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RESEARCH ARTICLE

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A mapping exercise using automated techniques to develop a search strategy to identify systematic review tools

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Abstract

The Systematic Review Toolbox aims provide a web-based catalogue of tools that support various tasks within the systematic review and wider evidence synthesis process. Identifying publications surrounding specific systematic review tools is currently challenging, leading to a high screening burden for few eligible records. We aimed to develop a search strategy that could be regularly and automatically run to identify eligible records for the SR Toolbox, thus reducing time on task and burden for those involved. We undertook a mapping exercise to identify the PubMed IDs of papers indexed within the SR Toolbox. We then used the Yale MeSH Analyser and Visualisation of Similarities (VOS) Viewer text-mining software to identify the most commonly used MeSH terms and text words within the eligible records. These MeSH terms and text words were combined using Boolean Operators into a search strategy for Ovid MEDLINE. Prior to the mapping exercise and search strategy development, 81 software tools and 55 'Other' tools were included within the SR Toolbox. Since implementation of the search strategy, 146 tools have been added. There has been an increase in tools added to the toolbox since the search was developed and its corresponding auto-alert in MEDLINE was originally set up. Developing a search strategy based on a mapping exercise is an effective way of identifying new tools to support the systematic review process. Further research could be conducted to help prioritise records for screening to reduce reviewer burden further and to adapt the strategy for disciplines beyond healthcare.

KEYWORDS

automation, evidence synthesis, information retrieval, literature search, search strategy, systematic reviews

Highlights

What is already known

Systematic reviews are time consuming and there are barriers to the uptake of tools to support and expedite the evidence synthesis process. This includes a lack of awareness about the tools available.

What is new

The Systematic Review Toolbox is a resource that collates evidence synthesis tools in one, easily accessible place. This article describes the process of developing a search strategy, using some automation techniques, to identify new tools to add to the Systematic Review Toolbox, to ensure it is maintained and up to date with less time-on-task for its Editors.

Potential impact for RSM readers outside the authors field

The search strategy has been developed in the context of health but may be transferable to other fields, such as computer science, software engineering and environmental sciences.

1 | INTRODUCTION

Systematic reviews are time-consuming to conduct, usually requiring large amounts of time, expertise and resources from multiple team members to deal with large amounts of evidence that must be screened and analysed so that conclusions can be made. A 2017 study found the mean estimated time to conduct and publish a systematic review was 67.3 weeks, with the number of studies retrieved by literature searches ranging from 27 to over 92,000.[1] Some tasks require duplication for quality assurance. For example, the screening of studies should ideally be conducted by two independent reviewers.[2] This further increases the amount of time and resources needed to complete a systematic review.

Many, if not all, tasks relating to systematic reviews are usually conducted manually, creating time-consuming and repetitive work for researchers. Developments in technological areas such as text-mining have allowed for some processes to become semi-automated, such as the screening of search results to identify included studies, which is considered one of the most time-consuming tasks.[3] There is also potential for automation to reduce human errors.[4] By automating some of the more repetitive tasks,[5] researcher time could be redirected to tasks which require nuanced judgement, such as the applicability of available evidence.[6]

Despite the wealth of systematic review tools now available, uptake of these tools can be slow. This can be due to many reasons, including lack of time to learn how to use a new tool in the context of a funded systematic review project that is subject to deadlines, and a lack of confidence that automated tools will lead to the same conclusions as a human reviewer. Furthermore, there are many barriers to using new tools, such as lack of knowledge about what relevant tools are available and inexperience with some of the more advanced underlying principles of tools, such as machine learning.[6,7]

The Systematic Review Toolbox (SR Toolbox) was developed in 2014.[8] The SR Toolbox aims to assist researchers by providing a searchable, web-based catalogue of tools that support various tasks within the systematic review and wider evidence synthesis process.[9] The SR Toolbox was initially set up to be community-driven, with the functionality for users to submit tools for inclusion via the website. However, the increase in available tools in recent years, and the aim to ensure the latest tools are added in a timely manner, drove the need to develop more robust methods for identifying tools.

