%) and forward (56%) citation searching were fully transparent with respect to the set of studies used. The remaining reports detailed that either *key* or *identified* studies were used for citation searching without reporting the specific studies used in either case, or did not report a set of studies. As noted above, we acknowledge that some review authors might have used the word identified synonymously with included when describing the set of studies used.

The location of reports about citation searching in the sample of reviews is presented in Table 5. Almost all reviews reported citation searching in the methods section. A small number reported backward citation searching in the abstract or PRISMA flowchart without also mentioning in the main text.

TABLE 5 Location of reporting of citation searching in cross section of Cochrane reviews

Location[a]	BCS n = 172	FCS n = 18
Abstract	9	0
Methods	162	18
PRISMA flowchart	1	0

Abbreviations: BCS, backward citation searching; FCS, forward citation searching.

[a]Reports in the abstract or PRISMA flowchart are only recorded if this was the sole location that citation searching was reported.

4 | DISCUSSION

4.1 | Conduct of citation searching

The conduct of backward citation searching in the cross section of Cochrane reviews appeared to be relatively uniform compared with forward citation searching. We have tentatively concluded that backward citation searching was conducted using a manual approach in all included reviews; however, this is dependent on the accuracy of our assumption that non-reporting of a citation index implies that a manual approach was used. The option to conduct backward citation searching using a citation index and export the results to reference management software has the potential to facilitate a more systematic and transparent approach than manual checking, by allowing multiple screeners to code and compare the results of screening and easily share the results with interested third parties. Furthermore, de-duplicating a large set of citations from multiple studies avoids the potential for screening the same cited study or studies multiple times. A shortcoming of this approach is the risk that cited studies are not indexed or not established as citations in the selected citation index. We suggest that searchers use their discretion as to whether to use a manual or citation index assisted approach.

The stipulation that included studies are used for backward citation searching is the only MECIR standard on the conduct of citation searching and is likely to account for the low number of reviews opting to conduct backward citation searching using key studies.

More variation in approach was found in the reviews that reported conducting forward citation searching. A manual approach is not an option when forward citation searching, but there are at least three available citation indexes that can be used. The popularity of Web of Science in the sample could simply be because it is the only available subscription-based citation index in the review authors' institutional library holdings. Cochrane review authors might also value the option to easily search specifically science content in Web of Science via the Science Citation Index, as was evident in several reviews in the sample.

Google Scholar, despite being freely available, was the least popular citation index. This might be due to several shortcomings documented in the information science literature. For example, the relatively basic facilities for exporting results to reference management software can make the process cumbersome and time consuming.[60] There is also increased incidence of duplicate citations due to its automated indexing of content.[61] However, Google Scholar should not be dismissed as a useful tool, particularly for identifying grey literature, which has

been estimated to comprise around half (48%-65%) of Google Scholar's content, including theses/dissertations, books and book chapters, conference proceedings, preprints, and reports, most of which are not indexed in Scopus or Web of Science.[62] This potentially makes Google Scholar particularly useful for identifying hard-to-find studies via citation searching, by combining a large amount of unique content with the aforementioned advantages of searching using citations.

The use of multiple citation indexes can avoid some of the shortcomings of using one citation index; however, this approach was only reported in one review. The time and resource implications of conducting multiple searches might be influential in the decision to use one citation index.

The relatively more frequent use of key studies for forward citation searching compared with backward citation searching is likely to be influenced by the lack of a MECIR standard stipulating the required set of studies.[20] It might also be influenced by the suggestion in the Cochrane Handbook that citation indexes can be used for identifying citations of an important study.[2] There is a risk that using key studies for citation searching introduces bias. Ultimately, however, citation searching in general is open to biases associated with citation practice, such as the selective citation of studies with positive results.[2] Thus, studies with the same or similar research question are not always linked via citations.[12]

4.2 | Reporting of citation searching

Compared with text-based search methods such as searching bibliographic databases[63] and web searching,[23,64] there is relatively little to report about citation searching in order to ensure transparency. We still, however, identified aspects of citation searching that could be better reported including the use of a manual approach for backward citation searching, the date of the search for forward citation searching, and the set of studies used for backward and forward citation searching. These details go beyond that required by the MECIR standards.[19]

We also suggest that it is optimal for review authors to report that citation searching was conducted in the methods section of the main body of the report, rather than only in the abstract or PRISMA flowchart, as witnessed in a small number of reviews in the sample. Reports that are not mentioned in the main text could be missed. Full details of citation searching, such as a list of studies used, can be reported in the appendices or supplementary material.

4.3 | Comparison with other studies

Page et al present the reporting characteristics of a cross section of systematic reviews published in February 2014, including 45 Cochrane reviews.[10] Of the 45 Cochrane reviews, 84% reported backward citation searching and 18% reported other search methods including forward citation searching.[10] These findings are similar to the prevalence of backward (87%) and forward (9%) citation searching in our sample of Cochrane reviews. Horsley et al reviewed 12 studies that evaluated the effectiveness of backward citation searching as a supplementary search method for a systematic review.[3] The frequency of using a manual approach or citation index is not reported, but they do report the set of studies used. A smaller proportion of systematic reviews than in our study used included studies (25% versus 59% in our review), and a proportion of systematic reviews only used other systematic reviews (33% versus 0% in our study). These differences could be explained by the inclusion of a wide variety of systematic reviews (ie not just Cochrane reviews) and the wider time frame in which the reviews in their sample were conducted (1985-2005).[3]

4.4 | Limitations

We have acknowledged that the descriptions of the set of studies used to conduct citation searching were in some cases ambiguous, particularly with respect to the difference between included studies and identified or retrieved studies. Although we categorized these descriptive accounts as two separate approaches, we acknowledge that the difference may be semantic rather than procedural. Thus, the number of reviews that actually used included studies might be higher than reported.

5 | CONCLUSION

Our findings show variations in the conduct and reporting of citation searching. Some of the variations of conduct, such as the use of a particular citation index or the set of studies used, might simply reflect the available time or resources. However, particularly for forward citation searching, this might also reflect the need for more evidence-based research and guidance on different approaches and more detailed methodological standards. Furthermore, we identified examples where citation searching could have been reported more transparently in fulfilment of the requirement for systematic reviews to include sufficient reporting for the methods to be reproducible. This goes beyond the requirements of the MECIR standards to include the approach used for

backward citation searching, the date forward citation searching was conducted, and the sets of studies used for backward and forward citation searching.[19]

CONFLICT OF INTEREST

The author reported no conflict of interest.

AUTHOR CONTRIBUTIONS

S.B. was involved in all stages of the study. A.B. contributed to designing and piloting the data-extraction form and read and commented on the final manuscript. M.R. contributed to designing and piloting the data-extraction form and data extraction and read and commented on the final manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Simon Briscoe https://orcid.org/0000-0002-6982-4521
Alison Bethel https://orcid.org/0000-0002-0963-9201
Morwenna Rogers https://orcid.org/0000-0002-6039-238X

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Chapter 8. Article 6

Briscoe S, Nunns M, Shaw L. How do Cochrane authors conduct web searching to identify studies? Findings from a cross-sectional sample of Cochrane Reviews. Health Info Libr J. 2020 Dec;37(4):293-318. doi: 10.1111/hir.12313.

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How do Cochrane authors conduct web searching to identify studies? Findings from a cross-sectional sample of Cochrane Reviews

Simon Briscoe, Michael Nunns & Liz Shaw
Exeter PRP Evidence Review Facility, Institute of Health Research, University of Exeter Medical School, University of Exeter, Exeter, UK

Abstract

Background: Searching the World Wide Web using search engines and websites can be conducted to identify studies for systematic reviews. When searching to support systematic reviews, the searcher faces challenges in using the basic search interfaces of most search engines and websites.
Objectives: To describe and evaluate current practice of web searching in a cross-sectional sample of Cochrane Reviews. The study also describes the stated aims of web searching, i.e. the identification of published or unpublished studies or both.
Methods: A six-month cross-sectional sample of Cochrane Reviews was identified via the Cochrane Library. Reviews were inspected for detail about web searching. Findings were described and evaluated using a framework of key principles for web searching.
Results: 423 Cochrane Reviews published August 2016–January 2017 were identified of which 61 (14%) reported web searching. Web searches were typically simplified versions of the bibliographic database search. Advanced and iterative approaches were not widely used. Google Search and Google Scholar were the most popular search engines. Most reports stated identification of grey literature as their aim.
Conclusion: Basic web search interfaces necessitate simple searches. However, there is scope to use more diverse search features and techniques and a greater variety of search engines.

Keywords: current awareness services; health care; information management; internet; literature searching; review, literature; review, systematized; Web 2.0

Key Messages

- Searches used to identify studies via web searching in a cross-sectional sample of Cochrane Reviews typically involved simplified versions of bibliographic database searches.
- There is scope for more advanced searching than observed in the sample, albeit the optimal use of advanced search features and techniques requires further research.
- Google Scholar and Google Search were the most popular search engines in the sample.
- Most reviews reported that their aim in web searching was to identify grey literature study reports.

Background

Searching the World Wide Web (hereafter, web searching) via search engines and websites is one of several supplementary search methods that can be used to identify studies for inclusion in a systematic review (Cooper, Booth, Britten, & Garside, 2017). The primary search method for a systematic review usually consists of searching bibliographic databases, which provide access to a large number of journal articles. Supplementary search methods, such as citation searching, contacting authors, searching trials registries and web searching, aim to identify studies that are not retrieved by searching bibliographic databases. This is important when carrying out a Cochrane

Correspondence: Simon Briscoe, South Cloisters, University of Exeter, St Luke's Campus, Heavitree Road, Exeter, EX1 2LU, UK. Email: S.Briscoe@exeter.ac.uk

Review in order to identify a comprehensive set of relevant studies for the purpose of ascertaining the best evidence based estimate of the effectiveness of an intervention (Lefebvre et al., 2019a). Reasons for missing studies in bibliographic databases include the omission of the necessary search terms and instances where relevant studies are not indexed in the searched bibliographic databases. Web searching is not, however, mandatory for Cochrane Reviews, and thus the decision to conduct web searching is made on a case-by-case basis depending on the likelihood of identifying relevant studies using this approach (Higgins, Lasserson, Chandler, Tovey, & Churchill, 2016).

Web searching usually involves using resources that are not purpose built for hosting and searching for studies. Commonly searched websites for systematic reviews that are not dedicated resources for identifying studies include those of charities, government health care departments and manufacturers – all of which have multiple purposes, such as dissemination of information and marketing, in addition to providing access to studies (Briscoe, 2015, 2018; Godin, Stapleton, Kirkpatrick, Hanning, & Leatherdale, 2015; Stansfield, Brunton, & Rees, 2014). Web search engines can be used to identify studies or hints to studies (i.e. a promising lead) on websites which are investigated (Eysenbach, Tuische, & Diepgen, 2001). Commonly used search engines for systematic reviews include Google Search (www.google.com) and the scholarly search engine Google Scholar (https://scholar.google.com; Briscoe, 2015, 2018). Google Scholar and other scholarly search engines, such as Microsoft Academic (https://academic.microsoft.com/), are exceptions to the general rule that web searching involves using resources that are not purpose built for identifying studies.

The non-specialist content and functionality of search engines and websites (i.e. from the point of view of searching for studies for systematic reviews) can present technical and logistical challenges (Lefebvre et al., 2019b; Stansfield, Dickson, & Bangpan, 2016). For example, the diverse content can make it difficult to focus a search sufficiently or decide how much time and resources to invest in searching and screening the results. Although some search engines and websites support the use of advanced search functions such as Boolean operators, truncation and date limits, they do not support the development of complex multi-line searches. Furthermore, websites are often searched by following links between webpages, which is potentially less systematic than searching using a pre-specified set of search terms due to its exploratory nature. With respect to reporting and updating searches, despite best efforts to report searches transparently, the reproducibility of searching is typically compromised because content on the web frequently changes and search engines use algorithms that change over time and personalise the results to the user's search history and location (Briscoe, 2015, 2018). By contrast, content on bibliographic databases is stable and the search results do not vary depending on the location or search history of the searcher.

Technical and logistical approaches to the challenges posed by web searching in the context of a systematic review have been presented with respect to conducting (Eysenbach et al., 2001; Giustini & Boulos, 2013; Godin et al., 2015; Haddaway, Collins, Coughlin, & Kirk, 2015; Haddaway, Collins, Coughlin, & Kirk, 2017; Harzing, 2007; Stansfield et al., 2016) and reporting web searching (Briscoe, 2015, 2018; Eysenbach & Trudel, 2005). This research on the challenges of web searching is summarised in systematic review guidance (Centre for Reviews & Dissemination, 2008; Collaboration for Environmental Evidence, 2013; Lefebvre et al., 2019b; Rethlefsen et al., 2019). A recent and comprehensive summary on conducting web searching for systematic reviews is presented in the online Technical Supplement (Lefebvre et al., 2019b) to the *Searching for and selecting studies* chapter of the Cochrane Handbook for Systematic Reviews of Interventions (hereafter, Cochrane Handbook; Lefebvre et al., 2019a).

To what extent web searching conduct in systematic reviews reflects research and guidance on web searching has not previously been studied. The rationale for carrying out such a study is twofold: both to glean insights on web searching from actual practice and to make suggestions for improving practice. To this end, the aim of this

study is to review current practice of web searching in a sample of Cochrane Reviews with reference to the web searching guidance in the aforementioned Technical Supplement (Lefebvre et al., 2019b). This includes two specific objectives:

1. To describe and evaluate the conduct of web searching in a cross-sectional sample of Cochrane Reviews published in the six-month period August 2016 to January 2017 with reference to a framework of key principles for conducting web searching derived from the Technical Supplement (Lefebvre et al., 2019b).
2. To document and report the stated aim of web searching in each of the Cochrane Reviews that conducted web searching, that is whether web searching aimed to identify published studies in journal article format or grey literature study reports, or both.

Given that the framework of key principles is derived from the Technical Supplement, which post-dates publication of the reviews in the cross-sectional sample, it was not used to critically appraise and score the conduct of web searching. Rather the framework provides a structure for describing and evaluating the findings (Lefebvre et al., 2019b).

Methods

Identification of key principles on the conduct of web searching

Key principles for web searching were identified by reading and re-reading the web searching section of the Technical Supplement and extracting key items of guidance (Lefebvre et al., 2019b). The primary sources on web searching cited in the Technical Supplement were also inspected for any additional useful detail. Update searches for primary studies on web searching for inclusion in the Technical Supplement were last reviewed in April 2019 (Lefebvre et al., 2019b).

In total, eight key principles on the conduct of web searching were identified in the Technical Supplement (see Table 1; Lefebvre et al., 2019b). They are divided into general principles (1–3), search engine specific principles (4–5) and website specific principles (6–8). Research in the peer reviewed literature relating to the key principles is cited in Table 1 where available.

Eligibility criteria

The cross-sectional sample of Cochrane Reviews used in this study was the same as in a sibling study on the reporting of web searching, i.e. the six-month period August 2016 to January 2017 (Briscoe, 2018).

Cochrane Reviews were eligible for inclusion if they reported using web searching to identify studies for inclusion in the review. Web searching was defined 'as the use of a search engine or website that has not been specifically designed to host and facilitate searching for studies' (Briscoe, 2018). This included general web search engines, such as Google Search, and the websites of topically relevant organisations, such as charities and manufacturers. The exceptions to these inclusion criteria were scholarly search engines, such as Google Scholar (https://scholar.google.com/) and Microsoft Academic (https://academic.microsoft.com/), which are specifically designed to host and facilitate searching for studies. These were included in the study as they have similar design features and functionality as general search engines. Web based trials registries were excluded as dedicated resources for identifying studies, for example ClinicalTrials.gov and the World Health Organisation (WHO) International Clinical Trials Registry Platform Search Portal (ICTRP).

Search, screening and data extraction

The searching and screening processes were undertaken as part of an earlier review on the reporting of web searching in Cochrane Reviews by SB (Briscoe, 2018). Cochrane Reviews were identified by searching the Cochrane Database of Systematic Reviews using the wildcard symbol (i.e. asterisk) and date limited using the Online Publication Date feature. The search was carried out in February 2017. The screening process to identify eligible reviews involved inspecting the methods section and appendices of each Cochrane Review thus identified for detail about web searching. In addition, to capture detail about web

Table 1 Key principles on conduct of web searching derived from the Technical Supplement (Lefebvre et al., 2019)

	Scope	Principle	Commentary†
1	General	Search terms used for web searching should be based on the search terms used for searching bibliographic databases	Using search terms derived from the bibliographic database search strategy for web searching ensures consistency between the two search methods (Eysenbach, Tuische, & Diepgen, 2001)
2	General	A simplified search strategy (compared to the bibliographic database search) or multiple searches of the same resource might be required	Web resources often have more basic search interfaces than bibliographic databases. Comparable complex multi-line searching and advanced search syntax is unlikely to be supported (Eysenbach et al., 2001; Godin, Stapleton, Kirkpatrick, Hanning, & Leatherdale, 2015)
3	General	Wherever possible, a similar approach should be used for different web resources	As when searching bibliographic databases, using a similar approach for different web resources ensures consistency. However, this might not always be possible (due to the functionality of search interfaces) or desirable (due to content differences between resources) (Stansfield, Dickson, & Bangpan, 2016)
4	Search engines	A search engine might retrieve an unmanageably high number of results, in which case the searcher will need a strategy for limiting how many are screened	Time and resource limitations will often preclude screening the full set of results retrieved by a search engine, which can number in the thousands (Mahood, Van Eerd, & Irvin, 2014). Instead, a limited pre-specified number of results may be screened or the screening process may stop after several pages of results are screened without identifying relevant information. A limited approach to screening is justified on the basis that search engines rank results according to relevance, so the probability of identifying relevant information is higher towards the beginning of the retrieved results (Stansfield et al., 2016). An exception is Google Scholar, where research suggests that it can be useful to screen the full set of available results, in particular, when seeking to identify grey literature (Haddaway, Collins, Coughlin, & Kirk, 2015). *Publish or Perish* software can be used to assist the search, download and screening process when using Google Scholar (Harzing, 2007)
5	Search engines	Experimenting with or combining the results of different search engines might be beneficial for retrieving relevant studies	Different search engines use different algorithms to retrieve results and have different search features. A searcher might identify more unique and relevant content by purposively selecting a search engine based on test searches or combining the results of search engines (Briscoe, 2015; Eysenbach et al., 2001)
6	Websites	Strategies to limit the number of results for screening are less likely to be needed for websites than search engines	The size and scope of websites is typically smaller than search engines, thus one would expect to see more exhaustive searches of relevant pages of websites than search engines. (Research on this was not identified in the peer reviewed literature. However, some evidence to substantiate it has been generated by the completion of this review)

(continued)

Table 1 (continued)

	Scope	Principle	Commentary[†]
7	Websites	Web searching involves following links between webpages and websites	Searching via websites is often less structured than using pre-specified terminology but a systematic approach should still be pursued (Stansfield et al., 2016)
8	Websites	The selection of websites to search will be determined by the review topic	The number of generic types and specific websites searched for different reviews will vary (Stansfield et al., 2016). Commonalities might be detectable between similar reviews

[†]The commentary is the authors' summary of the text in the Technical Supplement. Supporting references in the commentary are taken from the Technical Supplement.

searching that was not reported in the methods section or appendices, the Find (Control-F) search feature was used to search each review for the terms 'web', 'internet', 'online' and 'Google'.

Detail on the conduct of web searching was exported from the data extraction forms created for the sibling study on the reporting of web searching (Briscoe, 2018). The data extraction forms from Briscoe (2018) included detail on:

1. the names of any search engines or websites that were searched;
2. the URL(s);
3. the date(s) searched;
4. the search terms;
5. the number of search results.

The data extraction form also included a free-text box for 'Any other detail reported about web searching'. These five items and the free-text box provided sufficient detail for describing and evaluating the conduct of web searching. To facilitate this process, a new data extraction form was developed that mapped onto the key principles in Table 1. Detail on web searching in the data extraction forms from Briscoe (2018) was then imported into the appropriate section of the new data extraction form. The conduct of web searching was then described and evaluated according to each principle.

The MEDLINE search strategy from each Cochrane Review was used to describe and evaluate those key principles that made reference to bibliographic database search strategies (e.g. key principle 1, 'Search terms used for web searching should be based on the search terms used for searching bibliographic databases'). The comparative complexity of the web search and MEDLINE search in each review was described and evaluated for key principle 2 with respect to: the number of search terms in the web search strategy compared to the MEDLINE search strategy; the components and Boolean structure of the search as described by the PICOS question formulation format (*P*opulation, *I*ntervention, *C*omparator, *O*utcome and *S*tudy type); the use of phrase, proximity, truncation or wildcard searching; and the number of iterations of the search. Spider plots were used to show the distribution of types of websites searched per category of review for key principle 8. Included Cochrane Reviews were classified into categories of intervention with reference to the classification scheme for types of intervention described in Smith et al. (2015).

Findings relating to other key principles were summarised narratively and median or mean figures used where appropriate.

Data were also collected on the stated aim of web searching in the reviews in the sample. In particular, we sought to distinguish between searches that aimed to identify studies published in journal article format and searches that aimed to identify grey literature, that is 'that which is produced on all levels of government, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers' (Farace & Frantzen, 1997). In the context of a systematic review, potentially relevant grey literature typically includes ongoing

studies, recently completed studies not yet in journal article format, and studies not intended for journal article publication, such as study reports produced by organisations without using a commercial publisher. For some reviews, these data were reported in the data extraction form for Briscoe (2018). However, to ensure no data were missed the Cochrane Reviews were re-visited and inspected for this detail.

Results

Search results

The search identified 423 Cochrane Reviews published in the six-month period August 2016 to January 2017. Of these, 61 reviews (14%) reported using a search engine or website to identify studies or for an unspecified purpose (see Appendix). They included 25 reviews (6% of the total) that reported searching one or more search engine and 39 reviews (9% of the total) that reported searching one or more website. Three reviews (<1% of the total) reported web searching using both search engines and websites.

The 61 Cochrane Reviews that reported conducting web searching were all classified as Intervention reviews in the Cochrane library. The interventions in each review were further classified using the framework developed by Smith et al. (2015) as: complex interventions (n = 4); control of chronic disease (n = 19); diagnostic (n = 1); drugs for prevention of disease (n = 2); education and behaviour change (n = 6); health systems (n = 2); implementation programmes (n = 1); injury prevention (n = 1); maternal and neonatal (n = 1); nutrition (n = 1); pain management (n = 5); surgery and radiation (n = 10); treatment of infectious disease (n = 7); and vaccines (n = 1). See Appendix for a full list of included reviews classified by intervention type. All of the reviews included randomised controlled trial (RCT) study designs except two (Gaitonde, Oxman, Okebukola, & Rada, 2016; McLaren et al., 2016). A minority of reviews included other study types in addition to RCTs, including controlled before-and-after studies (n = 10), controlled clinical trials (n = 3), interrupted time series (n = 8), non-randomised controlled trials (n = 5) and uncontrolled before-and-after studies (n = 1). See Appendix for a breakdown of included study designs for each review. Twenty-five Cochrane Groups were represented in the sample (see Appendix).

Conduct of web searching in the cross-sectional sample of Cochrane Reviews

Findings on the conduct of web searching in the cross-sectional sample of Cochrane Reviews are described below with reference to the eight key principles in Table 1.

Key principles 1 to 3 relate to web searching in general.

1. Search terms used for web searching should be based on the search terms used for searching bibliographic databases.

Nine Cochrane Reviews reported sufficient detail about the search strategies used for web searching to be compared to the bibliographic database search strategies. Of these, five reviews reported the search terms used for one or more search engine (Barbaric et al., 2016; Chua, Akande, & Mol, 2017; Reavey, Vincent, Child, & Granne, 2016; Rikken et al., 2017; Smith et al., 2016) and four reviews reported the search terms used for one or more website (Flodgren et al., 2016; Gaitonde et al., 2016; McLaren et al., 2016; Wiysonge, Abdullahi, Ndze, & Hussey, 2016).

Of the five reviews that reported the search terms used in search engines, three reported using search terms that were all also used in the MEDLINE search strategy (Barbaric et al., 2016; Reavey et al., 2016; Rikken et al., 2017). The remaining two reviews used search terms that were not used in the MEDLINE search strategy, albeit this was only one search term per search strategy (Chua et al., 2017; Smith et al., 2016). In Smith et al. (2016), the additional term was combined using the OR Boolean operator, making this component of the search strategy more sensitive than the MEDLINE search strategy. In Chua et al. (2017), the additional term was combined with the AND Boolean operator making this component of the search strategy more precise than the MEDLINE search strategy.

Of the four reviews that reported search terms used for searching websites, all reviews used

search terms that were all also used for searching MEDLINE (Flodgren et al., 2016; Gaitonde et al., 2016; McLaren et al., 2016; Wiysonge et al., 2016). However, one review configured the Boolean relationship of two search terms differently for the website and MEDLINE search; in the former AND was used to combine two search terms and in the latter OR was used, thus making the website search more precise than the MEDLINE search (Wiysonge et al., 2016).

2. A simplified search strategy (compared to the bibliographic database search) or multiple searches of the same resource might be required.

The same nine Cochrane Reviews (see key principle 1) reported sufficient detail to compare the complexity of the web search strategies with the database search strategies (Barbaric et al., 2016; Chua et al., 2017; Flodgren et al., 2016; Gaitonde et al., 2016; McLaren et al., 2016; Reavey et al., 2016; Rikken et al., 2017; Smith et al., 2016; Wiysonge et al., 2016). The comparative complexity of the web search and MEDLINE search in each review is summarised in Table 2.

All the reported web search strategies were simplified versions of the MEDLINE search strategy. The median and range of search terms used for web search engines were 4(3–13), and the median and range of search terms in the corresponding MEDLINE search strategies were 21(15–63). The median and range of search terms used for websites was 5(1–17), and the number of search terms used in the corresponding MEDLINE search strategies was more than 100 in all reviews. Overall, the simplification process followed a trend of reducing the number of search terms to less than 10, regardless of how many search terms were used in the bibliographic database search strategy. Only two reviews used more than 10 search terms for web searching (13 and 17 search terms, respectively; Chua et al., 2017; Gaitonde et al., 2016). This general approach meant that the extent of the simplification was much greater in some reviews than others. For example, two reviews that included more than 300 search terms in the MEDLINE searches simplified the web search strategy to six search terms, i.e. less than 2% of the terminology in the original database search (McLaren et al., 2016; Wiysonge et al., 2016). By comparison, a review that included 16 search terms in the MEDLINE search simplified this to eight search terms for the web search strategy, i.e. half the number of terms in the original database search (see Table 2) (Barbaric et al., 2016).

In almost all web search strategies, the PICOS structure was also simplified. The most common simplification of the PICOS structure was the removal of study type terms from the search strategy used for web searching (see Table 2). All search strategies used in search engines ($n = 5$) included search terms for the population and intervention of interest. By comparison, the search strategies used in websites included multiple examples in three reviews where only one PICOS component was used (see Table 2; Flodgren et al., 2016; Gaitonde et al., 2016; McLaren et al., 2016).

Combinations of PICOS components are achieved using Boolean logic (AND, OR and NOT). Boolean operators were not always explicitly stated in the search strategies; instead, the Boolean logic was determined by the logic of the selected search interface, for example if a search was reported as 'With all the words' this implied the AND Boolean operator, whereas if a search was reported as 'With at least one of the words' this implied the OR Boolean operator (Barbaric et al., 2016). 'None of the words' was also used which is equivalent to NOT (Chua et al., 2017). Furthermore, search engines often combine search terms using AND by default, including both Google Scholar and Google Search (Lefebvre et al., 2019b). Two reported searches of Google Scholar and Google Search respectively did, however, use AND, in conjunction with parentheses and OR, to build search strings:

> *abscess AND (packing OR dressing) (Smith et al., 2016)*
>
> *(In Vitro Maturation OR IVM) AND (Human chorionic gonadotrophin OR HCG) (Reavey et al., 2016)*

No search strategies reported for search engines made use of phrase, proximity, truncation or wildcard searching. One search restricted results to

Table 2 Summary of comparative complexity of web search and MEDLINE search strategies in the cross-sectional sample

		Web searching					Medline		
Cochrane Review	Resource name	Search terms per query *(n)*	Iterations *(n)*	Search terms in total† *(n)*	PICO(S) structure	Phrase/ proximity/ truncation	Search terms (*n*)	PICO(S) structure	Phrase/proximity/ truncation
Search engines									
Barbaric et al. (2016)	Google Scholar	8	1	n/a	P ∧ I	None	16	P ∧ I ∧ S	Phrase, truncation
Chua et al. (2017)	Google Scholar	7-8	12	13	P1 ∧ I ∧ S P2‡	None	63	P ∧ I ∧ S	Phrase, proximity, truncation
Reavey et al. (2016)	Google Scholar	4	1	n/a	P ∧ I	None	21	P ∧ I ∧ S	Phrase, proximity, truncation
Rikken et al. (2017)	Google Search	1-2	3	4	P ∨ I	None	15	P ∧ I ∧ S	Phrase, proximity, truncation
Smith et al. (2016)	Google Scholar	3	1	n/a	P ∧ I	None	60	P ∧ I ∧ S	Phrase, proximity, truncation
Websites									
Flodgren, Hall, et al. (2016)	Agency for Healthcare Research and Quality American Academy of Neurology American Association of Neurological Surgeons American College of Chest Physicians American College of Obstetricians and Gynecologists American College of Radiology American Society for Gastrointestinal Endoscopy American Urological Association Education and Research, Inc. British Committee for Standards in Haematology Cancer Care Ontario	5§	1	n/a	I	None	>200	I ∧ S	Phrase, proximity, truncation

(continued)

Table 2 *(continued)*

		Web searching					Medline		
Cochrane Review	Resource name	Search terms per query *(n)*	Iterations *(n)*	Search terms in total† *(n)*	PICO(S) structure	Phrase/ proximity/ truncation	Search terms *(n)*	PICO(S) structure	Phrase/proximity/ truncation
	CancerControl Alberta								
	Centers for Disease Control and Prevention								
	Cincinnati Children's Hospital Medical Center								
	Congress of Neurological Surgeons								
	European Academy of Neurology								
	European Association of Urology								
	Hartford Institute for Geriatric Nursing								
	Institute for Clinical Systems Improvement								
	Michigan Quality Improvement Consortium								
	New York State Department of Health								
	Ontario Ministry of Health and Long-Term Care								
	Program in Evidence-based Care								
	Royal College of Nursing								
	Royal College of Obstetricians and Gynaecologists								
	Society of Obstetricians and Gynaecologists of Canada								
	U.S. Preventive Services Task Force								
	University of Michigan Health System								
Gaitonde et al. (2016)	UNDP Oslo Governance Centre	1	1	n/a	P	None	>100	P ∧ I ∧ S	Phrase, proximity, truncation
	Poverty Action Lab	1	1	n/a	P	None			

(continued)

Table 2 *(continued)*

		Web searching					Medline		
Cochrane Review	Resource name	Search terms per query *(n)*	Iterations *(n)*	Search terms in total† *(n)*	PICO(S) structure	Phrase/ proximity/ truncation	Search terms *(n)*	PICO(S) structure	Phrase/proximity/ truncation
	International Initiative for Impact Evaluation	17	1	n/a	P	Phrase			
	EU Cordis	9	1	n/a	P	Truncation			
McLaren et al. (2016)	World Health Organization	6	1	n/a	P ∧ I	Truncation	>300	P ∧ I	Phrase, proximity, truncation
	Public Health Agency of Canada	4	1	n/a	P ∧ I	Truncation			
	Institute of Medicine	3	1	n/a	P	None			
Wiysonge et al. (2016)	United Nations Children's Fund	6§	1	n/a	P ∧ I	None	>300	P ∧ I ∧ S	Phrase, proximity, truncation
	Alliance for Health Policy and Systems Research								
	United States Agency for International Development								
	Gavi, The Vaccine Alliance								
	Private Healthcare in Developing Countries								
	Population Services International								
	Shops *(sic)*								
	Department for International Development								
	Centre for Health Market Innovations								
	World Bank								

Key: ∧ denotes AND Boolean operator; ∨ denotes OR Boolean operator; denotes NOT Boolean operator.

†Total search terms reported where there is more than 1 iteration of a search.

‡Search includes problem of interest (P1 = infertility) and excluded population (P2 = men and animals).

§All listed websites were searched using same search strategy.

where search terms appeared in the title, which could be construed as a simplification of the database search (which searched in title and abstracts) or could be construed as a way of limiting the number retrieved for screening (see key principle 4). Phrase and truncation searching was reported in four website searches in two reviews (Gaitonde et al., 2016; McLaren et al., 2016).

Two reviews conducted multiple searches via a search engine using a different set of search terms for each iteration (Chua et al., 2017; Rikken et al., 2017). This meant that relatively complex database searches could be broken down into simplified parts to allow for a comparable search to be carried out via a search engine. In the remaining seven reviews, all web searches were conducted as a single search within each resource.

3. Wherever possible, a similar approach should be used for different web resources.

Four Cochrane Reviews reported searching more than one web based resource in sufficient detail to compare the conduct of searching between resources (Flodgren et al., 2016; Gaitonde et al., 2016; McLaren et al., 2016; Wiysonge et al., 2016). In all four reviews, the searches were of websites.

Flodgren et al. (2016) and Wiysonge et al. (2016) reported conducting the same search in 27 and 10 websites, respectively.

McLaren et al. (2016) reported searches of three different websites using mainly but not wholly the same set of keywords in each, differing by one or two search terms per search. Gaitonde et al. (2016) reported single keyword searches of two websites and multiple keyword searches (using nine and 17 keywords, respectively) of a further two websites. The single keyword searches both use the same word (‘corruption’) and the multiple keyword searches include a list of synonyms, for example.

> *corruption OR corrupt OR "corruptive payment" OR "corruptive payments" OR bribe OR bribes OR bribery OR forgery OR fraud OR fraudulence OR fraudulent OR swindle OR swindling OR kickback OR kickbacks OR "informal payment" OR "informal payments" (Gaitonde et al., 2016)* .

Inspection of the four websites searched using a single keyword revealed that they do not support multiple keyword searches.

Key principles 4 and 5 relate to search engines.

4. A search engine might retrieve an unmanageable number of results in which case the searcher will need a strategy for limiting how many are screened.

Five Cochrane Reviews that reported using a search engine also reported the total number of results that were screened. Of these, one review reported screening the total number of results (Barbaric et al., 2016) and one review reported using a date limit and then screening the total number of results (Chua et al., 2017). Three reviews reported screening a subset of the total retrieved results (Azarpazhooh, Lawrence, & Shah, 2016; Ohlsson & Shah, 2016; Vaona et al., 2017).

Barbaric et al. (2016) conducted one search of Google Scholar, retrieving 963 results that were screened in full. The search terms used were restricted to title only, either as a pragmatic limit for the purpose of screening or to increase the precision, reflecting the limitation that Google Scholar permits title or full-text searching but not abstract searching. Chua et al. (2017) conducted 12 searches of Google Scholar which were each date limited to one calendar year, namely 2016. The searches retrieved a total of 550 results which were de-duplicated to reveal a total of 146 unique results (Chua et al., 2017). The reviews that reported screening a subset of the total results screened:

- the first 500 results (Vaona et al., 2017)
- the first 200 results (Ohlsson & Shah, 2016)
- the first 100 results (Azarpazhooh et al., 2016).

All searches were conducted on Google Scholar. One review included a rationale for the number screened, stating that ‘in our experience the yield [in Google Scholar] after 200 hits is poor’ (Ohlsson & Shah, 2016).

The Technical Supplement states that searches can be limited to specific file types (e.g. PDFs) as a strategy for limiting the number of results retrieved (Lefebvre et al., 2019b). This approach was not observed in the cross-sectional sample.

5. Experimenting with or combining the results of different search engines might be beneficial for retrieving relevant studies.

Almost all reviews that reported using a search engine used either Google Scholar (n = 19) or Google Search (n = 11). One review reported using the Chinese scholarly search engine, Baidu Scholar (https://xueshu.baidu.com/) and one review reported using an unnamed search engine (see Appendix for full details).

Combinations of search engines were reported in seven reviews, in all cases combining Google Scholar and Google Search. Of these, six reviews reported that Google Search was used to identify topically similar systematic reviews, but did not report the expected complementary aim of searching Google Scholar (Barker et al., 2016; Chang, Thamboo, Burton, Diamond, & Nunez, 2016; Howard et al., 2016; Perry, Lee, Cotton, & Kennedy, 2016; Person et al., 2016; Venekamp et al., 2016). One review reported searching both Google Scholar and Google Search to identify unpublished studies (Barbaric et al., 2016).

Key principles 6, 7 and 8 relate to websites.

6. Strategies to limit the number of results for screening are less likely to be needed for websites than search engines.

Two reviews (Baker, Francis, Hairi, Othman, & Choo, 2016; Xiong, Chen, Luo, & Mu, 2016) reported the number of results identified via websites and one review (Clarke, Broderick, Hopewell, Juszczak, & Eisinga, 2016) reported searching for a known study of interest via a website.

Xiong et al. (2016) screened the results of a relevant webpage on three separate dates during the period that the review was undertaken, identifying three, zero and nine records, respectively. The search report suggests these are the total numbers of results on the page. ('Browsed the alphabetical list from the Interventions tab for "hyperbaric" and downloaded the webpage') (Xiong et al., 2016).

Baker et al (2016) conducted searches of 22 websites. The searches retrieved a median of 31 results (range 0 to 892), totalling 2143 results.

Neither of these two reviews reported that search results had been limited. In particular, neither indicated that only a subset of the retrieved results had been screened, as observed for the results of search engines. The total number of results retrieved by Baker et al. (2016) was much higher than Xiong et al (2016), mainly because one website retrieved 892 results, almost 30 times more than the median number of results in the full list of 22 websites searched.

Table 3 compares the median and range of reported results that were either retrieved in total or screened for search engines and websites per *resource* in the cross-sectional sample (column 1); and the median and range of results that were either retrieved in total or screened for search engines and websites per *review* in the cross-sectional sample (column 2). Table 3 shows that although websites typically return a lower number of results per *resource* than search engines, the actual number of results screened from website searches per *review* can be higher than the number retrieved (or screened) by search engines where review authors search multiple websites. However, this finding was influenced by an outlier result in one website (n = 892 hits). The results are the same per resource and per review for search engines because only one set of results from a search engine was reported per review.

7. Web searching involves following links between webpages and websites.

Three Cochrane Reviews reported following links between webpages (Gaitonde et al., 2016; McLaren et al., 2016; Xiong et al., 2016). Xiong et al. (2016) reported browsing the alphabetically listed Interventions tab of the Research Autism website (ResearchAutism.net) to identify and download relevant content, specifically, information on hyperbaric interventions. McLaren et al. (2016) reported following the menu headings of three websites to guide the search, in particular reporting the specific menu headings that were sequentially

Table 3 Median number of results for search engines and websites in the cross-sectional sample

	Results per resource Median (range)	Results per review Median(range)
Search engines	200 (100-963)	200 (100-963)
Websites	30 (0-892)	12 (1-2143)

followed. Gaitonde et al. (2016) reported browsing two websites but provided no specific detail on how the searches were conducted, that is stated 'browsed' without providing further details.

8. The selection of websites to search will be determined by the review topic.

Thirty-nine Cochrane Reviews reported searching a website. The frequency of types of website searched in these reviews is presented in Table 4.

Charities and NGOs included a diverse assortment of not-for-profit organisations; *commercial organisations* mainly included manufacturers of medical interventions and private health care providers; *government* included government departments and associated bodies (e.g. the US Centers for Disease Control and Prevention and the UK National Institute for Health and Care Excellence); *professional societies* included colleges of medicine and other health care professions; *research organisations* included universities and other organisations with a research focus (e.g. the international Alliance for Health Policy and Systems Research and the Canada-based Program in Evidence-based Care); *other* included clearing house websites (e.g. the US Clearing House on Abuse and Neglect of the Elderly).

Fifteen of the 39 reviews that reported searching a website did not report a full list of specific websites, for example reported examples of websites searched, or only reported searching types of websites, for example reported that charity websites were searched without reporting specific websites. A full list of websites searched was reported in 24 reviews (see Appendix). The median number of websites searched per review was two (range 1–30), and the most frequently reported number of websites searched was one (n = 9). The categories of review that searched the most websites (calculated as the mean number of websites searched per reviews in each category) were (where n = number of websites searched):

- complex intervention reviews (n = 6)
- education and behaviour change reviews (n = 22)
- implementation reviews (n = 29)

For the 24 reviews that reported a full list of websites searched, the distribution of types of websites searched per category of review is shown using spider plots in Figure 1.

Figure 1 shows that the distribution of types of website searched varied for different review topics (i.e. categories of review), demonstrating the principle that the type of website searched will depend on the review topic. The reasons why certain types of websites are searched for some review topics but not others are not obviously apparent in Figure 1. An exception to this is implementation reviews which are the only category of review to search websites of professional societies, reflecting an interest in translating research into a professional context. Four categories of review only searched one type of website (drugs for prevention of disease, injury prevention, nutritional and pain management).

Table 4 Types of websites searched in the cross-sectional sample

Type of website	Reviews (n) (Total n = 39)
Charities/NGOs	10
Commercial organisations	20
Government	12
Professional societies	3
Research organisations	4
Other	4

Aims of web searching

Of the 61 included Cochrane Reviews, 50 reviews reported the type of literature that web searching aimed to identify. These included 41 reviews that reported aiming to identify grey literature and nine reviews that reported aiming to identify published studies in journal article format. Websites were used exclusively to identify grey literature, mainly trial data from ongoing or recently completed studies, in 32 reviews. Search engines were used to identify journal articles in nine reviews and a further nine reviews reported using search engines to identify grey literature.