The International Collaboration for the Automation of Systematic Reviews (ICASR), established in 2015, aims to co-ordinate work on automation in systematic reviews so that individual tools and processes can be easily integrated with one another.[10] The ‘Vienna Principles’ were developed by ICASR with this aim in mind.[10] Although the SR Toolbox has a broader remit, and includes all types of systematic review tools rather than just those that can be described as ‘automated’, it is in line with these principles; namely, by sharing tools and any evaluations of tools. By identifying and collating relevant tools from multiple resources into one place, the SR Toolbox aids researchers by saving them the time they would need to spend finding tools (and any published evaluations) themselves.[8,9]

However, there is currently a challenge in identifying publications surrounding specific systematic review tools without retrieving large numbers of results containing systematic reviews themselves. Retrieving these records adds to the screening burden of reviewers, particularly as the SR Toolbox is updated and maintained in the Developer (CM) and Editors' (AS, HOK, EEJ) free time. The primary aim of this study is to describe the semi-automated methods used to develop a dedicated search strategy that could be set up as an auto-alert to ensure the SR Toolbox remains current and catalogues the latest tools.

2 | METHODS

To inform the development of the search strategy, a mapping exercise was undertaken between June and October 2017 to analyse the publications already indexed in the SR Toolbox and use this data to develop a strategy to regularly search for review production tools.

First, an experienced information specialist (AS) extracted the MeSH subject headings and free-text terms (appearing in the titles and abstracts) relating to systematic review tools from research publications of tools to support the systematic review process. The toolbox developer (CM) verified this process and any queries were resolved by discussion. The existing research publications in the SR Toolbox were imported into EndNote reference management software and checked for PubMed IDs (PMIDs). Where PMIDs were not found, references were identified by title on Ovid MEDLINE. Subsequently, the PMID for these references were recorded if available.

Research publications of tools to support the systematic review process were then analysed using two tools to enable the mapping of the literature: Yale MeSH Analyser and Visualisation of Similarities (VOS) Viewer text-mining software.[11,12] PMIDs were first entered into Yale MeSH Analyser and the retrieved MeSH headings were ordered by frequency. All MeSH headings assigned to the SR Toolbox research publications were included in the analysis. The bibliographic data and abstracts of publications with PMIDs were uploaded to VOSviewer,[12] where a density visualisation map (or 'heat map') was generated to identify a network of frequently occurring and relevant free-text terms. A single iteration of the density visualisation was produced, using the default settings and parameters of the VOSviewer software. The most common MeSH headings and most frequently occurring free-text terms (and their proximity to each other) informed the design of a search strategy for Ovid MEDLINE. The analysis of the free-text terms was not performed on individual search fields; terms appearing in titles and/or abstracts were analysed collectively. The free-text terms were selected by focusing on the red and amber areas of the heat map and grouping terms by theme. Some terms in the green areas of the heat map were also selected if pertinent to the themes identified. Other terms were excluded if they did not appear in close proximity with other useful terms and were felt to be of limited use (e.g. too sensitive) to identify SR tools. All search terms in the strategy were derived from the described approach. MeSH headings and free-text terms were combined with the Boolean Operator AND to ensure precision and specificity.

The search strategy was not formally tested but results were checked to ensure that all the SR Toolbox research publications indexed on MEDLINE were included. Several iterations of the search strategy were produced in discussion with the toolbox developer (CM) until an acceptable screening burden was reached. An auto-alert was set up to receive relevant search results via email on a weekly basis. The Ovid MEDLINE search strategy can be found in Appendix A.

Search results from MEDLINE are screened via the Rayyan systematic review tool,[13] according to SR Toolbox

TABLE 1 Systematic Review Toolbox inclusion and exclusion criteria.

Software tools	
Include	**Exclude**
• Special-purpose software tools to support specific systematic review/ evidence synthesis tasks or aspects of the process	• General-purpose systems such as word processors or spreadsheet packages.
• Custom add-ons to other software (e.g. meta-analysis add-on for Excel)	• Commercial statistical software (e.g. Stata, SPSS, etc.)
• Reference managers	• Tools older than 10 years and not being commonly used in systematic reviews/ evidence synthesis.
Other tools	
Include	**Exclude**
• Quality assessment or critical appraisal checklists	• Textbooks
• Relevant guidelines about how to perform systematic reviews/evidence synthesis	• Tools older than 10 years and not being commonly used in systematic reviews/ evidence synthesis.
• Reporting standards for systematic reviews/ evidence synthesis	