Discussion

Conduct of web searching

This study has reviewed the conduct of web searching in a six-month cross-sectional sample of

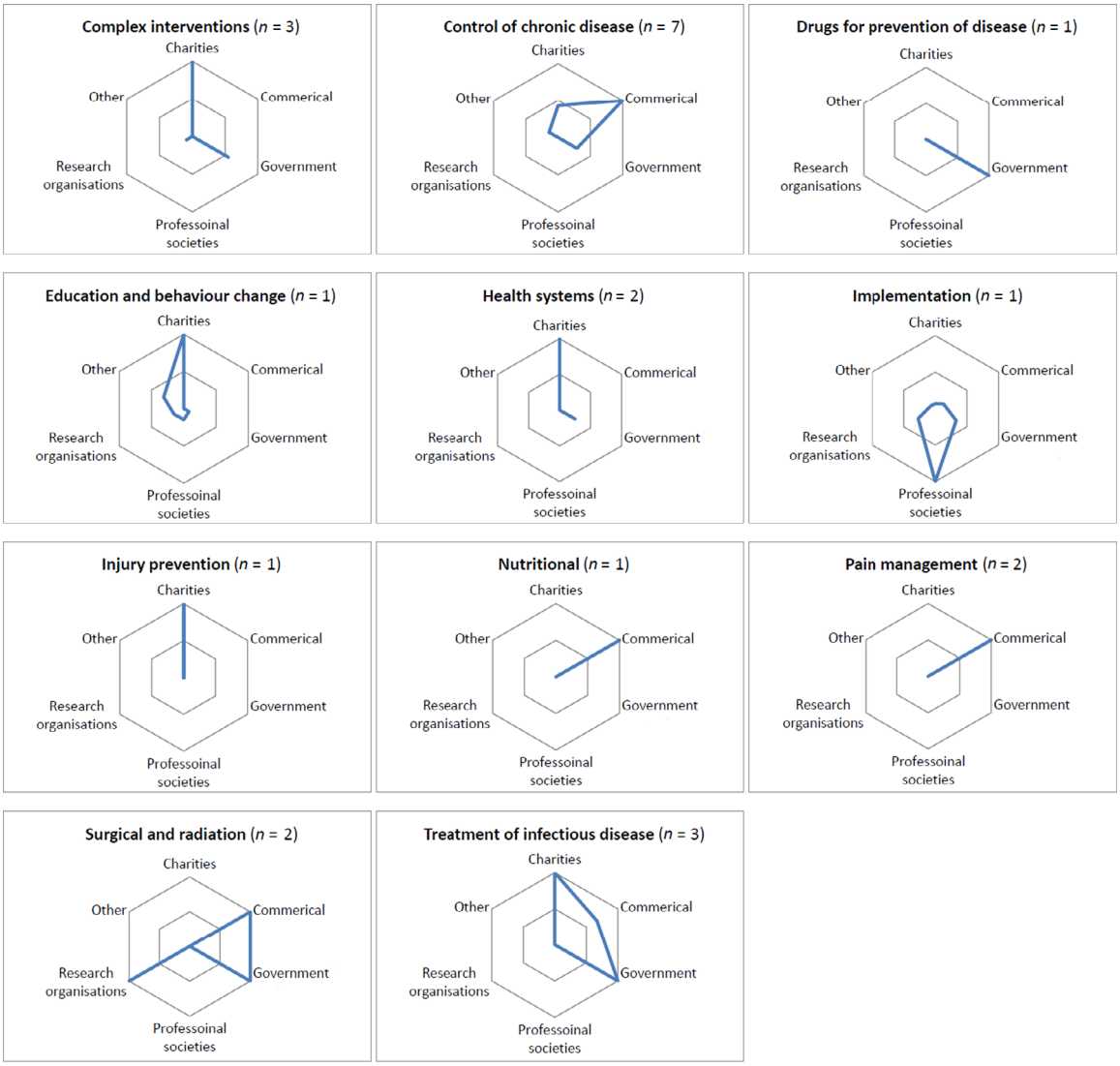

Figure 1 Distribution of types of websites searched per category of review in the cross-sectional sample of Cochrane Reviews (total number of reviews = 24). *n* in parentheses denotes number of *reviews* represented per category, for example 'Complex interventions (n = 3)' denotes 3 complex intervention reviews. The number of *websites* searched per type of website has been normalised so that the distribution of types of websites searched can be shown on the same scale, i.e. the most frequently searched type of website per category of review was set to 1, and the frequency of searching other types of websites was calculated relative to 1

Cochrane Reviews using a framework of key principles for web searching derived from the Technical Supplement (Lefebvre et al., 2019b) to the *Searching for and selecting studies* chapter of the Cochrane Handbook (Lefebvre et al., 2019a). The results clearly showed that web searches are simplified versions of bibliographic database searches. Overall, this is in accordance with the recommendations in the Technical Supplement (Lefebvre et al., 2019b).

The observed trend for using less than 10 search terms per search string might indicate that longer search strings are not well-supported by web search interfaces. No web searches used proximity searching and very few reported using phrase, truncation or wildcard searching – none via search engines. Although this reflects advice in the Technical Supplement that comparable advanced search features to bibliographic databases might not be supported in web search interfaces, such

features are sometimes supported and the Technical Supplement suggests that they might be useful (Lefebvre et al., 2019b).

To the advice presented in the Technical Supplement, we add two cautionary notes on the use of advanced search features in web search interfaces. First, in general search engines have moved away from supporting search features that enhance the user's ability to precisely map a search query to the search results (Manning, Raghavan, & Schütze, 2008). This so-called classical approach to information search and retrieval has been replaced by the use of algorithms to rank results according to their authoritativeness and relevance (Manning et al., 2008). In this context, the unqualified advocacy of complex search strings to improve the precision or sensitivity of search results in web search engines could be seen as a retrograde attempt to return to an earlier stage in the development of search engines.

Secondly, uncertainty exists about which advanced search features are supported. For example, two reported searches of Google Scholar and Google Search used the AND Boolean operator, in conjunction with parentheses and the OR operator, to build search strings. Some sources report that AND and parentheses are unsupported search operators in Google search engines, for example (Shameava, 2015; Tay, 2015), whilst other sources report that both are supported, for example (Hardwick, 2018; Van Hoosear, 2013). Furthermore, although neither AND nor parentheses are listed as supported operators on the Google Search syntax help page (Google Search Help, 2019), there are well-documented examples of supported search operators that are not listed by Google, for example the AROUND proximity operator (Chitu, 2010). This lack of clarity about supported features from search engine providers further complicates the use of advanced features (Bates, Best, McQuilkin, & Taylor, 2017). Our advice is that, when searching for studies for systematic reviews, searchers should try their hardest to use advanced search features appropriately, including checking whether the results of searches map onto what they are expecting to see, for example whether when using the AND Boolean operator, all the expected search terms are appearing in the results.

Perhaps surprisingly, the use of limits on the number of results screened was reported for Google Scholar but not its larger sibling, Google Search. Two reviews in our sample reported screening less than 300 results from Google Scholar, with one review presenting anecdotal evidence that 'the yield [in Google Scholar] after 200 hits is poor' to justify this decision (Ohlsson & Shah, 2016). However, research published around the same time as the reviews in the sample (Haddaway et al., 2015) indicates that at least 300 results should be screened when searching Google Scholar for published literature, and that the results should be comprehensively screened when searching for grey literature. No limits were observed for searches of websites, reflecting the advice in the Technical Supplement that the practice of limiting results from websites is less likely to be required due to their relative size and scope (Lefebvre et al., 2019b). The use of only one PICOS component in some website searches also reflects the more bounded content accessed via websites compared to search engines, where at least two PICOS components were always included in the search.

The almost exclusive use of Google Scholar and Google Search reflects their dominance amongst search engine users (Sullivan, 2013). The Technical Supplement suggests alternatives to Google Scholar and Google Search that might be advantageous for the identification of studies, including DogPile (www.DogPile.com) and DuckDuckGo (https://duckduckgo.com/; Lefebvre et al., 2019b). At the time of writing the most recent comparative study of search engines for the purpose of systematic searching for studies is almost 20 years old (Eysenbach et al., 2001). Eysenbach et al. (2001) evaluated 11 search engines with respect to their ability to handle complex search queries using Boolean, truncation and proximity search operators. Only one search engine, now obsolete, was found to be adequate to the task. In view of developments in search engines outlined above, any such comparative study today should also consider differences between search engine results arising due to algorithms, for example the identification of unique content and the reproducibility of search results.

When following links between webpages on websites to identify information, between one and three clicks to find relevant content is considered to be

optimal (MacFarlane, 2007). When searching for studies for systematic reviews, searchers might be expected to search more extensively. However, none of the reports of searching using this approach (e.g. using menu headings to move between webpages) described needing more than two clicks to satisfy an information need. The observed variation in the description about the search process when following links on websites might not simply reflect different reporting standards, but rather the difference between *browsing* and *navigating* websites. Browsing is exploratory and relatively haphazard, for example, it might involve speculatively following links between webpages and websites rather than a clearly labelled pathway, and there is no clear endpoint to the search process. Navigating is structured by following a clearly identifiable path using menu headings to access the required information. Clearly, browsing is more challenging to document and report in detail. By contrast, directed or navigational searching is helpful and relatively easy to document and report (Stansfield et al., 2016).

Aims of web searching

Viewed collectively, the stated aims of web searching via websites and search engines in the cross-sectional sample revealed a dominant expectancy that web searching would identify grey literature. Although search engines were used more broadly than websites to identify studies in journal article format and grey literature, the focus of searches for the former was the identification of systematic reviews (which were subsequently checked for relevant primary studies) rather than direct identification of relevant primary studies. This approach to web searching might reflect confidence in bibliographic databases and other supplementary search methods for identifying studies in journal article format – particularly in reviews that only include RCTs, which are well-indexed and largely identifiable via bibliographic databases and CENTRAL (Lefebvre et al., 2019b). Nonetheless, aiming to identify grey literature does not necessarily preclude the searcher from identifying journal articles, provided that the searcher does not attempt to exclude such studies. For example, through the use of publication type search terms. There was no evidence of this in the search strategies reported in the cross-sectional sample.

See Box 1 for practical tips on web searching arising from this discussion.

Box 1: Practical tips for conducting systematic web searching

- Experiment with different search terms to refine the best approach and be prepared to carry out multiple searches when using simple search interfaces.
- Experiment with using different PICO components – one PICO component might be sufficient.
- Take time to become familiar with the advanced search features of search engines and websites. Try to find up-to-date information as search features frequently change.
- To ascertain whether a search operator is working correctly, check whether the search results reflect what you expect to see, for example if using AND are all the relevant search terms appearing in the results?
- Take time to identify relevant sources to search – topic experts may be useful in this regard.
- Take time to become familiar with the layout of a website before deciding how to conduct a search.
- Document and report all web searching in sufficient detail for searches to be transparent and reproducible.

Strengths and limitations

This study uses a large cross-sectional sample of systematic reviews to derive data on the conduct of web searching, which has not been done before. The findings can be used to inform future web searching guidance and conduct in a unique way. The findings were, however, limited by the overall low standard of reporting of web searching in the sample. Although 61 reviews reported conducting web searching, only a minority of reviews reported sufficient detail for observations to be made regarding several of the key principles in the framework. The low standard of reporting of web searching in the sample is reported and discussed in detail in the sibling study (Briscoe, 2018).

A potential limitation is that the study relies on the Technical Supplement to develop key principles rather than a wider selection of guidance (Lefebvre et al., 2019b). However, the Technical Supplement was issued for consultation to all Cochrane information

specialists and members of the Information Retrieval Methods Group (the official group established to advise on Cochrane information retrieval activities) in January 2018, and we are confident that it contains reasonably comprehensive guidance on web searching for systematic reviews, with particular emphasis on Cochrane Reviews (Lefebvre et al., 2019b).

Finally, pharmaceutical manufacturer websites were included in the analysis which might have inadvertently captured data on searching company trials registries (which, if explicitly reported, would not meet the inclusion criteria for this study due to being specialised study identification tools). Furthermore, some of the data relates to searching repositories hosted on websites, which potentially have similar features to specialised study identification resources. Overall, a more in-depth exploration of the content, size and search features of web resources would be informative in terms of how the characteristics of web resources shape the development of search strategies and would facilitate a more detailed evaluation of web searching than has been possible in this study.

Conclusion

The systematic web searcher faces challenges when using non-specialist tools for systematic searching. This study has shown that web searching in the context of a systematic review is typically conducted using simplified versions of bibliographic database searches. This approach is necessitated by the limitations of web search interfaces. However, available search features extend beyond those identified within our cross-sectional sample, and potentially advantageous approaches such as iterative searching were not widely reported. There is also scope for using a wider selection of search engines. Future studies on the conduct of web searching should test how different approaches to web searching affect the results that are retrieved and the overall contribution to the results and conclusions of systematic reviews.

Conflict of interest

We have no conflicts of interest.

Author contributions

Simon Briscoe conceived and designed the study and was involved in all stages. Michael Nunns contributed to the presentation of results and read and commented on the manuscript. Liz Shaw contributed to the development and presentation of the framework of key principles and read and commented on the manuscript.

Appendix

All included Cochrane Reviews in the cross-sectional sample, classified by intervention type using Smith et al. (2015) (n = 61).

Study	Cochrane group	Search engine			Websites[†]	Non-RCT study types included
		Google Scholar	Google Search	Other		
Complex						
Gaitonde (2016)	EPOC				x (all)	CBA, ITS, NRCT
McLaren (2016)	Public Health				x (all)	CBA, ITS, UBA
Posadzki (2016)	Consumers and Communication		x			CBA, ITS
Wiysonge (2016)	EPOC				x (all)	CBA, ITS, NRCT
Control of chronic disease						
Abdul (2016)	Neuromuscular				x	
	Schizophrenia				x (all)	

(continued)

Table *(continued)*

Study	Cochrane group	Search engine			Websites†	Non-RCT study types included
		Google Scholar	Google Search	Other		
Chattopadhyay (2016)						
Dwan (2016)	Airways				x	
Ganaie (2016)	Airways				x	
Jones (2016)	Pain, Palliative and Supportive Care				x (all)	
Kearney (2016)	Neuromuscular				x (all)	
Kirkland (2017)	Airways	x				CCT
Korang (2016)	Airways				x (all)	
Lethaby (2016)	Gynaecology and Fertility	x				
Martineau (2016)	Airways				x	
Perry (2016)	ENT	x	x			
Person (2016)	ENT	x	x			
Petsky (2016a)	Airways				x	
Petsky (2016b)	Airways				x	
Simon (2016)	Pain, Palliative and Supportive Care				x (all)	CCT
Somaraju (2016)	Cystic Fibrosis and Genetic Disorders				x	
Tan (2016)	Airways				x (all)	
Xiong (2016)	Developmental, Psychosocial and Learning Problems			x (Baidu Scholar)	x (all)	
Zhu (2016)	Eyes and Vision				x	
Diagnostic						
Wikkelsø (2016)	Emergency and Critical Care		x			
Drugs for prevention of disease						
Azarpazhooh (2016)	Acute Respiratory Infections	x				
Garjón (2017)	Hypertension				x (all)	
Education and behaviour change						
Asnani (2016)	Cystic Fibrosis and Genetic Disorders				x	
Baker (2016)	Public Health	x			x (all)	CBA, ITS
Barker (2016)	ENT	x	x			
Gillen (2017)	Work			x (unnamed SE)	x	
Orton (2016)	Injuries	x				CBA, NRCT
Vaona (2017)	EPOC	x				CBA, ITS, NRCT
Health systems						
Flodgren (2016a)	EPOC				x (all)	CBA, ITS, NRCT
Weeks (2016)	EPOC				x (all)	CBA, CCT
Implementation programmes						
Flodgren (2016b)	EPOC				x (all)	CBA, ITS
Injury prevention						

(continued)

Table *(continued)*

Study	Cochrane group	Search engine			Websites[†]	Non-RCT study types included
		Google Scholar	Google Search	Other		
Clarke (2016)	Vascular				x (all)	
Maternal and neonatal						
Reavey (2016)	Gynaecology and Fertility	x				
Nutritional						
Bello (2016)	Acute Respiratory Infections				x (all)	
Pain management						
Derry (2017a)	Pain, Palliative and Supportive Care				x (all)	
Derry (2017b)	Pain, Palliative and Supportive Care				x (all)	
Hamilton (2016)	Pain, Palliative and Supportive Care				x	
Ohlsson (2016)	Neonatal	x				
Veys (2016)	Pain, Palliative and Supportive Care				x	
Surgery and radiation						
Barbaric (2016)	Skin	x	x			
Birch (2016)	Colorectal Cancer	x				
Chua (2017)	Gynaecology and Fertility	x				
Gracitelli (2016)	Bone, Joint and Muscle Trauma				x	
Howard (2016)	ENT	x	x			
Hu (2016)	Eyes and Vision				x (all)	
Paravastu (2016)	Vascular				x (all)	
Rikken (2017)	Gynaecology and Fertility		x			
Rose (2017)	Emergency and Critical Care				x	
Zhao (2016)	Anaesthesia	x				
Treatment of infectious disease						
Chang (2016)	ENT	x	x			
Gregorio (2016)	Infectious Diseases				x (all)	
Martí-Carvajal (2016)	Cystic Fibrosis and Genetic Disorders				x (all)	
Regan (2016)	Cystic Fibrosis and Genetic Disorders				x (all)	
Smith (2016)	Wounds	x				
van Driel (2016)	Acute Respiratory Infections		x			
Venekamp (2016)	ENT	x	x			
Vaccines						
Walters (2017)	Airways				X	

[†]*x* indicates that websites were searched and *all* indicates that all websites searched were reported and that the review was included in the analysis of key principle 8.

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Chapter 9. Article 7

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The *phronesis* of expert searchers on using forward citation searching and web searching to search for studies for systematic reviews: A hermeneutic phenomenological analysis

Simon Briscoe
University of Exeter Medical School, University of Exeter, UK

Rebecca Abbott
NIHR ARC South West Peninsula, University of Exeter Medical School, University of Exeter, UK

G J Melendez-Torres
University of Exeter Medical School, University of Exeter, UK

Abstract
Systematic reviews aim to use formalised and explicitly described methods. However, studies show that systematic reviews pose challenges which can only be resolved using expert judgement that is resistant to explicit formulation. The expertise required to make such judgements can be understood as practical knowledge or *phronesis*, and is based on lived experiences rather than following clearly defined rules. This study used qualitative methods to investigate the *phronesis* of expert searchers in the development and conduct of searches for studies for systematic reviews. In particular, the study focused on two 'supplementary' search methods: forward citation searching and web searching. Data collection used semi-structured interviews with 15 expert searchers and the analysis used a hermeneutic phenomenological approach. The findings describe five habits of *phronesis* when searching for studies: *Outcome-oriented; persistent; adaptive; critically engaged and holistic*. The study brings attention to the use of expert judgement when searching for studies for systematic reviews.

Keywords
Literature searching; phenomenology; qualitative research; systematic reviews

1. Background

Adherence to formalised and explicitly described methods which are pre-specified in a protocol is a key strength of systematic reviews. To different degrees, this is true of both aggregative reviews, which aim to use predefined concepts and methods to assess empirical data; and configurative reviews, which aim to test and refine theories to understand complex phenomena [1]. Librarians and information specialists have an integral role in searching for studies for systematic reviews and have developed detailed guidance on many aspects of this process [2–7]. However, the emphasis on formalisation and explicit description can obscure how expert judgement is also required when carrying out searching and reviewing tasks. Several studies have brought attention to this phenomenon. Boell and Cecez-Kecmanovic [8] describe how the identification and analysis of studies for systematic reviews is an interpretative process in which understanding is gradually gained and refined through reading and re-reading study reports. This interpretive process is exhibited in

Corresponding author:
Simon Briscoe, University of Exeter Medical School, University of Exeter, Saint Luke's Campus, 79 Heavitree Road, Exeter EX1 2LT, UK.
Email: s.briscoe@exeter.ac.uk

Moreira's [9] ethnographic study of a systematic review research team, which records the deliberative decision-making of researchers through the processes of 'disentanglement' (i.e. identifying and extracting data from studies) and 'requalification' (representing data in a synthesised format). Drawing out the importance of expertise for making interpretive decisions, Lorenc et al. [10] found that the need for expert judgement is intensified in complex reviews which synthesise heterogeneous data. Although methodological approaches have been developed to work with heterogeneity, Lorenc et al. [10] describe how reviewers use these approaches pragmatically rather than mechanistically to remain sensitive to complexity. Similarly, Cooper et al. [11] found that experienced researchers have different understandings of what 'effectiveness' means in the context of searching for studies, and Shepherd [12] describes how novice reviewers struggle to make expert judgements in the otherwise highly formalised context of systematic reviews. Melendez-Torres et al. [13] show how meta-analyses and narrative syntheses involve judgements about data which can lead to different conclusions. The judgements described in these studies are not necessarily explicitly documented in protocols or method reports, but they nonetheless influence the approach and findings of systematic reviews.

The expertise required to make competent judgements can be understood as *practical knowledge* or *phronesis* [14]. Gadamer [15], whose work underpins the methodology of this study, contrasts practical knowledge with technical knowledge, drawing on Aristotle's distinction between *phronesis* and *techne*. Whereas technical knowledge (*techne*) is learnt by studying abstract rules and formulae, practical knowledge is learnt through exposure to 'concrete situations' in their 'infinite variety' [15]. Once acquired, *phronesis* guides how to achieve a desired end through a form of pre-reflexive understanding more akin to perception (e.g. 'seeing' what to do) than deliberative analysis [16]. Due to its pre-reflexivity, there is debate about whether actions guided by *phronesis* can be retroactively analysed and explained in terms of their motivation [17]. In this study, we assume that, to some extent, the 'reconstruction of reasons for action not necessarily thought out in advance' is possible and desirable as a way of gaining understanding of expert judgement [16]. In particular, *phronesis* can be explored through hermeneutic phenomenological analysis (HPA), which seeks to understand how people make sense of their lived experiences, giving close attention to how they interpret situations that confront them [18].