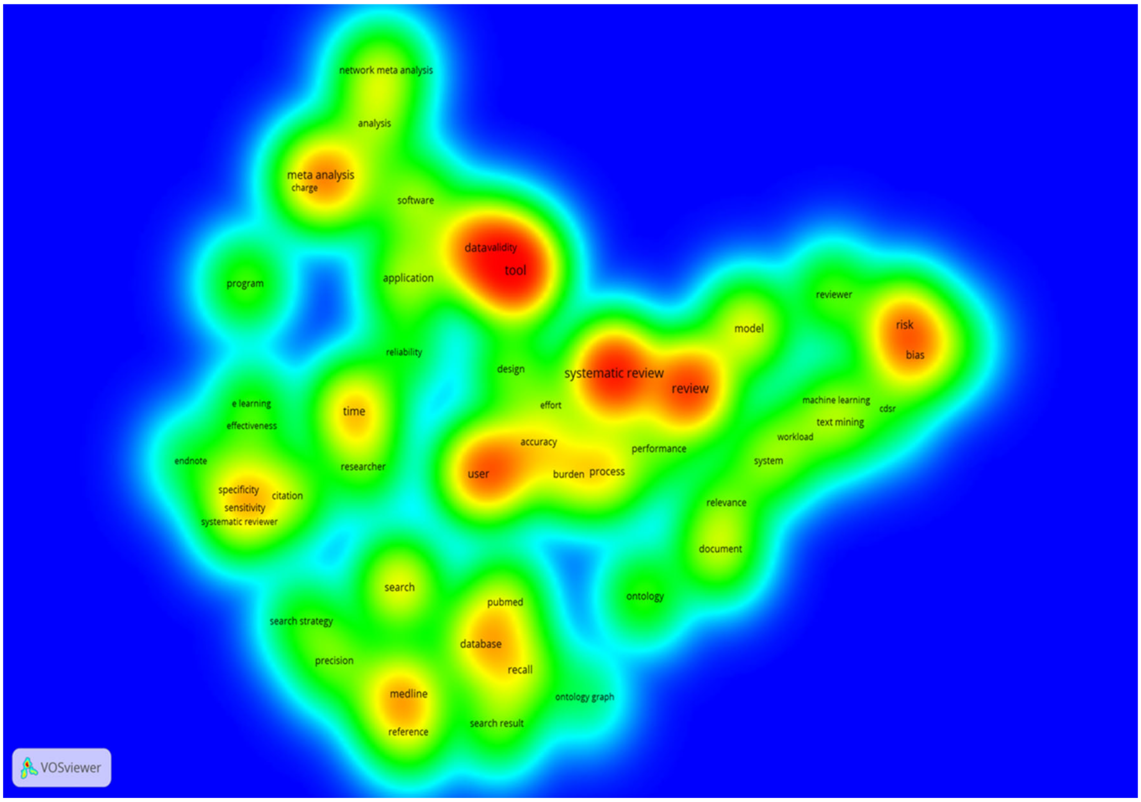

FIGURE 1 Density Visualisation ('Heat') Map. Most frequently occurring free-text terms appear in red. The proximity of terms to each other is depicted by their position in the map.

tool eligibility criteria (see Table 1). Tools that meet the eligibility criteria are added to the SR Toolbox.

3 | RESULTS

At the time of the mapping exercise (June 2017), the SR Toolbox contained 136 tools: 81 software tools and 55 tools classed as 'Other' (e.g. quality assessment checklists and reporting guidelines). The SR Toolbox was launched in October 2014, so this volume represents 3 years of tools being added to the Toolbox. The results of the mapping exercise and subsequent search strategy development are presented below. The SR Toolbox was subsequently relaunched in 2022 following a redesign and restructure.

There were 82 research publications relating to these tools indexed in the SR Toolbox at the start of the mapping exercise. Thirty-eight of these research publications (46%) were indexed on MEDLINE and therefore had a PMID to enter in Yale MeSH Analyser. From this, 77 MeSH headings were identified. The most frequently occurring MeSH heading was 'Software' ($n = 16$), followed by 'Information Storage and Retrieval' ($n = 15$). Thirty-three MeSH headings ranged between 2 to 16 occurrences. Forty-four MeSH headings had single occurrences. Five publications had no MeSH headings assigned.

The most frequently occurring free-text terms in the titles and abstracts according to the heat map generated by VOS Viewer included (not surprisingly, given the nature of the SR Toolbox); 'systematic review', 'review', 'tool'. Less predictable terms that frequently occurred were 'data', 'validity', 'risk', 'bias', and 'user' (see Figure 1).