The expertise that librarians and information specialists contribute to systematic reviews centres on the development and conduct of complex searches of bibliographic databases, and the appropriate use of 'supplementary' search methods [5,19–21]. The latter include a variety of search methods which can be used to mitigate the shortcomings of bibliographic databases, or, more substantially, as a major source of studies for systematic reviews where the desired literature is mainly outside of the published domain (e.g. 'grey' literature) [22] or where the use of keyword searching in bibliographic databases is unlikely to be successful due to diffuse or poorly defined terminology within a topic area [2,23–26]. In the field of health research, librarians historically took on the role of searching for studies for systematic reviews as an extension of curating and facilitating access to scientific journal articles for clinicians – a task for which bibliographic databases and other electronic resources gradually surpassed hand searching as technology improved and the scale of the literature grew exponentially [20]. Specialist roles, such as clinical librarians and information specialists, were developed in recognition of the need for experts to take on this task as their main specialism [27], and their expertise is increasingly acknowledged through co-authorship of systematic reviews [28] and evidence that involving expert searchers in systematic reviews improves the quality of searching [29] and reduces bias [30]. Thus, the role of the expert searcher within systematic reviews is well established, but, despite this, there is limited investigation of how expert judgement shapes the development of searches for studies [11]. Instead, evaluations of how experts carry out searches for studies typically rely on objective measures, such as the degree to which the application of formal guidance is visible in the reporting of search methods [28,29]. The relative lack of investigation of expert judgement in this context is a gap in understanding, which potentially accentuates the perceived importance of formal guidance relative to the role of expert judgement or *phronesis*. This study aimed to use HPA to investigate the *phronesis* of expert searchers in the development and conduct of searches for studies for systematic reviews. In particular, the study focused on two commonly used supplementary search methods: forward citation searching and web searching.

Forward citation searching uses a citation index to identify studies that cite a source study [3,6] and web searching uses search engines and topically relevant websites which are not specifically designed for hosting and retrieving studies [3,6]. We focused on these two search methods due to variability in both *if* and *how* they are used in systematic reviews, as exhibited in cross-sectional analyses of the conduct of these search methods [31–33]. In contrast, bibliographic databases are routinely searched for systematic reviews, so the initial decision to use bibliographic databases has less relevance from the point of view of *phronesis*. Exploring expert judgement in 'weak situations', that is, in which options are not determined by clearly define rules, affords the opportunity to consider both *why* search methods are used in addition to *how* they are used [34]. However, this does not mean that forward citation searching and web searching are necessarily peripheral search methods; indeed, in some reviews, they have as significant a role in study identification as bibliographic databases [35,36]. This has led to some commentators referring to these methods as 'complementary' rather than supplementary search methods [2,35].

Table 1. Characteristics of participants.

Characteristics	*n* (%)*
Gender	
Female	13 (86.7)
Male	2 (13.3)
Years of experience	
M (SD)	15.5 (5.99)
Role titles	
Information specialist	10 (66.7)
Senior information specialist	2 (13.3)
Research fellow	1 (6.7)
Senior research fellow	1 (6.7)
Realist reviewer	1 (6.7)
Employment setting	
Charity	1 (6.7)
Government body	4 (26.7)
Independent consultant	1 (6.7)
Research consultancy	1 (6.7)
University	8 (53.3)
Research field	
Health care	6 (40.0)
Health and social care	8 (53.3)
Health services research	1 (6.7)
Country	
Canada	2 (13.3)
Germany	1 (6.7)
United Kingdom	12 (80.0)

**n* (%) unless otherwise specified.

2. Methods

2.1. Ethics approval and recruitment

Ethics approval was obtained from the University of Exeter College of Medicine and Health Research Ethics Committee (project reference number: Jul20/D/250; date of approval: 1 July 2020). All participants returned signed consent forms via email.

Recruitment used a purposive sampling strategy that aimed to recruit participants from a variety of research settings with experience of both aggregative and configurative reviews. Potential participants were sent an information sheet via email which described the aim of the study and the requirement to agree a time and date to be interviewed for a maximum of 1 h via MS Teams™ or Zoom™. The information sheet also described how all interview data would be anonymised prior to analysis and stored in a secure digital format. No payments or rewards were offered for participation. Participants were required to have at least 2 years experience of searching for studies for systematic reviews on health and social care topics. We focused on health and social care research due to the formative role that researchers in these fields have had in the development of searching conduct for systematic reviews, for example, through Cochrane and the Campbell Collaboration. Participants were also required to have used either forward citation searching or web searching in this context. The majority of people we approached were information specialists, although some had other role titles as there is variation in how the expert searcher role for systematic reviews is described. However, the substantive part of all potential participants' roles was either searching for studies or a combination of searching for studies and other systematic review tasks.

Overall, 28 people were approached, of which 15 with relevant experience agreed to be interviewed. The participants' characteristics are summarised in Table 1. All participants had experience of web searching and 14 had experience of forward citation searching.

2.2. Data collection

A semi-structured interview guide was developed which aimed to facilitate participants to explore their experiences of using forward citation searching and web searching in systematic reviews (see Supplemental Material). Follow-up

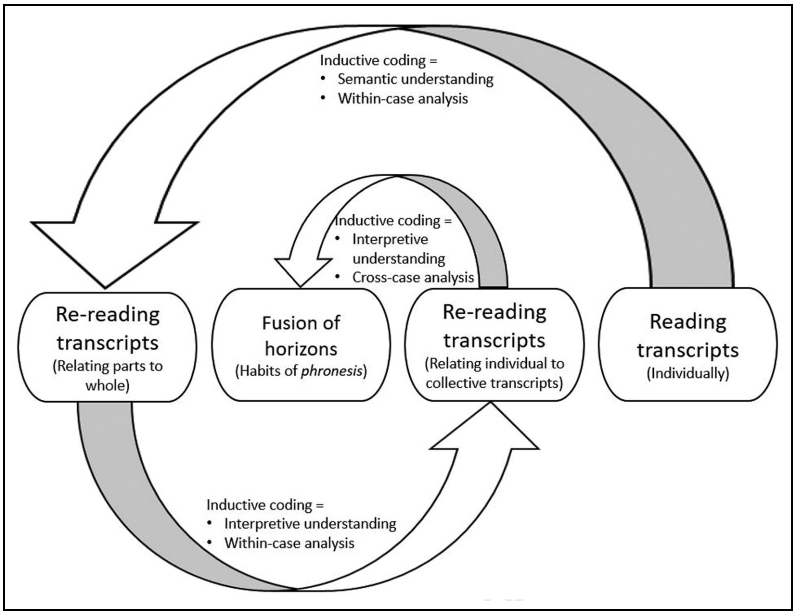

Figure 1. Application of HPA using hermeneutic circle.

questions were included alongside the main questions to encourage participants to reflect on their answers. Following a hermeneutic phenomenological approach, the interviews aimed to be responsive to the participants' answers and pursue relevant issues as they arose [37]. In particular, the interviews aimed to facilitate a dialogue between the interviewer and participant which enabled a shared understanding of phenomena or 'fusion of horizons' [38]. This meant that the order in which questions were asked was not always the same nor were all the questions always asked. However, all the interviews consisted of two main sections, the first on forward citation searching and the second on web searching. We did not aim for data saturation, which commentators have argued is not relevant to HPA [39,40]. Instead, we relied on the specificity of the sample and in-depth dialogue to generate sufficient 'information power' to explore the phenomenon of interest [39]. The interview guide was piloted with an information specialist colleague. All the interviews were carried out by SB via MS Teams or Zoom video call software between September 2020 and June 2021. Interviews were recorded using the video call software and transcribed by a professional transcription service. All interviews were conducted in English, including one participant for whom English was not their first language but was sufficiently proficient to participate without hindrance.

Prior to the interviews, SB undertook a bracketing interview with GJMT and RA to become more aware of their own perspectives on forward citation searching and web searching. This led to the recognition by SB of a tacit assumption that the search methods had an important role to play in study identification, which might not be shared by all participants. Thus, it was recognised as important to allow the interviewees to present their own views on the value of the search methods without SB challenging them if their views differed.

2.3. Data analysis

Transcripts were anonymised using an alphabetical letter (A to O). Data analysis aimed to describe the *phronesis* which guided the participants' searching practice in such a way that was expressive of the group as a whole, while remaining alert to differences in the group [18,38]. To remain sensitive to how *phronesis* is resistant to explicit formalisation while still being able to articulate a descriptive account of its content, we followed McDowell in conceptualising *phronesis* in terms of 'habits of thought and action', that is, tendencies to perform certain actions which were identified in the data we collected [41]. Thus, we use the phrase 'habits of *phronesis'* when describing our findings.

The analysis used an interpretative process which followed a hermeneutic circle, moving iteratively between analysing transcripts as a whole and analysing parts of transcripts (see Figure 1) [38,42]. We started by reading and re-reading the transcripts to become familiar with the content. An initial round of inductive coding was then undertaken which highlighted key phrases or words that described the experiences of using the search methods for each participant. The transcripts were then read again alongside the initial codes with a view to developing the codes with new understandings

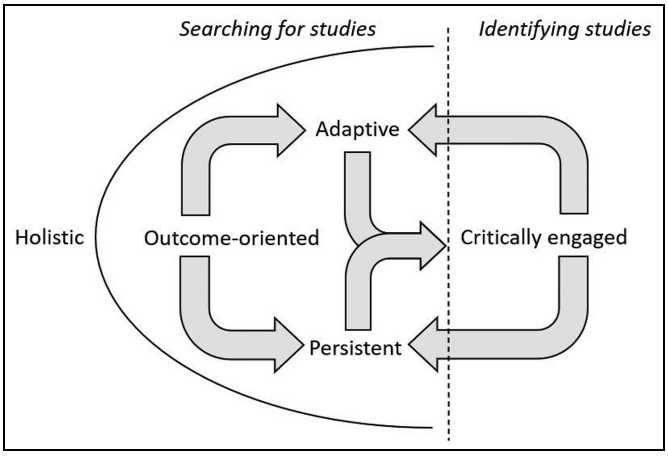

Figure 2. Five habits of phronesis.

which were uncovered by considering how they are related to other sections of a transcript or the transcript as a whole. This process was repeated iteratively with the aim of producing a rich account of each participant's understanding of forward citation searching and web searching. As the analysis progressed, understanding gained from reading transcripts was explored within other transcripts, which enabled the development of a shared understanding of the *phronesis* of the participants. As described by Smith et al. [18] through each iteration, our understanding of the transcripts moved from a high-level semantic understanding to a more in-depth, interpretative understanding. We did not separate analysis of forward citation searching and web searching, but we remained alert to differences in their usage. As recommended in Smith et al.'s [18] guidance on HPA, we sought to ensure validity in the analysis by implementing Yardley's [43] criteria of commitment, rigour, transparency and coherence. Specifically, we were attentive to Yardley's [43] recommendation for phenomenological analysis to make 'effective use of prolonged contemplative and empathic exploration' which aims to 'transcend superficial, ''common sense'' understandings'. SB read all the transcripts and undertook the coding; GJMT and RA read selected transcripts and met regularly with SB to discuss the emergent habits of *phronesis*.

3. Findings

Data analysis identified five habits of *phronesis* that guide searching for studies using forward citation searching and web searching: *outcome-oriented; persistent; adaptive; critically engaged* and *holistic* (Figure 2). All five were closely related and used alongside each other by the participants; in particular, *adaptive* was closely related to *persistent* and thus these two approaches are discussed together. The interrelation of the five identified habits of *phronesis* is depicted in Figure 1. Outcome-oriented, persistent and adaptive relate to searching for studies; critically engaged relates to the identification of studies from the results of searches, with feedback from this stage going back into searching for studies. Holistic describes an overall approach to the use of different search methods alongside each other. Other approaches to searching were also identified in the analysis; however, these were typically framed by participants as 'rule-following' approaches which relied more on *techne* than *phronesis*. These included process-oriented searching, uniform or standardised searching, and exhaustive or comprehensive searching. We refer to these rule-following approaches in our findings where they bring out the contrasting character of the identified habits of *phronesis*, but do not discuss them in detail.

In the following sections, we describe the identified habits of *phronesis*. Unless it is clear which search method a participant is discussing, we refer to web searching as *WS* and forward citation searching as *FCS* alongside the ascription of quotations to participants.

3.1. Outcome-oriented searching

Outcome-oriented searching prioritises the *identification of relevant studies* above *how* studies are identified. The participants distinguished this from *process-oriented* searching, which aimed to show that searches fulfilled the expected criteria for the type of systematic review that was undertaken. Process-oriented searching was a rule-following approach which correlated with seeking to minimise the need for expert judgement, whereas outcome-oriented searching was predicated on expert judgement about how to achieve the desired outcome. Key phrases among participants discussing

outcome-oriented searching included 'do[ing] what works' (N), 'focusing…where it's going to add value' (G) and searching when it 'seems like it's going to be fruitful' (J).

Outcome-oriented considerations were strongly determinative of whether a search method was used. This was also true of process-oriented considerations, but the rationale was different. One participant contrasted process-oriented with outcome-oriented searching, reflecting on the motivation for focusing on the process rather than the outcome:

> I always have the impression that what people really want to do is demonstrate and show that that they have done [everything possible] … you know it's like they don't want someone to say 'Well why did you not do forward citation searching?' ….I think … there is a real kind of value system around that, and like, *doing everything that it was possible to do in the time that was available*. (J, our emphasis)

Here, the motivation for process-oriented searching is 'doing everything possible', irrespective of whether this is useful. They went on to give a hypothetical example, asking the rhetorical question, '[W]hat are the chances, really [in an effectiveness systematic review of RCTs] … that there was a huge trial that you never heard about, but then turned up in a forward citation search?' Although they accepted this approach was sometimes expected for aggregative reviews which aim to search exhaustively, they considered there were lessons to be learned from other types of review (in particular, configurative reviews) in which searching is 'more about what seems like [is] going to be fruitful'. WS was more frequently used as standard than FCS, but the emphasis was still on usefulness: 'If I spend a lot of time doing something, then I need to know it's going to be useful' (I, WS). Commonly mentioned situations in which FCS and WS were considered useful included where search terms were hard to define and where studies were not published in journal article format. However, in practice, it was not always possible to know a priori whether a search method would be useful: 'I think that it's very unlikely that you actually have the data about that review topic to show that it [i.e. FCS or WS] is worthwhile' (N). Thus, participants relied on 'instinct' based on past experiences: 'in practice there's […] an instinct for topics, whether that's right or wrong. But I would tend to do it then' (M).

Decisions relating to WS had an additional factor to consider regarding the reproducibility, or lack thereof, of the searches. Participants were mindful that searches using a search engine, such as Google Search or Google Scholar, were not reproducible due to variation in search results for different users. This was also the case for websites that used search engines as the basis for their search function. Thus, even if a carefully constructed search strategy was developed, searching was compromised from the point of methodological rigour:

> I think it is like this fundamental question about science. I feel more comfortable when searches are scientific in the way they're designed, and the way you can, you know, conduct them, the way you can evaluate them, and reproducibility is key to that. (N, WS)

One participant in a research consultancy setting was strongly disinclined to recommend using a search engine due to lack of reproducibility, which was seen as a key criterion of searches for a systematic review, that is, a process-oriented consideration. More typically, participants sought to balance the 'science' of searching with the end product:

> is there any point in doing web searching, because you can't really be completely scientific and reproducible about it? But then ultimately is that … I don't know, in terms of a review, is it more about the science of it? Or is it about the product, you know, the things that you've identified for it? So it's a bit of a balance of those two things, I think. (F)

To this end, the participants cited examples where search engines had identified relevant studies and used this to justify the inclusion of search engines in systematic reviews, that is, an outcome-oriented justification. This even extended to preferring Google Search, which has known problems with the reproducibility of searches, over search engines which purport to have less variation in the search results: 'there's a few [search engines] that don't track … I tried testing different web search engines but unfortunately the results weren't as good' (N). Similar concerns about the technology used for FCS were not raised.

Outcome-oriented considerations guided the development and conduct of search methods after the initial decision to carry out a search was made. The main consideration for FCS was how to select source studies, that is, the studies on which FCS is carried out. Studies were usually selected from the known set of studies which met the inclusion criteria, and richness of data and 'highly relevant' were common reasons for choosing such studies. One participant gave an example from a scoping review:

> [S]ome of the [potential source] studies had a brief mention [of the review topic], but it was so small that we felt it wasn't going to be as useful as some of these ones where it was the major focus of the article. (F, FCS)

By contrast, participants who preferred a process-oriented approach typically used *all* known studies for FCS, which they considered less biased, and which was perceived to correlate with the emphasis on exhaustiveness in some types of systematic reviews. One participant noted that this approach 'treats everything consistently. We're not having to make a judgment call as to which studies might be most important' (O). Another participant cited Cochrane guidance to support this decision. Thus, participants were divided about whether outcome- or process-oriented searching was superior when FCS, which was partially but not entirely delineated by whether participants mainly worked on aggregative (process-oriented) or configurative (outcome-oriented) reviews. However, the idea that using all known included studies evades the need for judgement was questioned by one participant: 'all the studies known to me, it's already a selection of studies' (E). They considered that although such studies met the criteria for *synthesis* purposes, this did not a priori entail that they also met criteria for *searching* purposes. Instead, they proposed separate criteria for selecting source studies, designed to optimise the outcome of searching:

> I think it would be more systematic to establish criteria that could help us in selecting studies from known studies, via a different method and then say, 'Okay. I've identified a specific set of studies, and I apply, for example, a criterion of currency, or a criterion of number of participants, or, for cohort studies specifically, the time of follow up'. Because of course a cohort study that has follow up for 10 years, that's a big, big project, and I'm pretty sure this is a well cited study as well. (E)

Other participants made the related point that publications that do *not* meet the inclusion criteria could be worth FCS, such as topically relevant commentaries, or studies which fail to meet inclusion on relatively arbitrary criteria, such as publication date or language. This challenged the view that using all included studies was exhaustive.

Whereas at least some participants considered a process-oriented approach was feasible with FCS, all of the participants were sceptical of this for web searches. A typical viewpoint was, 'whatever you're doing is a compromise, because you can't do the type of search that you want to do.'.. (O). In addition to the aforementioned lack of reproducibility, participants described basic search interfaces which severely limited the type of search it was possible to conduct:

> it's very difficult to search in a systematic way with the tools that are often … you know, with the very poor tools that are actually available where you can't do even phrase searching in a lot of websites or … or when you do phrase searching, it's an AND search. (C)

This necessitated a pragmatic approach to searching, using trial and error with each newly encountered website to achieve the desired end. Demonstrating methodological rigour was considered unrealistic. Although participants were aware of searching guidance, they considered it of limited use on a case-by-case basis:

> The guidance and the literature, I think, is sparse in this area. So I don't think it's a matter of doing what you're, you know, supposed to do or not supposed to do. I think it's […] a question of not knowing what you're supposed to do and doing what works for the particular review. And then I think you develop over time. I'm sure lots of information specialists feel this way as well. You develop your own practice based on what's worked in the past, and so you continue to do it that way in the future. (N)

For both FCS and WS, although outcome-oriented searches could theoretically be pre-specified and explicitly described, their fullest realisation typically seemed to depend on being responsive to developments in a review and to the searchers' immersion in the searching process as the review got underway. We explore this in more detail below.

3.2. Persistent searching and adaptive searching

Persistent searching uses multiple attempts to search a resource to identify relevant studies. Persistent searching was sometimes contrasted with *exhaustive* or *comprehensive* searching. Whereas comprehensive searching aims to identify all relevant studies within a resource, often with a single large-scale search, persistent searching acknowledges that, for some resources, this is not possible due to limitations of the search interface. Thus, persistent searching aims to identify as many studies as is feasible using multiple smaller-scale searches. The related *adaptive* searching was detected as complementing persistent searching because of the need to adapt searches when searching persistently to retrieve different results. Adaptation was typically informed by feedback from initial attempts at searching. Adaptive searching was contrasted with *standardised* or *uniform* searching, which aims to retain the same approach for consistency between different resources.

3.2.1. Persistent searching. Persistent searching emerged as a strategy for dealing with search interfaces, which are not amenable to complex search strategies, described by one participant as 'difficult [websites] to search':

> [I]f it's a difficult one to search I usually search it as much as I can, but then I sometimes use Google advanced search to search [using] the website URL … [I]t's another way, sometimes, to see if I can find anything else. (A)

Here, a persistent approach is clearly described, searching a website 'as much as I can' before searching it further via the Google Search Advanced Search page. They went on to contrast this approach with using a single search for a bibliographic database which aims to retrieve all relevant studies:

> [W]ith a database, once you've got your search strategy you can feel like, 'I'm confident that this will pick up, hopefully, everything that there is as far as precision and sensitivity and so on go'. It'll pick up the right papers. But with a web search, because of the nature of them you can't have that confidence from one search. Usually you need to try quite a few different things. (A)

The contrast between the persistent web search and the single or comprehensive bibliographic database search was echoed by other participants, for example, 'You put some terms in, see what happens, put some more terms in and it's not like that final MEDLINE search where this is definitely what we're definitely doing' (G). This iterative and developmental nature of persistent searching was sometimes seen as haphazard ('web searching is just messy' [O]); however, there was still an element of discernment and refinement when persistently WS:

> I would try and identify … from my database search strategy […] the most highly discriminating terms and search on those, and, again, I wouldn't necessarily map those out in advance before I started. It would be, like, trial and error, and just seeing how it responded, did I think that the returns I'd tried had been effective, was I retrieving what I would expect to retrieve? If I hadn't, I might then start … start putting in kind of additional terms. (O)

This approach of trying to identify the most discriminating terms as a starting point was mentioned by several participants. However, there was an acceptance that, unlike bibliographic databases, an objectively optimal way of searching was unlikely to be found in view of uncertainties about search algorithms and unstable content on websites: 'I suppose the databases are much more of a controlled environment […] So there is that feeling of being able to tinker and improve something in a way that's objective that you can't do with web searching' (G).

One participant, who mainly worked on configurative reviews, described persistent searching when using FCS, which entailed using studies identified by FCS for further citation searching (also described as 'citation snowballing' in the literature) [44]. This was deemed useful for gaining an understanding of the context in which research is produced:

> You get that kind of broader picture of where the literature is coming from … I think a lot of reviews are very focused on the content of the studies they include … and then almost miss the bigger picture, like, the wider context in which the research was produced. And I think the more citation searching you do, and, you know that feeling of 'Oh I've stumbled into this nest of studies again'. (J)

This approach was seen as particularly useful for configurative reviews where the perspectives of the producers of studies were perceived as connected to the outcome of the research.

Due to its iterative nature, the participants noted that persistent searching requires the searcher to know when to stop in order to be manageable within the time constraints of a systematic review: 'the reason I'm strict with my myself about it is … is, like, not because I think it's wrong, but because three hours will have passed' (J, FCS). Understanding how to stop searching depended on knowing the purpose of the search. In the context of WS, the participants gave several examples of targeted searches which aimed to identify a known study or studies with a narrow focus. For example, one participant described using web searches to investigate ongoing studies identified via other means: 'you think, oh, that was three years ago, I wonder if they've actually published anything to do with this' (K, WS). In a broader but still clearly bounded example, another participant described how WS 'may be for a particular purpose [such as] you're only looking for more views studies or … you take a look at the geographical focus … or it may be one certain stakeholder perspective' (B). These searches could stop when the information need was fulfilled. However, if the purpose of the search was open-ended, the stopping point was harder to define. A broadly outcome-oriented approach, which was persistent within the bounds of usefulness, was detected in these scenarios. For example, one approach when using a search engine was a stopping rule, often after 100 results were screened, or when two or three pages were screened with no relevant results. It was also considered helpful to identify specific websites to search, rather than relying on a search engine, which would give a sense of boundedness. Within these bounds, a persistent approach was used; for example, using the 'site'

command in Google Search to search websites: 'if you search with the site command in Google, it's often quite good, and I have the impression that […] I would find things there that aren't accessible through the website itself any more' (J).

3.2.2. Adaptive searching. The participants considered that persistent searching should be combined with adaptive searching by incrementally altering a search with each new attempt at searching a resource. To this end, participants adapted search terms using feedback from the results that they retrieved from previous searches, or simply to ensure that a wide selection of search terms from the bibliographic databases were used for the web searches. However, adaptive searching was also used to be sensitive to the context of the resource that was being searched. One participant gave an example of searching websites for user involvement studies:

> you start to learn the terminology that people are using … Different organisations have their own terminology for what they mean by 'user involvement'. So some people call it 'advocacy', another organisation will call it something else, 'patient focused'. So you quickly pick up that you're not using … you can't use the same language in each resource, because in fact, the culture of the organisation that you're searching has a role to play in what you're going to find. (C)

They concluded, 'if systematic is being the same, it's quite hard to be systematic. What I think people need to be is adaptable, and … and tailor what they're doing to be appropriate to the website they're searching' (C). Consistency was still sought, however, if at all possible, rather than introducing variation almost at random: 'I would *try* to be consistent [when selecting search terms]' (E, WS, our emphasis). Participants acknowledged that adapting searches for different interfaces was difficult to do with confidence that a resource was being searched appropriately:

> It's not that you don't know what you're doing. But like every time it's a new thing that you're having to get used to and having to figure out the quirks of. So there's sort of less confidence in like have I done that right? (M)

The adaptive process was thus also closely aligned with a persistent process in the attempt of a searcher to satisfy themselves that they have searched a resource appropriately.

Several participants described how, because FCS does not typically take place until after the bibliographic database searches have been screened and an initial number of included studies identified, it is not clear until relatively late in the review process whether additional searches are needed to identify a suitable selection of studies (particularly for configurative reviews), or whether there was enough time and resources to screen the results of FCS (either for aggregative or configurative reviews). Adaptiveness was necessitated to take account of these variables, which also drew on outcome-oriented considerations to maximise the usefulness of the approach. One participant noted that FCS was sometimes written into a protocol as a potential 'reserve' search method, using an example of a configurative review where FCS was reserved for identifying additional studies if required. Discussing a realist review protocol, they noted that:

> we used lots of phrases […] in the protocol like 'if necessary'. 'If necessary, we will …' [use FCS]. I guess probably what I'll do is, there'll be some studies that will seem to be contributing a lot of data to the review, and those are the ones that I'll go and look for forward citations. (J)

Once FCS was underway, review teams were sometimes surprised at how many results were retrieved and this necessitated re-visiting the approach that was taken:

> Sometimes people say well, 'let's do the citation search' and I think they're assuming that we're not going to find that many hits … And they're quite surprised sometimes when we find hundreds or thousands … and then we've got to kind of go back and re-think the whole thing again. (D)

3.3. Critically engaged searching

The participants described how outcome-oriented and persistent searching required an understanding of how successful a search was at retrieving relevant studies. From this perceived need to be alert to the content of search results emerged 'critically engaged' searching. Critical engagement extends the searcher's involvement beyond the practical knowledge required to develop and carry out search methods to a reviewer role in study selection.

Participants reported that searching and screening would sometimes overlap:

> There's an element of screening that's involved with both forward citation searching and web searching and reference checking as well … And so there's always a discussion with the author team who's going to conduct that work because practically if I'm going to check all of the citing references for a particular study, I need to decide if they meet the inclusion criteria. (N)

This overlap was universally acknowledged when carrying out WS: 'you need to be really familiar with the inclusion and exclusion criteria, [because] you're almost kind of screening as you go along' (K). This overlap of roles occurred partly because search engines and websites rarely have a function for exporting content to reference management software: 'a challenge … is exporting results, because you usually can't export them. Usually we have to put them manually into our reference management which is time consuming' (A, WS). Thus, searchers often elected to select relevant results themselves. Similarly, the precision of web searches was typically low due to basic search interfaces and the wide range of content that was indexed; thus, it was considered inefficient for every identified item to be screened by a second reviewer: 'If in doubt I would send it to [the review team], but there is an element of me looking at titles thinking, ''Oh, that's nothing to do with this''' (G). A small number of participants were disinclined to carry out WS themselves because of the need to be familiar with the review content and because they felt that WS did not require specialist search skills:

> ideally, all of it gets moved down to the reviewer or their research assistants, because I don't think that it takes necessarily librarian skill to read websites and pick out either citations or interesting bits of information […] I mean, ideally that would be a job for someone else on the review team with content expertise. (L)

This was sometimes done with a view to focusing the available expert searcher time on the more advanced search interfaces of bibliographic databases. One participant who expressed this view in a research consultancy setting was doubtful about the scientific credibility of WS due to problems of reproducibility' and appeared to consider that investing their time in WS risked 'validating' it as systematic search method in the eyes of reviewer colleagues. When FCS, there was the option to export the results which meant it was less common for information specialists to be involved in screening. However, some participants were involved to divide the screening labour: 'Most screening teams are pretty exhausted by this time, so they elect for me to do a little bit of extra screening on their behalf' (N).

For participants to be involved in identifying studies, they needed to be critically engaged with the content of the search results. However, the approach they used to select studies was not necessarily determined by the strict application of inclusion criteria. Instead, participants often took an inclusive approach to selecting studies for potential inclusion in a review: 'I will look [at the results] and if I think there's the *slightest* chance it might be relevant then I'll include it' (A, WS, our emphasis). This approach was guided by the fact that if the searcher excluded studies which were not exported to reference management software, they would not be seen by a second reviewer. Although citation indexes do facilitate exporting of references, some participants used a similar approach when using Google Scholar to carry out FCS, which has more limited export features than subscription-based citation indexes: 'I used it just using the regular interface and then scanning the … the references and going through them manually so if I did that then I would have to be quite involved in that bit of the review' (B). One participant described how there are sometimes mistakes in the citations of studies:

> you have to be fairly imaginative to take account of the ways that people might have cited a paper, there can be variations and mistakes. So … you need to be looking out … you need to be actively searching for mistakes as well as the real reference that's been accurately cited. (C)

When using Google Scholar, this extended to searching for mistakes in the citations of studies which were introduced by the automated algorithms which the search engine uses to retrieve citing studies.

The participants noted that they learned about the performance of searches from reading the search results in detail. The search performance feedback gained from critical engagement with the search results was then used when searching persistently to adapt subsequent searches.

3.4. Holistic searching

Holistic searching seeks to ensure that search methods complement each other. To this end, participants assembled search methods, including FCS and WS, into a coherent strategy based on what was consistent with an overall plan. This was contrasted with approaches to searching which focus on assembling search methods, including simply long lists of bibliographic databases, without considering how they work together.

Demonstrating holistic searching, one participant noted that 'as time goes by, I'm not interested in just putting together a list of databases to show that I've searched everywhere. I want to have some rationale for my choices [of search methods]' (L). Similarly, other participants noted how the 'default' option of compiling a long list of databases was not necessarily the optimal way of finding relevant studies for a review:

> From someone who has supported just tons of very […] 'systematic' systematic reviews, and was from that school of comprehensiveness […] the big comprehensive database search is … the linchpin of that, and everything else is additional. But, like … now because I do more chaotic reviews [i.e. configurative reviews], I think that I'm not even that confident that it is the most useful thing. I think it's probably just the … the big thing that you do first, and then it feels like a lot of the studies that are included in reviews come from it, because that's where I looked first. (J)

This quotation highlights how the bibliographic database search is often viewed as the *main* search method and other search methods are relegated to *additional* methods. In contrast, holistic searching was often associated with assigning a more prominent role to other search methods, such as FCS and WS, alongside searching bibliographic databases. In this respect, holistic searching shares similarities to the already existing literature on using traditionally viewed 'supplementary' search methods as 'complementary' search methods [23,33]; however, we suggest that there is more emphasis in holistic searching on how the search methods fit into an integrated whole. Discussing how FCS could have a more prominent role in searching for studies, one participant noted that, in the context of large-scale public health systematic reviews,

> I feel like in a lot of cases what I would like to do is do a much simpler PICO search [i.e. bibliographic database search], not try and bottom out every single synonym and all those kind of things … I have done that for topics where … I did forward and back[-ward] citation searching and that was the first bit of the strategy. And I was almost using the PICO element after that to fill in for the stuff that we didn't capture there. (M)

In this example, using FCS as a starting point might be a more effective or efficient way to identify studies initially, and this can be complemented with a smaller database search to identify studies that might have been missed.

Holistic searching often overlapped with outcome-oriented searching. In particular, an outcome-oriented approach to one search method would typically have strengths and weaknesses which could be balanced by combining it with other search methods which used a different mechanism for retrieving studies:

> none of these individual methods, particularly in a review that isn't the traditional kind clinical, efficacy, RCT type review, those more kind of public health, social science reviews, […] feels like it's enough, but when you use the individual methods together and they start to overlap [inaudible] database search and citation search, and then you might check references and then you might contact people working in that field for extra stuff, all … all those individual methods, as you know, kind of allow for the inadequacies of other methods. (O)

Specific examples were mentioned with respect to FCS and WS:

> I'm never just relying on that [i.e. WS] on its own […] I've already got results from databases and results from this that and the other … it feel likes there are enough facets to the places that information's coming from that if … if that one is in a little bit of a bubble, that's okay. (J)

('Bubble' in this quotation refers to the problem that web search results are tailored to the searchers' search history and geographic location).

Decisions about how to develop holistic searching typically relied on the participants' experience and expert judgement. Participants did sometimes have 'maxims' or evidence-based criteria for making a decision; for example, discussing searching for diagnostic test accuracy reviews, one participant noted 'there's sort of a base assumption that PICO works, which if you look at the filter studies and things like that, and diagnostic filters, we know for a fact that in some cases it just doesn't' (M). However, the many varied situations that a searcher might face made knowing exactly how to approach a search dependent on 'instinct and experience':

> it's a judgement call. I guess the fundamental problem in our business is if you want to falsify what you've done, if you want to say well, that wasn't the best way to do it, you've got to have a tonne of resources to do it again better […] So I go on instinct and experience. (M)

The perception that it was sometimes hard to explicitly formalise why a particular set of search methods was preferable reflected the tension between the acknowledged aim of systematic reviews to use a rules-based approach and the underlying reality that judgements which rely on the discretion of the review team are inevitable. This was perceived to be a phenomenon which was not only limited to the searching component of a review but also related to wider questions about systematic reviews:

> I think we probably need more clarity in terms of what people want from it [i.e. searches for studies], and what they are aiming at in terms of the final product. I can't give you that definition of a systematic review. I don't know whether people prize transparency more or they prize speed more or … yeah. I don't know what it is. (M)

4. Discussion

This study has identified and described five habits of *phronesis* which expert searchers use when searching for studies for systematic reviews using FCS and WS: outcome-oriented; persistent; adaptive; critically engaged and holistic. Our findings suggest that it is not always feasible, or desirable, to approach searching for studies using formalised and a priori described methods. Instead, review teams should make allowance within pre-specified descriptions of searching to be responsive to study identification needs as they arise in the review process, and to dimensions of searching (e.g. 'persistent' and 'adaptive') which only become apparent when searching is underway. This may also mean, as Moreira [9] and Boell and Cecez-Kecmanovic [8] have also shown, appreciating the non-linearity of searching and reviewing tasks as the 'critically engaged' searcher develops an understanding of a review topic through screening the results of searches which feeds back into the development of additional searches.

Traces of the identified habits of *phronesis* are detectable in guidance and expert commentaries on searching, for example, the recommendation of repeated attempts at searching a website using different search terms [6,26] or purposively selecting 'key' studies as source studies for citation searching [2]. These approaches are also visible in reporting of search methods in systematic reviews [31,32]. However, the unique contribution of this study is the articulation of practical reasoning that shapes the development of searching, rather than the specific processes involved in searching. Indeed, it is inherent to *phronesis* that its dependence on the expert judgement of the practitioner means that it cannot be mechanistically applied. As McDowell says of the possibility of drawing up a code of principles which are sensitive to practical knowledge,

> however subtle and thoughtful one was in drawing up the code, cases would inevitably turn up in which a mechanical application of the rules would strike one as wrong – and not necessarily because one had changed one's mind; rather, one's mind on the matter was not susceptible of capture in any universal formula [16].

Variables which led to the requirement of *phronesis* in this study included factors such as the aims and objectives of a systematic review, the needs of the end-user, and the time and resources available. Relevant factors were also identified relating to the tools which were used, particularly for WS, wherein the mechanical application of rule-following could lead to suboptimal searching. The difficulty of articulating a rules-based account of searching for studies caused some of the participants to reflect on whether the required judgements fitted within the framework of a scientific endeavour which aimed for methodological rigour. To accommodate for this, a balance was sought between the pursuit of science and the development of a product that was useful for the end consumer, who, for example, would prefer that studies were included rather than omitted because the methods used to identify them lacked methodological rigour. This does not, however, mean that *techne* is irrelevant for systematic reviews, or that technical guidance is not valuable – but rather that it is unrealistic and indeed not desirable to develop, carry out and assess the validity of systematic reviews entirely by the application of pre-specified criteria and rule-following. Lorenc at al. [10] report similar findings on how reviewers work with heterogeneous data for which guidance is limited, seeking a fine line between applying methods in 'rigid and uninformative way' and compromising the integrity of a review by taking too relaxed an approach. Furthermore, both this study and Lorenc et al. [10] found that expert judgement in making these decisions may remain unarticulated in even the most detailed description of methods conduct.

All of the identified habits of *phronesis* were shown to be distinct from formulised or rule-following approaches to searching (i.e. *techne*), but perhaps the strongest contrast was between outcome- (*phronesis*) and process-oriented (*techne*) approaches. By focusing on the outcome of searching rather than the process, outcome-oriented approaches explicitly challenge the central importance of methodological rigour when carrying out a systematic review [3,45,46]. In particular, a key strength of systematic reviews is that studies are identified by a rigorous searching and screening process using predefined inclusion criteria which prevents bias arising from 'cherry picking' studies for inclusion [4,5].

Thus, a risk of outcome-oriented approaches is that searches fail to retrieve studies that are less immediately identifiable, for example, which are not cited by a 'core' set of studies used for FCS, or which are relatively hidden within websites or ranked lower down a list of search engine results. Indeed, outcome-oriented approaches may be susceptible to confirmation bias if search parameters are narrowed without due consideration, such as focusing on websites of organisations with a similar perspective on a phenomenon of interest or using studies which report positive results for FCS [47]. To mitigate this problem, it may be helpful to extend the 'critically engaged' habit of *phronesis* to include awareness of the potential for confirmation bias to influence outcome-oriented searching. This might mean searching the websites of a suitably varied set of organisations or using studies for FCS which disconfirm the dominant findings of a review [48]. There is also a long-standing awareness of the value of WS to identify studies which are not published in journal article format as a strategy for tackling publication bias [49,50]. Adaptive and persistent approaches can also be used to extend outcome-oriented searching, and, as participants noted, potential shortcomings of one search method can be mitigated by combining it with other search methods.

Regarding 'adaptive' and 'persistent' searching using a search engine, it was interesting to note that the participants did not emphasise the need – as recommended in systematic review searching guidance – to clear search histories between carrying out searches to minimise the personalisation of search results based on relevancy feedback from earlier attempts [6]. We suggest that, in view of the aims of adaptive and persistent searching, relevancy feedback may be useful for encouraging a search engine to rank potentially similar items higher in a list of search results; however, when commencing searching for different content, clearing search histories remains useful.

In keeping with the overall approach to HPA, we sought to achieve a 'fusion of horizons' which was both expressive of the group as a whole while remaining sensitive to different perspectives [38,42]. This was mainly achieved through attentiveness to contrasting views among participants on whether *phronesis* or *techne* was more appropriate, with the emphasis on the practical reasoning which underpinned searching decisions rather than specific cases where they were considered more or less helpful. Sometimes, however, it was possible to articulate factors which led to different perspectives; for example, there were different perspectives on process-oriented (*techne*) versus outcome-oriented (*phronesis*) approaches to FCS which were in part reflective of whether participants mainly worked on aggregative or configurative reviews. Yet, even where contrasting views could be linked to different contexts, they were rarely held in an absolute sense, and participants showed awareness of the potential value of the habits of *phronesis* for developing and carrying out searches for studies for all types of systematic review, from the more 'traditional' rule-following Cochrane review to the more exploratory realist review. Hypothetically, differences in knowing when and how to use *phronesis* might reflect how much experience someone has, in view of how expertise is acquired overtime through practice [51]. However, any such differences between the participants in this study were not identifiable, which perhaps reflects that all of the participants had several years of experience of searching for studies – specifically, only 1 of 15 participants had less than 9 years of experience.

4.1. Strengths and limitations

The participants exhibited a depth of searching experience which was based on many years of practice. Although the participants all worked in health and social care research settings, we think that the findings will be applicable to other topics areas, as the methods used for systematic reviews more widely are probably similar. Indeed, it is unlikely that other topic areas have as extensive guidance on systematic review methods as health and social care research, and they may also have more limited bibliographic database resources and indexing standards, thus the need for expertise on using supplementary search methods may be increased. Although we focused on FCS and WS, these are not peripheral methods, as evidence attests [35,36]. However, there is scope to extend the investigation of expert judgement to other search methods, for which reference to the design of this study may be helpful as a guide. The use of HPA facilitated in-depth investigation of expertise which has hitherto not been explored. We did not, however, iteratively contact participants to follow up lines of investigation, as is recommended in HPA guidance [38]. This was mainly due to the time required to carry out iterative interviews with a large cohort of participants during a challenging time for both interviewer and interviewees during the COVID-19 pandemic. Instead, we sought to exhibit validity using Yardley's [43] principles of commitment, rigour, transparency and coherence.

5. Conclusion

The expertise of information specialists in searching for studies for systematic reviews extends beyond the formal rules-based approaches set out in guidance and evidence-based practice, and challenges the convention of pre-specified and explicit step-by-step reporting of methods in protocols and systematic review publications. This analysis contributes to

accounts of how systematic reviews unfold in ways that may not be explicitly avowed, drawing attention to searching as an area of systematic reviews that is central to their credibility but as yet poorly understood in terms of its expert practice.

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ORCID iD

Simon Briscoe https://orcid.org/0000-0002-6982-4521

Supplemental material

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Supplemental material Interview schedule

Forward citation searching questions

Topic	**Guiding questions**	**Follow up questions**
Initial decision	How do you decide whether to carry out forward citation searching for a systematic review?	Are there particular types of review or review topics that influence your decision? What do you hope that forward citation searching will add to a review? What is the value of forward citation searching?
Approaches to conduct	How do you decide what approach to take to forward citation searching?	What factors influence your approach? What are some of the approaches that you might take? Snowball searching? Iterative citation searching? How do you decide which resources to use? How do you ensure that your approach is systematic, if at all?

Challenges	What are the main challenges that you face when conducting forward citation searching?	Does the technology you use pose any specific challenges? How do you approach the practical issue of time and resource constraints?

Web searching questions

Topic	**Guiding questions**	**Follow up questions**
Initial decision	How do you decide whether to carry out web searching for a systematic review?	Are there particular types of review or review topics that influence your decision? What do you hope that web searching will add to a review? What is the value of web searching?
Approaches to conduct	How do you decide what approach to take to web searching?	What factors influence your approach? What are some of the approaches that you might take? How do you decide which resources to use?

		How do you ensure that your approach is systematic, if at all?
Challenges	What are the main challenges that you face when conducting web searching?	Does the technology you use pose any specific challenges? How do you approach the practical issue of time and resource constraints?

Chapter 10. Article 8

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ORIGINAL ARTICLE

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Expert searchers identified time, team, technology and tension as challenges when carrying out supplementary searches for systematic reviews: A thematic network analysis

Simon Briscoe MSc[1] | **Rebecca Abbott PhD**[2] | **G. J. Melendez-Torres PhD**[1]

[1]University of Exeter Medical School, University of Exeter, St Luke's Campus, Exeter, UK

[2]NIHR ARC South West Peninsula, University of Exeter Medical School, University of Exeter, St Luke's Campus, Exeter, UK

Correspondence
Simon Briscoe, University of Exeter Medical School, University of Exeter, St Luke's Campus, Heavitree Road, Exeter EX1 2LU, UK.
Email: s.briscoe@exeter.ac.uk

Abstract

Background: Systematic reviews require detailed planning of complex processes which can present logistical challenges. Understanding these logistical challenges can help with planning and execution of tasks

Objectives: To describe the perspectives of expert searchers on the main logistical challenges when carrying out supplementary searches for systematic reviews, in particular, forward citation searching and web searching.