The search strategy was developed between November 2017 and January 2018. The top 11 most frequently occurring MeSH headings were selected to be used in the search strategy, as these were all used five or more times and were thought to be those most relevant to publications about systematic review tools (see Table 2). The MeSH headings used less than or equal to four times tended to apply to other concepts within the publication, such as research design. The free-text terms extracted by VOSviewer were categorised into five concepts for the search strategy: 'tools', '**systematic reviews**'; 'the **underlying approach** that the tool supports' (e.g. machine learning, text mining); 'the **challenges** that tools are designed to overcome'; and terms around the '**features** of tools' (e.g. sensitivity, specificity). See Table 3 for the free-text terms for each concept. The proximity data (e.g. where terms appear on the 'heat map' in relation to each other—see Figure 1) was only used in the 'challenges' (user burden) and 'tool function' concepts. This was because terms relating to time were shown to be in close proximity of the term 'user' (challenges), and the terms 'data' and 'validity' and "risk and bias' (tool functions) were also shown to appear together.

The search strategy was developed in MEDLINE via Ovid and is run weekly by an AutoAlert search in the whole of MEDLINE, including Epub Ahead of Print, In-Process, In-Data-Review & Other Non-Indexed Citations. PubMed-not-MEDLINE records are included in the search results.

In the three-year period since the search strategy was deployed (January 2018 to 2021), there were 206 software tools and 76 'Other' tools within the SR Toolbox, totalling 282 records. This is an increase of 146 tools in 3 years, representing a similar rate of growth in tools as the previous 3 years prior to implementing the search strategy. The rate of growth in software tools compared to guidance tools has increased over time. At the start of the mapping exercise in June 2017, 60% of the tools in the SR Toolbox were classified as software tools and 40% were classified as guidance tools. Over 5 years, the percentage of software tools has increased by to 68%. Between January and May 2022, the SR Toolbox was on hiatus for a redesign and restructure so no new tools were added until the SR Toolbox relaunched in May 2022.[14] As of May 2022, there are 235 software tools and 112 guidance tools (previously categorised as 'other').

TABLE 2 Most frequently occurring MeSH headings.

MeSH heading	Number of occurrences
Software/	16
'Review Literature as Topic'/	15
Data Mining/	12
Evidence-Based Medicine/	11
MEDLINE/	10
Natural Language Processing/	7
Internet/	7
Algorithms/	6
Machine Learning/	5
PubMed/	5
User-Computer Interface/	5

4 | DISCUSSION

4.1 | Brief summary of results

The developed search filter for the SR Toolbox was initially implemented in 2018 and, since then, the rate at which tools have been identified for the resource has grown at the same rate as in the prior 3 years. In 2018, an analysis of the tools added since the development of the search strategy compared with other retrieval methods found that Twitter identified the most tools in a 12-month period..[15] However, during a three-year period (2018–2022), the majority of tools were discovered by the search strategy, rather than ad hoc methods such as monitoring Twitter or submissions by the systematic review community. The percentage of software tools indexed in the SR Toolbox versus the guidance tools has increased over time by approximately 10%, but this is likely to be due to computer science, and its application to evidence synthesis, being an innovative and developing field, compared with established systematic review guidance. Also, over time, there has been an increase in publications associated with tool development and evaluation of their use. This can be attributed to the change in approach to

TABLE 3 Free-text search concepts and synonyms.

Tools	Reviews	Underlying approaches	Challenges	Features
software	review	machine learning	reviewer	data AND validity
program	meta-analysis	text mining	researcher	
tool		ontology	user	sensitivity
model system		search	AND	specificity accuracy
database			time	recall
			effort	precision
			burden	risk AND bias
			process	
			performance	
			workload	

identifying tools, using a structured search strategy of a bibliographic database compared to ad hoc, community-driven methods.

4.2 | Areas for further research

The search strategy currently focuses on MEDLINE, where it was developed. There would be some benefit to translating the search across a range of multidisciplinary bibliographic databases, including those that index conference abstracts, as these may have early evidence regarding tool developments. The search strategy may also be developed further to improve sensitivity. Ideally, a methodological search filter would be developed and validated to identify software tools.

There are challenges associated with maintaining the SR Toolbox. For example, checking and ensuring that links to the tools, including any associated publications, are up to date is a time-consuming task. Screening the papers picked up by the search to identify eligible tools is currently conducted manually and, while the number of records to screen is often large, very few records are considered eligible for inclusion. Currently, the search is identifying approximately 1250 results per month, which adds roughly four tools to the resource following screening of the search results. Furthermore, in addition to the MEDLINE search, the PubMed Systematic Review Methods filter was also being used but has since been discontinued, meaning that filtering out systematic reviews from the search has become more difficult. As such, maintenance is becoming increasingly difficult as the SR Toolbox continues to expand, particularly as it is a 'community enterprise' reliant on the free time of the Developer (CM) and Editors (AS, HOK, EEJ).