Methods: Qualitative interviews were undertaken with 15 experts on searching for studies for systematic reviews (e.g. information specialists) working in health and social care research settings. Interviews were undertaken by video-call between September 2020 and June 2021. Data analysis used thematic network analysis.

Results: We identified three logistical challenges of using forward citation searching and web searching which were organised under the global theme of 'tension': time, team and technology. Several subthemes were identified which supported the organising themes, including allocating time, justifying time and keeping to time; reviewer expectations and contact with review teams; and access to resources and reference management.

Conclusion: Forward citation searching and web searching are logistically challenging search methods for a systematic review. An understanding of these challenges should encourage expert searchers and review teams to maintain open channels of communication, which should also facilitate improved working relationships.

KEYWORDS

grey literature; library and information professionals; research, qualitative; review, systematic; supplementary searching

BACKGROUND

The use of supplementary search methods in systematic reviews focuses on the identification of studies not retrieved by bibliographic databases (Cooper et al., 2017; Mahood et al., 2014; Papaioannou et al., 2010). Commonly used supplementary search methods include checking reference lists, forward citation searching, hand searching journals, inspecting conference proceedings, and web searching using search engines and websites (Booth et al., 2020; Briscoe, Bethel, & Rogers, 2020; Briscoe, Nunns, & Shaw, 2020; Page et al., 2016). In some systematic reviews, especially those with diffuse bodies of evidence, supplementary search methods are akin to 'complementary' methods which have an equally important role to bibliographic databases in study identification (Booth et al., 2018; Cooper et al., 2018). In these scenarios, the ability of supplementary search methods to identify studies outside of commercially published journals, or to use non-text-based approaches to searching (such as citation links), can make supplementary searches more than usually effective at identifying relevant studies. The term complementary is used as an indicator of the increased value of these search methods relative to bibliographic databases for some topics or types of systematic review (Booth et al., 2018; Cooper et al., 2018).

Supplementary search methods pose both technical and logistical challenges to expert searchers on systematic review teams (typically, health librarians or information specialists). The technical challenges concern the step-by-step processes which are used to conduct and report searching, particularly with a view to ensuring that searching and reporting is systematic and transparent (Briscoe, 2018; Briscoe, Bethel, & Rogers, 2020; Cooper et al., 2017; Mahood et al., 2014; Rader et al., 2014; Stansfield et al., 2016). Logistical challenges concern how to integrate these additional search methods into the workflow of systematic reviews in such a way that is manageable for the review team (Cooper et al., 2017; Levay et al., 2016). Thus, whereas the technical challenges concern factors which are 'internal' to searching conduct, such as how to select and combine search terms, logistical challenges concern factors which are 'external' to searching, such as resource constraints.

The technical challenges of supplementary searching are discussed in an expanding literature base (Cooper et al., 2017) which forms the basis of detailed guidance (Booth et al., 2018; Centre for Reviews and Dissemination, 2008; Kugley et al., 2017; Lefebvre et al., 2019a, 2019b; Rethlefsen et al., 2021). The logistical challenges of supplementary searching are discussed by relatively few studies to date, and these discussions are typically limited to measurement of time requirements (Cooper et al., 2017) and challenges relating to reference management (Godin et al., 2015; Levay et al., 2016; Stansfield et al., 2016). These are also typically case studies (Cooper et al., 2018; Mahood et al., 2014; Papaioannou et al., 2010; Stansfield et al., 2014) or expert commentaries (Stansfield et al., 2016). What is missing from these studies is in-depth exploration of expert searchers' experiences of the logistical challenges of supplementary searching using qualitative methods. This would facilitate a more nuanced understanding of these challenges, taking into account the lived experiences of expert searchers in their naturalistic settings (Green & Thorogood, 2009). Forward citation searching and web searching are useful supplementary search methods to consider in this context, as they are commonly used in both aggregative reviews, which aim to search for studies exhaustively using all available methods (Lefebvre et al., 2019b), and configurative reviews, which use search methods more selectively to achieve the required sampling approach (Booth, 2016; Booth et al., 2013). Further detail on forward citation searching and web searching is provided in Table 1.

Key Messages

- Logistical challenges of supplementary searching included time, team and technology.
- Challenges of searching could lead to tension in the review team.
- Communication within the review team is important for addressing these challenges.

AIM AND OBJECTIVE

This study aimed to understand the perspectives of expert searchers on the main logistical challenges when carrying out supplementary searches, in particular, forward citation searching and web searching. To this end, our objective was to undertake a qualitative study of expert searchers' perspectives on the logistical challenges of using forward citation searching and web searching. The findings of this study will form part of a larger study on how expert searchers develop and carry out supplementary searches for systematic reviews (Briscoe et al., 2022).

METHODS

Ethics approval

Ethics approval was obtained from the University of Exeter College of Medicine and Health Research Ethics Committee (project reference number: Jul20/D/250; date of approval: 1 July 2020). All participants returned written consent forms.

TABLE 1 Description and purpose of forward citation searching and web searching

Search method	Description	Purpose
Forward citation searching	Forward citation searching uses a citation index to identify studies which cite a 'source' study. Commonly used citation indexes include the Science Citation Index, Scopus and Google Scholar. Forward citation searching works on the assumption that studies which cite a study are likely to have similar content, thus the search method is commonly carried out on studies which meet the inclusion criteria for a systematic review.	Due to forward citation searching using links between studies rather than pre-identified search terms, forward citation searching is particularly useful for topics where it is difficult to identify an exhaustive set of search terms.
Web searching	Web searching involves searching websites and search engines which have multiple purposes other than hosting and retrieval of studies. This includes the websites of organisations which are topically relevant to a systematic review, such as charity and government websites, and general search engines, such as Google Search.	Web searching is often used to identify grey literature which is not indexed by bibliographic databases, but it can also be used to identify published studies.

Recruitment of participants

Participants were required to have at least 2 years' experience of searching for studies for systematic reviews, including using forward citation searching or web searching in this context. Recruitment used a purposive sampling strategy that aimed to recruit participants from a variety of settings with experience of both aggregative and configurative reviews. Potential participants were approached by email. The majority of people we approached were information specialists, although not everyone had this role title as there is variation in how the expert searcher role for systematic reviews is described.

Data collection

We undertook qualitative semi-structured interviews with 15 expert searchers working in health and social care research settings between September 2020 and June 2021 (see Appendix 1 for interview schedule). All interviews were undertaken using video-calling software by SB (either MS Teams or Zoom depending on the participants' preferences) and were between 45 and 70 min in duration. The video-calling software was used to record the interviews which were then transcribed by a professional transcription service.

Data analysis

Data analysis followed Attride-Stirling's approach to thematic network analysis (2001). We started by coding key words or phrases in the interview transcripts which referred to logistical challenges when using forward citation searching or web searching. Our definition of 'logistical' followed the *Cambridge Dictionary* as 'relating to the careful organization of a complex activity' (Cambridge Dictionary, 2022). In this respect our coding was based on pre-established criteria rather than data-driven, that is we approached the data with specific interests in mind (Attride-Stirling, 2001). The initial codes were collated into themes which were reviewed against the coded extracts. Once we were satisfied that these 'basic themes' sufficiently represented the logistical challenges described in the interview transcripts we arranged them into networks grouped around 'organising themes' (Attride-Stirling, 2001). The organising themes were then grouped around an identified 'global theme' supported by the basic and organising themes (Attride-Stirling, 2001). Following Attride-Stirling's (2001) appropriation of Toulmin's argumentation theory (1959), the global theme was conceptualised as a conclusion which was based on the data in the basic themes and warranted by the organising themes. Finally, we described and explored the thematic network through writing up the findings (Attride-Stirling, 2001). Supporting quotations from the interviews were tabulated and extracts from these quotations were included in a narrative summary of our findings. Coding was undertaken by SB and discussed with GJMT and RA as the thematic network was developed.

RESULTS

Participants' characteristics

Twenty-eight people were approached of which 15 with relevant experience agreed to be interviewed. The participants'

characteristics are summarised in Table 2. All participants had experience of web searching and 14 had experience of forward citation searching.

Description and exploration of thematic networks

We identified three organising themes which relate to logistical challenges when searching for studies for systematic reviews using forward citation searching and web searching: *time*; *team*; and *technology*. These were grouped around the global theme of *tension*. Figure 1 shows the complete network of identified themes. Supporting quotations are presented in Table 3. In the remainder of this section, we narratively summarise the identified themes.

TABLE 2 Participants' characteristics

Characteristics	*n* (%)[a]
Gender	
Female	13 (86.7)
Male	2 (13.3)
Years of experience	
Mean (SD)	15.5 (SD 5.99)
Median (range)	14.0 (range 5.5–28.0)
Role titles	
Information specialist	10 (66.7)
Senior information specialist	2 (13.3)
Research fellow	1 (6.7)
Senior research fellow	1 (6.7)
Realist reviewer	1 (6.7)
Employment settings	
Charity	1 (6.7)
Government body	4 (26.7)
Independent consultant	1 (6.7)
Research consultancy	1 (6.7)
University	8 (53.3)
Main research fields	
Health care	6 (40.0)
Health and social care	8 (53.3)
Health services research	1 (6.7)
Countries of residence	
Canada	2 (13.3)
Germany	1 (6.7)
UK	12 (80.0)

[a]*n* (%) unless otherwise indicated.

Time

The participants described logistical challenges that related to the time required to carry out and screen the results of searches. Neither forward citation searching nor web searching was considered particularly difficult to carry out, but the resource needs for both were thought hard to estimate, making it challenging to subsequently contain searching and screening within the estimated timeframe. This was particularly challenging within the highly structured workflow of a systematic review, in which tasks require completion within a strict timescale to meet a funding or client deadline.

Allocating time

Participants noted that allocating sufficient time was a challenge due to the unknown quantity of studies that might be identified by searches and the screening labour that this created. This was particularly challenging for forward citation searching as this was often carried out using studies identified by bibliographic databases, the number of which was unknown when allocating time: 'If it's in the protocol you say that it will be the included studies on the expectation that it's not going to be too many [...] [but] you don't know what is going to happen in practice' (B, forward citation searching [hereafter, FCS]). A large number of included studies could correspond with a high number of citing studies to screen; and individual studies could be cited many hundreds of times. Participants also reported that either search method could return zero or relatively low numbers of studies to screen. Web searching presented additional challenges when allocating time due to the possibility of encountering many different websites on which the searcher would need to orientate themselves: 'If you encounter a website [...] for the first time, it does take you some time to orientate yourself and see what search methods are possible' (E, web searching [hereafter, WS]). This was complicated further by the basic search interfaces of web resources which made extensive searching time consuming. One participant reported that, on average, forward citation searching retrieved around 30 citing studies per study, which could be reliably used as a 'rule of thumb' for estimating the amount of time required for screening. However, allocating sufficient time still required knowing how many studies would be identified on which to carry out forward citation searching.

Justifying time

Some participants felt a burden to make a convincing case for the value of supplementary searches for clients and review teams. This was particularly the case for those in consultancy or government settings where there was a

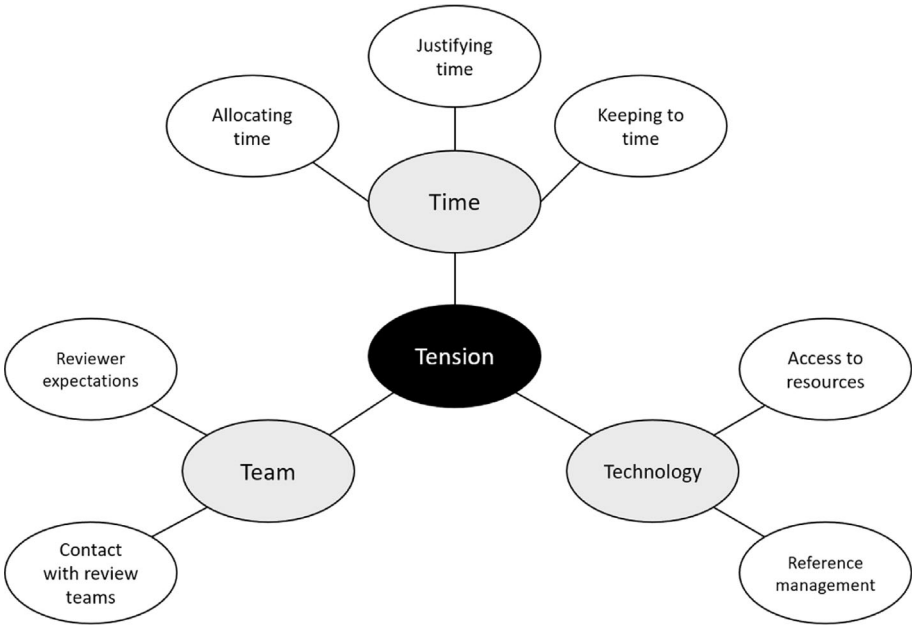

FIGURE 1 Thematic network of logistical challenges of forward citation searching and web searching

strong sense of the cost implications of supplementary searching, in terms of labour time required. If they failed to make a convincing case, even if time could be feasibly allocated and searching was manageable, the participants noted that searching might not be undertaken: 'When we start talking about websites, they're [i.e. the review team] like, "Why do I want websites? What on earth would I need those for? Just like complicating things with a load of evidence I'm never going to include"' (G, WS).

Keeping to time

Once supplementary searching was underway, the participants noted that unexpectedly high numbers of results could be challenging to manage and screen. Participants described how sometimes the planned approach to searching needed to change for this reason, despite what might be written into a protocol. When forward citation searching, this could mean reducing the source studies (i.e. those on which citation searching is carried out) from all included studies to 'key' studies, or selecting just one citation index rather than using multiple citation indexes. When web searching, participants described prioritising the most promising websites rather than searching a long list of sources, and limiting the screening process to the first several pages of results when using a search engine. The participants also described how they would become involved in screening for potentially relevant studies from the results of searches if the number of results was particularly high, thus dividing the screening labour between themselves and the review team: 'It just depends on the volume. Most screening teams are pretty exhausted by this time, so they elect for me to do a little bit of extra screening on their behalf' (N, FCS). Relatedly, manually adding references identified by web searching to reference management software was considered challenging within the available time (see also Reference Management section).

Team

Systematic reviews are undertaken by a team of researchers. The participants described challenges of managing the expectations of review teams with respect to the work involved in supplementary searching, and maintaining contact with a review team to ensure that supplementary searching was carried out as planned.

Reviewer expectations

Forward citation searching and web searching were sometimes undertaken when a review had progressed considerably beyond the initial bibliographic database searches and other review tasks were underway. Despite what might be written into a protocol, the participants described how a review team's immersion in other tasks could reduce their interest in additional screening generated by supplementary searching, or indeed their interest in identifying additional relevant studies. Participants also described how reviewers sometimes had low expectations of the value of supplementary searching. In these scenarios, the participants described how reviewers could

TABLE 3 Supporting quotations for thematic network

Global theme	Organising themes	Basic themes	Supporting quotations[a]
Tension	Time	Allocating time	If it's in the protocol you say that it will be the included studies on the expectation that it's not going to be too many [...] [but] you don't know what is going to happen in practice. (B, FCS)
			The main challenge [is] that it's time consuming, because you really have to consider different types of website, and I would say if you encounter a website [...] for the first time, it does take you some time to orientate yourself and see what search methods are possible. If they do have a search interface, how does it work? Can I use operators? Can't I? (E, WS)
			I have rules of thumb for how many references I'm going to get when I do citation searching on Web Science and it always works... well, it works out 30 articles per input article in both directions. So 30 forward citations, 30 backward citations. And I'm kind of basing my timings and what I do on, okay, if I input 30 articles I'm going to get 900 forward citations and 900 back. And it's not literally 30 every time. Some you get an absolute whale where it's 500 and sometimes you get like zero forever. But it seems to work out overall. (M, FCS)
		Justifying time	If we're going to do it it's because I've proposed it to the team and told them this is something they need to do. So I kind of have to be prepared to make that argument. So I think that's a bit of a challenge because you're always operating from a point of basically, you're requesting more time and more money to do this. (N, FCS)
			When we start talking about websites, they're [i.e. the review team] like, 'Why do I want websites? What on earth would I need those for? Just like complicating things with a load of evidence I'm never going to include.' (G, WS)
		Keeping to time	If you've got [...] a key paper that was written 20 years ago and has been highly cited, that's a real challenge to then go through all those citations and decide if [...] you haven't seen some of them before, whether they're relevant or not. So [...] it can be quite a substantial amount of work depending on the age of the papers you're looking for citations for. (C, FCS)
			Sometimes people say well, let's ... 'let's do a citation search' and I think they're assuming that we're not going to find that many hits [...] And they're quite surprised sometimes when we find hundreds or thousands of studies ... and then we've got to kind of go back and re-think the whole thing again. (D, FCS)
			I could either give them everything that had cited their study, or I could pick to create records for those records that I saw were relevant to the review. And it just depends on the volume. Most screening teams are pretty exhausted by this time, so they elect for me to do a little bit of extra screening on their behalf. (N, FCS)
	Team	Reviewer expectations	If I need to add 100 results [to reference management software] manually, that's pretty tedious, time-consuming task at the end, whereas what's quicker is if I just put stuff into a Word document, copy and paste the title and a summary in the link, and send them the Word document. But what that does is the reviewer says, 'I've got 5,000 results in EPPI, what's this Word file? I can't be bothered looking at that. I'll just do what's in EPPI.' (G, WS)
			inevitably the reviewers have moved on, and their deadlines are, you know, data extraction and everything. So I'm kind of conscious that if I leave it too late and I'm sending them more stuff it's not ideal for them. (H, WS)
			I think the citation searching can happen at a time where they think they've basically finished [...] [I]t's almost like an equivalent of an update search that they're doing [...] and [they] don't necessarily maybe want to find anything else ... [laughs] ... thank you very much. (K, FCS)
		Contact with review teams	I support some teams where [...] I don't really see it [i.e. the systematic review] much at all after the [bibliographic database] search until perhaps the write up and discover that they've ... they've gone off-piste, [...] they've done some extra things

TABLE 3 (Continued)

Global theme	Organising themes	Basic themes	Supporting quotations[a]
			and they've done some citation searching in a certain way and [...] the level of control is different sometimes. (B, FCS)
			I think sometimes when you've done the [bibliographic database] search and you send it off, if you don't have any further involvement, it's difficult to kind of keep track of what stage your review is at sometimes [...] Um, so the main challenge for me is having the agreement that it's going to be done... and who's going to do it. Because I think I've been neglectful in the past about maybe that I've not been clear. (K, FCS)
			A worst case scenario I've had has been [...] we've written [in the protocol] that we're going to do some citation searching and I've literally had an email from someone saying, um, "you know, you're a co-author, we're submitting this". And I've looked at it and thought, well ... [laughs] ... you know, apart from ... handing the [bibliographic database] search over, I've had no further involvement in this review. And I've said, "well, you know, did you do the citation searching?" They're like, "Oh, we did that" [...] It's almost my fault I think sometimes, for taking on too many reviews. Um, sometimes a review gets away from you. (K, FCS)
	Technology	Access to resources	When I was still working at [organisation name] I would be able to access Web of Science and Scopus, so I would usually search Web of Science. But now I don't have access to those resources so I'm searching Google Scholar and using other [...] tools like Publish or Perish to search Google Scholar and Microsoft Academic. (C, FCS)
			You can do it with Google Scholar. You can do it with Web Science. Now you can do it with Citation Chaser and Microsoft Academic. Time is a big factor and access to those databases. And even understanding coverage of like what's Web Science got in it? It's how does it overlap with PubMed? [...] There are so many things that you just don't know, and you can investigate all these questions but you'd never get anything done. (M, FCS)
		Reference management	I kind of copied and pasted everything into a Word document, using quite a few different macros and [...] kind of got it into a format which ... which is a RIS format and then import it to EndNote. So I do do that, I can do that; when I try and get my other information specialists to do that they go into a bit of a blind panic as if it's some sort of magic I'm wielding. But it's ... it's ... yeah, it's possible to do and if you've got a big enough ... big enough website full of records of information that you want that's going to take a huge time just to screen through then I think it's ... it's worth going through that process of ... of trying to create a RIS file out of it. (D, WS)
			A lot of manual downloading of references or even typing them into Endnote is necessary, and this is really a nuisance, I have to say. (E, WS)
			Challenges? Getting the results out in a way that is useful for the reviewers to be able to assess them. Very often we just cut and paste them into a Word document, and it's just hard to manage and then... then we think, 'should they be put into Endnote so all our records are together?', but then that requires a lot of research assistant time to input all the records in [...]. So we have that issue, the kind of logistics of managing them. (O, WS)

Abbreviations: FCS, forward citation searching; WS, web searching.

[a]Quotations are attributed to participants using anonymous alphabetical identifiers from A to O and labelled FCS or WS as relating to forward citation searching or web searching respectively.

be dismissive of supplementary searches, even if time had been allocated, or interpreted additional searching as more akin to 'update' searching (particularly, forward citation searching) which was non-essential:

> I think the citation searching can happen at a time where they [i.e. the review team] think they've basically finished [...] [I]t's almost like an equivalent of an update search

> that they're doing [...] and [they] don't necessarily maybe want to find anything else ... [laughs] ... thank you very much. (K, FCS)

Contact with review teams

Sometimes the participants were not in regular contact with the review teams they supported. For example, if they were working remotely (as was particularly apparent during the COVID19 pandemic, when the interviews for this study were undertaken), or if they were working with several different teams concurrently at different stages of the systematic review process. This could make it challenging to keep abreast of developments in a systematic review, which sometimes meant 'losing control' of the searching process:

> I think sometimes when you've done the [bibliographic database] search and you send it off, if you don't have any further involvement, it's difficult to kind of keep track of what stage your review is at sometimes [...] Um, so the main challenge for me is having the agreement that it's going to be done ... and who's going to do it. (K, FCS)

Some participants reported discovering that reviewer colleagues had carried out searches themselves, which could lead to substandard quality of work and a lack of clarity in the reporting of the methods. This meant that the participants' role in searching was reduced to 'signing off' on substandard work or without being sure of what had been done.

Technology

The participants described how the technology used for forward citation searching and web searching presented logistical challenges. Challenges centred around access to resources, particularly subscription-based citation indexes, and management of studies identified.

Access to resources

Participants described using several different citation indexes, but not all citation indexes were available to all participants. Specifically, Scopus and Web of Science, which are subscription-based, were only available to participants who worked at institutions where access was provided. In some cases, participants had previously worked at institutions where one or both of these were available, and then moved on to settings where they were not. This meant using alternatives, such as Google Scholar and Microsoft Academic, and participants also described using newer technological developments such as Citation Gecko (https://www.citationgecko.com/) and Citationchaser (https://estech.shinyapps.io/citationchaser/) (Haddaway et al., 2021). Limited access to citation indexes was challenging for participants, particularly as the functionality of freely available citation indexes was sometimes more limited than the subscription-based options, and could be more time consuming to use. In particular, Google Scholar was reported as having relatively basic features for exporting to reference management software and did not include abstracts. Participants also described challenges of knowing how to choose between resources, finding it difficult to know how citation coverage compared between resources.

Reference management

Participants described how web-based resources, including search engines and websites, and also web-based citation indexes, typically had limited – if any – export features. This meant that reference management when searching these resources was challenging. Typically, the participants described manually copying references out of web-based resources into Word documents. Sometimes they added references to reference manager software manually, but this was noted as particularly time consuming: 'A lot of manual downloading of references or even typing them into Endnote is necessary, and this is really a nuisance, I have to say' (E, WS). Using a Word document was faster than adding to reference management software, but some participants reported that review teams preferred to have all references in one library, and indeed could be reluctant to screen results in other formats. One participant described copying web search results into a Word document and using macros to create a file which could be imported as a RIS document into reference management software. They noted that other information specialists in their team did not have the skills to do this: 'When I try and get my other information specialists to do that they go into a bit of a blind panic as if it's some sort of magic I'm wielding' (D, WS).

Tension

The participants described how the logistical challenges of time, team and technology sometimes created tension between the expert searcher and the wider review team. Tension was typically evident through a sense of exasperation amongst the participants, for example, at trying to convince review teams to reserve time for supplementary searching or trying to ensure that searches were carried out to the required standard. The participants perceived

that dismissive attitudes or resistance to the search methods amongst review teams was based on several different factors which we describe in the basic themes. These included uncertainty about the value of searching, the use of relatively low-tech approaches such as reading through Word documents, and immersion in other tasks when supplementary searching was carried out. On other occasions, the participants reported not being consulted about how to carry out a search method, which led to substandard searching and reporting which searchers were reluctant to accept but had no or limited opportunity to rectify:

> I support some teams where [...] I don't really see it [i.e. the systematic review] much at all after the [bibliographic database] search until perhaps the write up and discover that they've ... they've gone off-piste, [...] they've done some extra things and they've done some citation searching in a certain way and [...] the level of control is different sometimes. (B, FCS)

DISCUSSION

This study identified three logistical challenges and one 'global' theme when carrying out forward citation searching and web searching for systematic reviews: time, team, technology (logistical challenges) and tension (global theme) (Attride-Stirling, 2001). The findings contribute to existing literature on the logistical challenges of using these search methods by developing a more nuanced account, based on expert searchers' experiences in their naturalistic settings (Green & Thorogood, 2009). The main focus in studies to date is time, which is reported as a quantitative measure of how long searches take to carry out (Eysenbach et al., 2001; Godin et al., 2015; Levay et al., 2016; Papaioannou et al., 2010; Wright et al., 2014). Levay et al.'s (2016) study of forward citation searching also reported the cost of searches based on the time taken. Cooper et al. (2017) reviewed case studies which describe and evaluate a wider selection of supplementary search methods, including contacting authors, forward citation searching, hand-searching, searching trials registries, and web searching. In addition to studies of forward citation searching and web searching, Cooper et al. (2017) found that studies of hand-searching also reported the time taken to perform. The use of qualitative methods in the present study has facilitated exploration of different dimensions of the logistical challenge of time, including allocating time, justifying time and keeping within time. Furthermore, the findings show the limited value of reporting time on a case-by-case basis for prospective planning, in view of variables which are unknown when allocating time such as number of studies used for forward citation searching, and variability of search interfaces and functionality for managing references when web searching.

The use of a qualitative approach also enabled a more adept exploration of the dimension of team working, which to date is little explored. The importance of logistical planning for web searching is discussed by Stansfield et al. (2016), including the value of allocating someone with the required expertise to the task. The findings of the present study add weight to this finding, particularly in view of the challenge of maintaining contact with review teams to ensure that searches are carried out to the required standard. The present study also extends this finding by drawing attention to expert searchers' perception that their reviewer colleagues sometimes dismiss forward citation searching and web searching as relatively unimportant. This meant that expert searchers were additionally concerned that left to their reviewer colleagues these search methods would not be undertaken with due care and attention. A small number of studies which explore team working between expert searchers and reviewers more widely, that is not limited to supplementary searching, support this finding on the importance of communication (Nicholson et al., 2017; O'Dwyer & Wafford, 2021). One such study reports survey data on 'interpersonal challenges' arising between library-based expert searchers and review teams (Nicholson et al., 2017). This identified managing reviewer expectations of time and effort required for reviewing tasks, and keeping in touch with review teams after initial searches are completed, as frequently reported challenges (Nicholson et al., 2017). Commentary on how expert searchers work with review teams notes the challenge of 'resistance [from researchers] to including grey literature', which in part manifests itself as reluctance to carry out web searching (O'Dwyer & Wafford, 2021). Studies also report the technical challenge of managing references, both from web searching (Godin et al., 2015; Stansfield et al., 2016) and when using web-based citation indexes (Levay et al., 2016).

The present study further extends the insights of existing literature through the identification of the global theme of tension using thematic network analysis (Attride-Stirling, 2001). We suggest that the interconnectedness of the organising themes via the global theme indicates that addressing challenges in one part of the network might have benefits across the network, perhaps noticeable through reduced tension in the working relationships of expert searchers and reviewers. What is less clear is how to address the challenges, particularly those challenges that are outside of the review teams' control (such as time and technology). However, we suggest that

improved communication and closer working-relationships between expert searchers and review teams might help to address team-based challenges. This could include allocating people to specific tasks and ongoing communication about when tasks should be completed, and a shared awareness of technological limitations, and of uncertainties of time required to carry out searching and screening tasks. These measures are supported by Wafford and O'Dwyer's 'toolkit' for facilitating collaborative working between expert searchers and researchers, which recommends establishing regular communication throughout the review process (2021). Similarly, survey data on interpersonal challenges experienced by expert searchers who support systematic reviews found that clear and frequent communication with reviewers, and clarification of roles, were the most frequently used strategies for addressing these challenges (Nicholson et al., 2017). There is also the potential for challenges posed by technology, such as limited access to resources and basic export features, to be addressed through technological development. For example, technological advances in web searching, such as web-scraping software (Haddaway, 2015) and automated citation searching tools (Haddaway et al., 2021) might alleviate some of the challenges we describe by making processes faster.

Strengths and limitations

This is the first qualitative study to explore logistical challenges of supplementary searching for systematic reviews. The sample of participants included a diverse selection of expert searchers with a wide range of experience, and the use of thematic network analysis was helpful in showing how the data we collected coalesced around the global theme of tension (Attride-Stirling, 2001). The data was limited on solutions to challenges, but the identified importance of communication appears to be a valid inference from the data and supported by existing studies (Nicholson et al., 2017; O'Dwyer & Wafford, 2021; Stansfield et al., 2016; Wafford & O'Dwyer, 2021). We suggest that future research on how to mitigate the logistical challenges of supplementary searching could usefully focus on technological solutions, such as web-scrapping software (Haddaway, 2015) and automated citation tools (Haddaway et al., 2021). Given the importance of team work and communication, it might also be helpful to undertake evaluation studies on how systematic review teams work together.

CONCLUSION

Forward citation searching and web searching are logistically challenging components of a systematic review. An understanding of these challenges should encourage expert searchers and review teams to maintain good communication between each other, which should also facilitate improved working relationships. Furthermore, this could improve the quality of searches if expert searchers subsequently have more opportunities to carry out searches at latter stages of reviews.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

Data are available on request from the authors.

ORCID

Simon Briscoe https://orcid.org/0000-0002-6982-4521

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AUTHOR BIOGRAPHIES

Simon Briscoe is a research fellow at the University of Exeter Medical School and has over 10 years' experience of searching for studies for systematic reviews.

Rebecca Abbott is a senior research fellow at the University of Exeter Medical School with expertise in evidence synthesis.

G. J. Melendez-Torres is a professor of Social and Clinical Epidemiology at the University of Exeter Medical School and director of the Peninsula Technology Assessment Group.

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APPENDIX 1

INTERVIEW SCHEDULE

Forward citation searching questions

Topic	Guiding questions	Follow up questions
Initial decision	How do you decide whether to carry out forwards citation searching for a systematic review?	Are there particular types of review or review topics that influence your decision? What do you hope that forward citation searching will add to a review? What is the value of forward citation searching?
Approaches to conduct	How do you decide what approach to take to forwards citation searching?	What factors influence your approach? What are some of the approaches that you might take? Snowballing? Iterative citation searching? How do you decide which resources to use? How do you ensure that your approach is systematic, if at all?
Challenges	What are the main challenges that you face when conducting forwards citation searching?	Does the technology you use pose any specific challenges? How do you approach the practical issue of time and resource constraints?

Web searching questions

Topic	Guiding questions	Follow up questions
Initial decision	How do you decide whether to carry out web searching for a systematic review?	Are there particular types of review or review topics that influence your decision? What do you hope that web searching will add to a review? What is the value of web searching?
Approaches to conduct	How do you decide what approach to take to web searching?	What factors influence your approach? What are some of the approaches that you might take? How do you decide which resources to use? How do you ensure that your approach is systematic, if at all?
Challenges	What are the main challenges that you face when conducting web searching?	Does the technology you use pose any specific challenges? How do you approach the practical issue of time and resource constraints?

Chapter 11. Article 9

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RESEARCH ARTICLE

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Feasibility and desirability of screening search results from Google Search exhaustively for systematic reviews: A cross-case analysis

Simon Briscoe | **Rebeca Abbott** | **Hassanat Lawal** | **Liz Shaw** | **Jo Thompson Coon**

University of Exeter Medical School, University of Exeter, UK

Correspondence
Simon Briscoe, University of Exeter Medical School, University of Exeter, UK.
Email: s.briscoe@exeter.ac.uk

Abstract

A commonly reported challenge of using Google Search to identify studies for a systematic review is the high number of results retrieved. Thus, 'stopping rules' are applied when screening, such as screening only the first 100 results. However, recent evidence shows that Google Search estimates a much higher number of results than the viewable number, raising the possibility of exhaustive screening. This study aimed to provide further evidence on the feasibility of screening search results from Google Search exhaustively, and to assess the desirability of this in terms of identifying studies for a systematic review. We conducted a cross-case analysis of the search results of eight Google Search searches from two systematic reviews. Feasibility of exhaustive screening was ascertained by calculating the viewable number of results. Desirability was ascertained according to: (1) the distribution of studies within the results, irrespective of relevance to a systematic review; (2) the distribution of studies which met the inclusion criteria for the two systematic reviews. The estimated number of results across the eight searches ranged from 342,000 to 72,300,000. The viewable number ranged from 272 to 364. Across the eight searches the distribution of studies was highest in the first 100 results. However, the lowest ranking relevant studies were ranked 227th and 215th for the two systematic reviews. One study per review was identified uniquely from searching Google Search, both within the first 100 results. The findings suggest it is feasible and desirable to screen Google Search results more extensively than commonly reported.

KEYWORDS

information science, literature searching, systematic reviews, world wide web

What is already known

The extensiveness of information which can be found on the web makes search engines such as Google Search valuable resources for identifying studies for systematic reviews. The reported number of results which are retrieved by Google Search

is typically prohibitive to screen in full, thus 'stopping rules' are applied, such as limiting the screening process to the first 100 results. However, a recent study found that the number of estimated results in Google Search is much higher than the viewable number of results, thus raising the possibility of screening the results exhaustively.

What is new

This study contributes further evidence on the feasibility of screening Google Search results exhaustively, demonstrating that the viewable number of results is typically in the low hundreds rather than the hundreds of thousands or millions which are estimated by the search engine. The study also found that screening a higher proportion of the results is potentially useful for identifying relevant studies for inclusion in systematic reviews.

Potential impact for *research synthesis methods* readers outside the authors' field

Systematic reviews may benefit from more extensive screening of Google Search results than commonly carried out if this leads to the identification of additional relevant studies for inclusion in analyses.

1 | BACKGROUND

Searches for studies for inclusion in systematic reviews typically use a variety of different resources. Bibliographic databases are usually the main source of studies, with 'supplementary' sources used alongside to identify additional studies not retrieved by bibliographic databases.[1,2] One such supplementary resource are search engines such as Google Search (www.google.com), which are a gateway to a vast amount of content on the World Wide Web (hereafter, web). Several case studies report the value of using Google Search or another search engine in a systematic review, measured in terms of 'uniquely' identified relevant studies, i.e. studies which meet the inclusion criteria for a systematic review and which are not identified by other search methods.[3–5] Despite this, search engines have been contested as valid sources of studies for systematic reviews.[6] This is mainly due to how search engines retrieve and rank results using hidden algorithms which take into account a user's search history and geographical location.[6,7] However, in view of the potential for finding relevant studies uniquely, systematic review guidance on searching for studies recommends their use as supplementary to bibliographic databases and other search methods.[1,8]

The extensiveness of information which can be found on the web makes search engines valuable resources for identifying studies, but this also poses challenges. One such challenge is that Google Search often estimates very high numbers of search results, numbering in the hundreds of thousands or more, which would be impractical to screen exhaustively.[5,9] Thus, systematic reviewers typically use 'stopping-rules' which rely on Google Search's algorithms for ranking search results according to relevance to a search query.[10] Stopping-rules for web searching involve limiting the search results to either a pre-specified number of results (e.g. the first 100) or screening the results until one or two pages of results are inspected without identifying any relevant content.[5,11,12]

However, a recent study by Briscoe and Rogers showed that the number of estimated results in Google Search is sometimes far in excess of the viewable number, thus raising the possibility of screening the results exhaustively.[13] In summary, Briscoe and Rogers showed that the mean number of viewable results for three Google Search searches was 463, in contrast to the mean number of estimated results reported by the search engine of 569,454,000.[13] The viewable number of results was calculated by setting Google Search to display 100 results per page and scrolling to the final page of results.[13] Despite this finding, it is not clear whether exhaustive screening is desirable, particularly in view of Google Search's PageRank algorithm which ranks content according to relevance, which might make screening the results in full unprofitable (in terms of the identification of studies) even if feasible.[14]

1.1 | Aims and objectives

This study had two main aims:

1. To provide further evidence on the *feasibility* of exhaustively screening the results retrieved by Google Search.
2. To assess the *desirability* of screening the results exhaustively, measured in terms of the likelihood of identifying studies for a systematic review.

The second aim was assessed in two stages:

i. the distribution of journal articles and grey literature within the results of Google Search searches, irrespective of relevance to a particular systematic review question, and
ii. the distribution of journal articles and grey literature within the results which met the inclusion criteria for two pre-specified systematic review questions, including specifically journal articles and grey literature which were uniquely identified by Google Search.

The purpose of the first stage of the second aim was to ascertain whether studies in general are distributed evenly throughout the results or whether they are grouped within a specific section of results. This was undertaken in view of how Google Search indexes all web-crawler accessible content on the web, which makes it helpful to know whether studies are more or less likely to be identified throughout the results. The purpose of the second stage was to narrow this focus to the identification of studies for systematic reviews which the searches were intended to resource.

We achieved this by analysing Google Search results from two reviews which included a systematic search for studies: (1) a scoping review of qualitative studies on the perspectives of primary care clinicians on interacting with women patients with gynaecological conditions or symptoms suggestive of gynaecological conditions (hereafter, the Women's Health review);[15] (2) an umbrella review of effectiveness and cost-effectiveness systematic reviews which evaluate multi-disciplinary occupational health interventions that aim to help people return to work (hereafter, the Occupational Health review).[16] Searches for studies for both reviews used a variety of search methods, including bibliographic database searches, checking reference lists, forward citation searching, and web searching using the UK version of Google Search (www.google.co.uk).

2 | METHODS

2.1 | Data collection

For the Women's Health review, we carried out six searches for studies using Google Search on 3rd November 2021. This included five searches which aimed to identify qualitative studies relating to specific gynaecological conditions or symptoms included in the review (namely, endometriosis, menopause, menstrual disorders, polycystic ovary syndrome and chronic pelvic pain), and one search which aimed to identify studies relating to gynaecological conditions generically. For the Occupational Health review, we carried out two searches for studies using Google Search on 6th July 2021. This included one search which aimed to identify systematic reviews of multidisciplinary return to work interventions and one search which aimed to identify systematic reviews of multidisciplinary vocational rehabilitation interventions. However, because we did not document the results of the Occupational Health Google Search searches in sufficient detail for the present study, we re-ran the searches on 14th June 2022.

The search strings were constructed prior to the commencement of the two reviews, using an iterative process which attempted to adapt the complex searches used in the bibliographic databases for the more basic search interface of Google Search. This involved experimentation with different search terms, and ascertaining that the search operators worked as expected. The resulting search terms and basic structure of the searches reflected the bibliographic database searches for each systematic review, albeit in a simplified format which was appropriate for Google Search.[15,16] Ascertaining that the search operators worked as expected included: checking that the Boolean operator 'OR' retrieved the various terms that we had specified; checking that the use of quotation marks retrieved the specified phrases; and checking that at least one term from each set of terms within parentheses were retrieved in the search results. We did not use the AND Boolean operator as this is automatically applied in between search terms if OR is not specified.[17] All the operators we used are included on the Google Search help page except for parentheses.[18] There is discrepancy in unofficial guidance on whether parentheses are supported by Google Search.[11] However, there is consensus that the OR Boolean operator is prioritised over AND in the order of execution, and in all eight searches parentheses were used solely to group search terms which were combined with OR.[17] Thus, the logic of the search strings was the same whether or not the parentheses were functioning. We were able to confirm this by comparing the first pages of search results with and without parentheses. The full details of searches that were carried out are presented in Table 1.

In order to facilitate data analysis, we set Google Search to display 100 results per page as described in Briscoe and Rogers.[13] This involved using the slide-bar option in the 'See All Settings' submenu of the main settings menu (accessed via the 'gear cog' icon on the

TABLE 1 Google search searches for women's health review and occupational health review

	Women's health review searches
Endometriosis	endometriosis (views OR perspectives OR experiences) ("general practitioners" OR doctors OR clinicians OR nurses)
Menopause	menopause (views OR perspectives OR experiences) ("general practitioners" OR doctors OR clinicians OR nurses)
Menstrual disorders	"menstrual disorders" (views OR perspectives OR experiences) ("general practitioners" OR doctors OR clinicians OR nurses)
Polycystic ovary syndrome	polycystic (views OR perspectives OR experiences) ("general practitioners" OR doctors OR clinicians OR nurses)
Chronic pelvic pain	("pelvic pain") (women OR females) (views OR perspectives OR experiences) ("general practitioners" OR doctors OR clinicians OR nurses)
Generic search	(gynaecological OR gynaecological) (views OR perspectives OR experiences) ("general practitioners" OR doctors OR clinicians OR nurses)
	Occupational health review searches
Return to work	"return to work" ("multi-disciplinary" OR multidisciplinary) (report OR review)
Vocational rehabilitation	"vocational rehabilitation" ("multi-disciplinary" OR multidisciplinary) (report OR review)

Google Search homepage) to increase the results per page from the default of 10 to the maximum of 100. Prior to searching we also ensured that we were logged out of our personal Google accounts and used the option in the Search Settings page to deactivate search customisation, which stops Google from using the user's search history to personalise the ranking of search results according to their previous searches. These are recommended measures when searching for systematic reviews in order to reduce the bias associated with the personalisation of search results.[8]

2.2 | Data analysis

2.2.1 | Feasibility of exhaustive screening

The feasibility of exhaustive screening was ascertained by calculating the viewable number of results for each search. We assumed that numbers of results which were of a similar order of magnitude to the numbers reported when using a stopping-rule, for example, the first 100 results, were feasible to screen in full.[5] The viewable number was also compared with Google Search's estimated number of results. The estimated number of results was taken from underneath the search bar on the first page of results. The viewable number was calculated using the following procedure described by Briscoe and Rogers.[13] First, we selected the final page of results using the page numbers at the bottom of the page. We then selected the option to "Repeat the search with the omitted results showing", which includes search results that are similar to the initial set of results, but which Google Search initially omits to avoid potential duplication. We selected the final page of results from this more exhaustive set and manually counted the number of results on this page. Finally, we multiplied the number of results per page (i.e. 100) by the total number of pages minus one; then, added the number of results on the final page to ascertain the total viewable number of search results.