Consequently, it may be beneficial to consider a semi-automation process to assist the maintenance of the SR Toolbox. A potential solution would be to use Machine Learning Classifiers, though identifying a predesigned classifier to cover the needs of this screening set may not be possible. Instead, work is underway to develop a text-mining methodology which uses mini-filters to identify priority records from the search strategy. This is being validated by testing against the current process of manual screening and identification.[16] If successful, such a process would help streamline maintenance of the SR Toolbox. Additionally, a tool of this nature may be potentially adaptable to individual systematic review projects where screening burden is high but eligible records are low.

Although developed in the context of identifying publications to assist with regularly updating the SR Toolbox, other resources that require similar maintenance may benefit from undertaking a similar mapping exercise and using automation to develop information retrieval strategies to ensure currency. We have also found, in the screening of references, that the search strategy appears to be effective in identifying software tools used in other aspects of medicine, though this has not been evaluated and requires further formal investigation.

4.3 | Strengths and limitations

Established software tools, Yale MeSH Analyser and VOSviewer, were used for evaluating the pre-existing content of the SR Toolbox. These software tools have been demonstrated to be robust and produce consistent results.[17] Furthermore, the results from these tools were interpreted by a highly experienced information specialist (AS) with extensive knowledge of search strategy development and a clear understanding of the limitations of such tools.

In terms of limitations, we recognise that not all publications contained within the SR Toolbox had associated PMIDs, so they were unable to be included in the analysis. This is because not all tools contained within the SR Toolbox have associated publications indexed on PubMed, MEDLINE or Embase, as some of the included records are software packages or extensions hosted on sites such as GitHub. As such, it is possible that additional, relevant text words for analysis may have been missed. The data extraction was conducted by one researcher (AS), with validity checks by a second researcher (CM). Performing double, blinded data extraction may have decreased the risk of bias. We acknowledge that the mapping exercise was conducted some years ago now, but this was conducted to inform the development of the search strategy. We have since conducted an updated analysis (not related to developing search methods) prior to the SR Toolbox subsequently relaunching in 2022, following a redesign and restructure.

Additionally, the search strategy is currently designed to run in health literature databases, though there are various fields of research outside of health that conduct systematic reviews. As such, the current search strategy has a potentially limited applicability to other disciplines. There is a potential need to expand the search to other sources. Computer science and software engineering literature may prove valuable for retrieving additional tools for systematic reviews. Similarly, the work conducted by the Stockholm Environment Institute focuses on systematic reviews in the Environmental and Developmental research field.[18] This search strategy could be a foundation for the identification of records in different disciplines but may need adaptation and translation to databases which are more focused towards other fields of research. Currently, we do not know how the search terms would perform to retrieve relevant grey literature, particularly conference abstracts, which can be a rich source of tool development work.

5 | CONCLUSIONS

Developing a search strategy based on a mapping exercise using text-mining methods is an effective way of identifying new tools to support the systematic review and wider evidence synthesis process. The strategy is also effective at identifying publications that report evaluations of tools (including independent evaluations and those conducted internally by the developers) or major tool updates (such as new and/or expanded features of existing tools). To ensure currency, the search strategy should be regularly maintained, with an annual mapping exercise to identify any additional MeSH headings and free-text terms (if capacity allows).

AUTHOR CONTRIBUTIONS

Anthea Sutton: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; writing – original draft; writing – review and editing. **Hannah O'Keefe:** Data curation; writing – original draft; writing – review and editing. **Eugenie Johnson:** Data curation; writing – original draft; writing – review and editing. **Christopher Marshall:** Conceptualization; supervision; validation; writing – original draft; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

AS, HOK, EEJ and CM all report no conflicts of interest.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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APPENDIX A: MEDLINE Search Strategy

1. Software/
2. 'Review Literature as Topic'/
3. Data Mining/
4. Evidence-Based Medicine/
5. MEDLINE/
6. Natural Language Processing/
7. Internet/
8. Algorithms/
9. Machine Learning/
10. PubMed/
11. User-Computer Interface/
12. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11
13. (software or program or tool or model or system or database).ti,ab.
14. 12 and 13
15. (meta analysis or review).ti,ab.
16. 14 and 15
17. (machine learning or text mining or ontology or search).ti,ab. (321830)
18. 14 and 17
19. ((reviewer or researcher or user) and (time or effort or burden or process or performance or workload)).ti,ab.
20. 14 and 19
21. ((data and validity) or (sensitivity or specificity) or (accuracy or recall or precision) or (risk and bias)).ti,ab.
22. 14 and 21
23. 16 or 18 or 20 or 22