2.2.2 | Desirability of exhaustive screening

The desirability of exhaustive screening was ascertained according to two criteria:

i. the distribution of journal articles and grey literature within the results, irrespective of relevance to a particular systematic review question,
ii. the distribution of journal articles and grey literature within the results which met the inclusion criteria for our pre-specified systematic review questions, including specifically journal articles and grey literature which were uniquely identified by Google Search.

To facilitate the analysis of these criteria we first copied and pasted the results of each search into Microsoft Word documents in 'chunks' of 100 results as displayed per page. To assess the first criterion, we counted how many journal articles and grey literature publications were retrieved within each page of 100 results per search. Journal articles were counted if they were empirical studies, commentaries or opinion pieces; letters and editorials were excluded. Grey literature publications were counted if they were conference abstracts, pre-prints, reports (typically, topical reports produced by charities or government) or theses; guidance documents were excluded unless they also reported in full the study on which the guidance was based, e.g. UK NICE guidelines with accompanying systematic review.[19] This criterion broadly reflects the inclusion criteria for the types of *document* eligible for inclusion in the Women's Health and Occupational Health reviews, although unlike these two reviews we did not limit according to *study design* for the purpose of

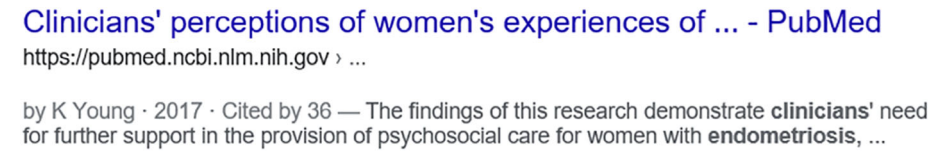

FIGURE 1 Example of Google Search result linking to study [Colour figure can be viewed at wileyonlinelibrary.com]

assessing the first criterion of our second aim. Furthermore, for a result to be counted it had to link directly to a journal article or grey literature publication, usually indicated by the publication title, author and/or the source website in the search result (for example, see Figure 1). Ambiguous links were investigated. SB counted studies per page in all eight sets of search results, documenting each type using colour coded highlighting in the Word documents. BA and HL each checked one set of search results to corroborate that they agreed with SB's decision about which results constituted published or grey literature studies.

To assess the second criterion, i.e. the distribution of journal articles and grey literature within the results which met the inclusion criteria for our pre-specified systematic review questions, we made a note of any such studies while assessing the first criterion. We only noted the *first appearance* of relevant journal articles and grey literature publications within the results, in order to ascertain how many results needed to be screened to see all relevant results. Furthermore, we extended the analysis to include links to webpages which provided 'hints' to relevant journal articles or grey literature publications which were not directly linked via the URL. For example, we documented webpages which were news items discussing ongoing or recently completed studies which on further inspection were relevant to the review question. This type of exploratory searching can be particularly valuable for identifying studies which are not retrieved by bibliographic databases. For example, recently completed studies which are not yet indexed in databases. In this respect, the analysis for the second criterion was different to the first criterion, for which the URL needed to link directly to a study. We only explored hints to studies for the second criterion because it would have been prohibitively time consuming to explore hints to any study throughout all eight sets of Google Search results. Thus, focusing on hints to potentially relevant studies provided a helpful boundary for this part of the analysis.

Due to re-running the Google Search searches for the Occupational Health review 1 year after the initial searches, we only included relevant studies in the analysis of uniquely identified studies if on inspection they were: (a) published online prior to the date of the initial searches (i.e. July 2021) and (b) would not be retrieved by bibliographic databases, due to lack of appropriate terminology in the bibliographic database search strategy or not indexed in the databases we searched.

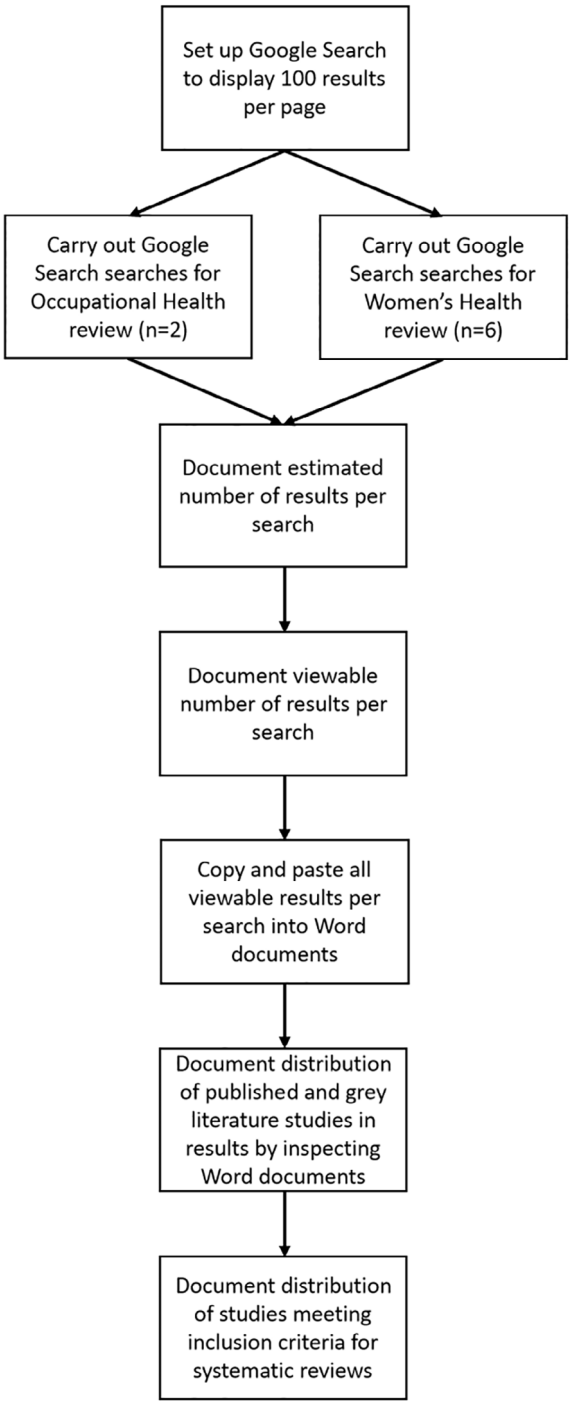

FIGURE 2 Flow diagram of processes undertaken to carry out study

The methods we used are summarised in a flow diagram in Figure 2.

TABLE 2 Estimated and viewable search results, and lowest ranking included studies

Search	Estimated results	Viewable results, (% of estimated)*	Lowest ranking included study, (rank, % needed to screen)†
Women's health review			
Endometriosis	11,100,000	364 (0.00328%)	Rowe 2021[29] (227, 62.3%)‡
Gynaecology	11,900,000	291 (0.00245%)	O'Flynn 2004[30] (106, 36.4%)
Menopause	16,800,000	358 (0.00213%)	Davis 2021[31] (8, 2.2%)
Menstrual disorders	342,000	272 (0.0795%)	O'Flynn 2004[30] (1, 0.4%)
Pelvic pain	1,350,000	325 (0.0241%)	None identified
Polycystic ovary syndrome	1,730,000	331 (0.0191%)	Arasu 2019[32] (3, 0.9%)
Mean	*9,798,667*	*324 (0.0033%)*	*69, 21.3%*
Occupational health review			
Return to work	72,300,000	332 (0.0005%)	Schaafsma 2013[19] (215, 64.8%)§
Vocational rehabilitation	337,000	319 (0.0947%)	None identified
Mean	*36,318,500*	*326 (0.0009%)*	-

*Searches repeated with omitted results showing.
†'Rank' refers to the ranking of the study within the results, e.g. Rowe 2021 was the 227th of 364 viewable results in total; '% needed to screen' refers to the percentage of the viewable results needed to screen in order to identify the lowest ranking included study.
‡Lowest ranking uniquely identified study = Bullo 2021,[22] ranking = 7 (7% needed to screen).
§Lowest ranking uniquely identified study = NICE 2019,[20] ranking = 74 (74% needed to screen).

3 | RESULTS

3.1 | Feasibility of exhaustive screening

The estimated and viewable number of results for the eight Google Search searches are shown in Table 2. The mean number of estimated results for the six searches for the Women's Health review was 9,798,667 (range 342,000-16,800,000) and the mean number of viewable results was 324 (range 272–364). The mean number of estimated results for the two searches for the Occupational Health review was 36,318,500 (range 337,000-72,300,000) and the mean number of viewable results was 326 (range 319–332). Thus, the viewable numbers of results were of a similar order of magnitude to that typically screened when using a stopping-rule in Google Search, i.e. in the low hundreds of results, albeit three times more than the 100 results commonly reported.[3,5,7] On this basis, we suggest that the viewable numbers were feasible to screen in full for these eight searches; indeed, this was the approach used for the systematic reviews to which these searches contributed.[15,16]

3.2 | Desirability of exhaustive screening

3.2.1 | Distribution of journal articles and grey literature irrespective of relevance to review questions

The distribution of journal articles, grey literature publications, and publications included in the two systematic reviews per page of results are shown in Table 3. Table 3 shows that on average the number of journal articles was highest on page one (i.e. the first 100 results), and gradually diminished throughout subsequent pages of results. Only one of eight searches did not conform to this trend, which was the 'vocational rehabilitation' search for the Occupational Health review. For this search, the number of journal articles per page was higher on page three ($n = 78$) than page one ($n = 71$). This partly explains the higher proportion of journal articles on page three of the Occupational Health review search results (61%) than in page three of the Women's Health review search results (16%). However, the 'return to work' search also retrieved proportionally more journal articles on page three (45%) than any of the Women's Health review searches. For both the Women's Health review and the Occupational Health review searches, the distribution of grey literature was more consistent across the search results than journal articles. A higher proportion of the search results were grey literature publications for the Occupational Health review searches than the Women's Health review searches (see Table 3).

3.2.2 | Distribution of journal articles and grey literature relevant to women's health or occupational health reviews

Table 3 also shows that journal articles which met the inclusion criteria for the women's health review were more likely to be identified in the first 100 results. Up to

TABLE 3 Mean number of studies per page of google search results

	Page 1 (1–100)*	Page 2 (101–200)	Page 3 (201–300)	Page 4 (301–400)
Mean, (range), %				
Women's health review				
JAP (all)	61 (32–83), 61%	45 (27–72), 45%	16 (3–23), 16%	2 (1–3), 7%
GLP (all)	1 (0–2), 1%	1 (0–3), 1%	<1 (0–2), <1%	0
JAP (includes)†	2 (0–4), 2%	<1 (0–1), <1%	<1 (0–1), <1%	0
Occupational health review				
JAP (all)	75 (71–78), 75%	64 (62–65), 64%	61 (44–78), 61%	3 (2–3), 6%
GLP (all)	14 (8–19), 14%	20 (18–21), 20%	13 (8–17), 13%	0
JAP (includes)‡	1 (0–1), 1%	1 (0–1), 1%	2 (0–2), 2%	0
GLP (includes)‡	1 (0–1), 1%	0	0	0

Abbreviation: GLP, grey literature publication; JAP, journal article publication.
*Numbers in parentheses indicate range of results displayed on each page, e.g. page 1 displays results from 1 to 100.
†Including 'hints' to studies; there were no grey literature includes for the Women's Health review.
‡All includes were identified via one search ('return to work').

four relevant journal articles per search were identified on page one (mean = 2), whereas no more than one relevant journal article was identified per search on subsequent pages. Only one of the two Occupational Health review searches identified any relevant journal articles, namely, the 'return to work' search, and these were sparsely dispersed across pages one to three (see Table 3). Across both the Women's Health review and the Occupational Health review searches, the lowest ranking first appearance of a relevant journal article was on page three, ranked at 227 for the women's health review and 215 for the occupational health review (see Table 2). Thus, across both sets of searches, all included journal articles were identified within the first 65% of the search results (range 62.3%–64.8%, see Table 2). Across the other five women's health review searches, the lowest ranking first appearances of relevant journal articles were identified higher in the rankings of the results (range 1–106).

Across the two reviews, Google Search retrieved two uniquely identified relevant studies, i.e. studies which were not identified by other search methods used in either review. One was the 74th result in the 'return to work' search for the occupational health review, which was also the only grey literature publication which met the inclusion criteria for either review.[20] The other was the seventh result in the endometriosis search for the Women's Health review, which was a hint to a recently completed study which had not yet been published.[21] Following correspondence with the authors we ascertained that the study was due publication in journal article format during the period that the review would be undertaken, and thus was included in the review later in the review process.[22] Although the occupational health review Google Search searches were re-run 11 months after the initial searches for the purposes of this analysis, we did not identify any previously unidentified relevant studies for the occupational health review which were not also identifiable by the bibliographic database searches, i.e. no additional uniquely identified studies were found by Google Search.

Based on our criterion of identifying relevant studies, for the eight Google Search searches carried out across these two reviews it was most desirable to screen at least the first 100 results in order to identify the two uniquely retrieved studies. It was also desirable to screen until the third page of results to identify all first appearances of relevant studies, as a potentially useful strategy for ensuring that studies were not missed by bibliographic databases and other supplementary search methods. Of those Google Search searches which retrieved more than 300 results, not only were no relevant studies retrieved beyond this point, there were also fewer studies in journal article format (6%–7% of results in total) and no grey literature publications (see Table 3). Thus, there was no evidence that screening these results was useful for identifying relevant studies, nor that there was much chance of identifying a study at all, relevant or not. Therefore we suggest that the desirability of screening to the end of the search results was diminished, particularly where there were more than 300 results.

4 | DISCUSSION

This cross-case analysis of eight Google Search searches adds to existing evidence on the feasibility of screening

the results of searches exhaustively.[13] We have also suggested that, for the two case studies in the present study, it was desirable to screen to the third page of results, where the lowest ranking first appearances of relevant studies were identified (approximately 65% of the retrieved results in total in both cases). The distribution of studies, relevant or not, was much lower on page four, which diminished the desirability of screening these results.

The feasibility of screening the results of Google Search searches exhaustively, in cases where there are relatively low numbers of viewable results, is important because it sets a new baseline for the development of appropriate approaches to screening the results for a systematic review. That is, historically, systematic reviewers and expert searchers have reported that high numbers of results in Google Search necessitate the use of a stopping-rule, or make screening impractical,[5,7,9,11,12] but the present study and Briscoe and Rogers challenge this assumption.[13] Thus, the rationale for developing an approach to screening will need to incorporate the desirability of screening exhaustively. However, this does not necessarily mean that when using Google Search it will *always* be feasible to screen in full. For example, there may be instances where searches retrieve higher numbers of results than are feasible to screen; and, if multiple Google Search searches are carried out per review, the sum total number of results to screen may not be feasible to screen in full.[23] But, on some occasions, our findings show that Google Search results are feasible to screen exhaustively.

It is unclear why there is a large discrepancy between the estimated and viewable number of results. As noted in Briscoe and Rogers, the relatively small number of viewable results is unlikely to account for all webpages indexed by Google Search that match a search query.[13] The difference may partly be explained by how search engines organise their indexes in "tiers and partitions", not all of which are scanned on every search.[24] Thus, for example, a webpage deep inside a website may not be retrieved by a general web search, but will be retrieved if the search is restricted to the website using the 'site' command.[24] However, this does not account for why the search engine would still report a number of results that is higher than that which is viewable. We also noted that the numbers of results retrieved by Google Search were not always what we would expect. In particular, we sometimes found that adding a term to a search string using the OR Boolean operator *decreased* the estimated number of results, whereas this ought to *increase* the number of results. For example, searching for women OR females within the chronic pelvic pain search string for the Women's Health review retrieved fewer results than searching solely for women (see Table 1). Despite this, we were satisfied that Google Search recognised the OR Boolean operator because we could see both the words "women" and "females" in the search results when combined using OR. However, it is important that systematic reviewers more familiar with searching bibliographic databases than search engines are alert to the hidden mechanisms that determine which results are retrieved, and do not place too much faith in the careful construction of Boolean searches for retrieving all potentially relevant studies. Furthermore, as undertaken for this study, and recommended by Gusenbauer and Haddaway,[25] and Briscoe et al.,[11] the extent to which search operators are supported needs careful consideration when searches are developed.

The increased proportion of relevant studies in higher ranking search results in the Women's Health review searches is consistent with the commonly reported view that the value of screening diminishes for lower ranking results, i.e. those studies appearing higher in the list of search results are more likely to be relevant than those appearing lower in the search results.[5,8,11,12] We are aware of one other study to date by Cooper et al. which has assessed the distribution of studies within Google Search results, with a particular focus on comparing the results when searching in different geographical locations.[7] However, the search they used for analysis retrieved fewer than 100 results, thus they were not able to assess the desirability of screening more than this number.[7] Furthermore, assuming it is not common practice to use the "repeat the search with omitted results showing" function in Google Search, each 'chunk' of 100 results in our searches might look different to searches which are typically carried out without using this function (for which the number of viewable search results, as in Cooper et al., will be even fewer than the numbers reported in the present study).[7] In order for the findings of the present study be usefully applied to, or compared with, other Google Search results, it is necessary for searchers to apply this function before screening. We suggest this is valuable because it potentially increases the likelihood of identifying relevant evidence through increased exposure to search results. Nonetheless, as Cooper et al. found, we suspect that the ranking of search results would still be distributed differently depending on the geographical location of the searcher when using this function.[7]

Although not part of our assessment of the feasibility or desirability of screening exhaustively, the potential difference in the distribution of studies within the results with and without using the repeat search function also makes it difficult to assess the appropriateness of using 'feedback' based stopping-rules, such as screening until one or two pages of results have been inspected without

identifying any relevant content.[5] However, we did note that there were over 100 results between included studies in some searches, which suggests that feedback based approaches may not be effective if using the default setting in Google Search of ten results per page.

Theoretically, extensive screening might also be supported by the fact that search engine algorithms interpret relevancy differently to systematic reviewers. Whereas the latter assess relevance according to content and study design, search engines assess relevance according to an array of factors, including content (typically measured as frequency of search terms within webpages), age, length, and 'authority' based on number of links to a webpage.[24] Thus, it may be desirable to screen the results more extensively in order to see results which contain relevant content but are not prioritised by a search engine algorithm due to non-relevant factors. Relatedly, rather than routinely clearing a web browser's search history before searching (as recommended in some guidance),[8] it may be worth only doing this prior to the development of searches for new topics, thus potentially encouraging the retrieval of content that is missed on initial iterations of searches. Indeed, qualitative research on how expert searchers undertake web searching suggests that relatively rapid and repeated attempts at identifying relevant studies is sometimes preferred to the careful construction of an intricate search strategy.[26] This is particularly the case where the searcher is seeking to fulfil a clearly bounded information need (such as a known study or a sample set of a specific type of study), and is expecting to see relevant search results towards the top of the list.[26] In contrast, more exploratory or speculative searches can require more extensive screening. However, in either scenario (i.e. where multiple searches are used for the same search topic), it may be useful to retain a browser's search history in order to encourage the retrieval of search results which are similar to results from earlier attempts at searching.

Finally, we note that we copied and pasted the search results into Word documents for screening, rather than manually adding them into reference management software. The latter option, although preferred by some reviewers, would most likely be sufficiently time consuming to greatly reduce the desirability of screening a full set of search results from Google Search.[27] Thus, we suggest that screening is undertaken using an approach similar to that outlined in this study.

4.1 | Strengths and limitations

To the best of our knowledge, this is the first study to explore the distribution of studies within Google Search results which retrieve more than 100 results, i.e. the commonly reported screening limit applied when searching for studies for systematic reviews. We have focused only on Google Search to the exclusion of other search engines, such as DuckDuckGo (https://duckduckgo.com/) and Bing (https://www.bing.com/). However, this reflects current practice where generally search engines other than Google Search are not widely used for the purpose of searching for studies for systematic reviews.[11,28] By using eight searches for the analysis, we have avoided relying on a small set of data, although additional testing would be welcome to strengthen the evidence-base. We did not measure the additional time required to screen more extensively, but we have suggested that the feasibility of this approach is based on the search results being in the same order of magnitude as the number commonly screened, i.e. the low hundreds. We also note that the analysis of identified studies for the first criterion of the second aim reflects the types of document which met the inclusion criteria for the Women's Health and Occupational Health reviews, albeit not limited by study design. Other reviews might have narrower or broader inclusion criteria, particularly with respect to grey literature, editorials and letters. However, we are confident that most systematic reviews include published studies, for which the analysis we present will be informative.

5 | CONCLUSIONS

The feasibility of screening the results of Google Search exhaustively for some searches is now clear. Although the desirability of this is less apparent, this study has provided evidence that it may be useful to screen Google Search results more extensively than is often reported.

AUTHOR CONTRIBUTIONS

Simon Briscoe: conceptualization (lead), data curation, investigation, writing – original draft preparation, writing – review and editing. **Rebecca Abbott:** investigation, writing – review and editing. **Hasanat Lawal:** investigation, writing – review and editing. **Liz Shaw:** writing, review and editing. **Jo Thompson Coon:** writing, review and editing.

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CONFLICT OF INTEREST

The authors confirm that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

ORCID

Simon Briscoe https://orcid.org/0000-0002-6982-4521
Liz Shaw https://orcid.org/0000-0002-6092-5019
Jo Thompson Coon https://orcid.org/0000-0002-5161-0234

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