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REVIEW

Citation tracking for systematic literature searching: A scoping review

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Abstract

Citation tracking (CT) collects references with citation relationships to pertinent references that are already known. This scoping review maps the benefit of and the tools and terminology used for CT in health-related systematic literature searching. We included methodological studies on evidence retrieval by CT in health-related literature searching without restrictions on study design, language, or publication date. We searched MEDLINE/Ovid, Web of Science Core Collection, CINAHL/EBSCOhost, LLISFT/EBSCOhost, LISTA/EBSCOhost, conducted web searching via Google Scholar, backward/forward CT of included studies and pertinent reviews, and contacting of experts. Two reviewers independently assessed eligibility. Data extraction and analysis were performed by one reviewer and checked by another. We screened 11,861 references and included 47 studies published between 1985 and 2021. Most studies (96%) assessed the benefit of CT either as supplementary or primary/standalone search method. Added value of CT for evidence retrieval was found by 96% of them. Science Citation Index and Social Sciences Citation Index were the most common citation indexes used. Application of multiple citation indexes in parallel, co-citing or co-cited references, CT iterations, or software tools was rare. CT terminology was heterogeneous and frequently ambiguous. The use of CT showed an added value in most of the identified studies; however, the benefit of CT in health-related systematic literature searching likely depends on multiple factors that could not be assessed with certainty. Application, terminology, and reporting are heterogeneous. Based on our results, we plan a Delphi study to develop recommendations for the use and reporting of CT.

KEYWORDS

citation tracking, literature search, methods, research methodology, scoping review, supplementary search methods, systematic review

1 | INTRODUCTION

As systematic literature reviews aim at finding and synthesizing all available evidence on a topic,[1,2] they are critical to inform health care practice and future research.[3–5] Systematic reviews rely on information retrieval through systematic search strategies.[2] It is challenging to design a systematic literature search that covers the ever-growing research volume, deals with the lack of universal terminology and indexation of research articles, and that keeps the number of results in an acceptable range for reviewers.[6–8] According to current methodological guidance, systematic literature searching should apply both electronic database and supplementary search methods.[9] In addition to contacting experts in the field, handsearching, trial registry searching, and web searching, supplementary methods include citation tracking (CT).[10]

CT exploits citation relationships to discover further eligible studies.[11] While the methodological terminology around CT techniques is diverse,[12,13] we will herein use CT as an umbrella term for multiple methods which collect related references from "seed references" through citation relationships.[11] These seed references are references that are either known at the beginning of the review or emerge as eligible records following study selection and are usually eligible for inclusion in a review.[14,11] CT methods can be sub-categorized into *direct* and *indirect* CT (for graphical representation see[11]). For direct CT, the words "backward" and "forward" denote the directionality of tracking.[12,2] Backward CT is the oldest form of CT. It identifies references that were cited by a seed reference which can be achieved at the title level by manually checking the reference list.[15,2] In contrast, forward CT identifies citing references, that is, references that cite a seed reference[11] which can only be achieved by using an electronic citation index (e.g., Web of Science, Scopus, or Google Scholar). *Indirect* CT describes the identification of (i) co-cited references (i.e., publications sharing citing papers with a seed reference) and (ii) co-citing references (i.e., publications sharing references with a seed reference). Both direct and indirect CT may be conducted over one or more layers of iteration. To this end, researchers may use newly retrieved, relevant references as new seed references which we herein refer to as CT iterations.

The added value of any form of CT might not be the same for all systematic reviews. CT may be beneficial in research areas or for research questions in which core concepts are difficult to capture using text words or index terms, or in which the used vocabulary is unspecific or inconsistently used.[10] However, the use and benefit of CT in systematic literature searching as a basis for evidence-guided recommendations has not been systematically investigated.[11] To fill this gap, we conducted this scoping review that was guided by the following three research questions:

- What is the benefit of citation tracking for systematic literature searching for health-related topics?
- Which methods, citation indexes, and tools are used for citation tracking?
- What terminology is used for citation tracking methods?

2 | METHODS

A scoping review was conducted following the framework by Arksey and O'Malley[16,17] and reported according to the "Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews" (PRISMA-ScR).[18] A structured protocol has been published prospectively.[11]

2.1 | Eligibility criteria

We included any study that aimed at evaluating CT as an evidence retrieval method in a health-related context, if one of the following criteria was met: (i) Assessment of benefits/problems and/or effectiveness of CT, comparison of (ii) different methods of CT (e.g., backward vs. forward, direct vs. indirect) or (iii) technical uses of CT (e.g., citation indexes or tools). There were no restrictions on study design, language, and publication date.

We excluded studies that (i) solely applied but did not assess CT for evidence retrieval, (ii) assessed benefits and/or use and/or effectiveness of CT to explore a network or citation impact (i.e., bibliometric analyses), (iii) described the method of CT without further assessing it (e.g., guidelines for developing search strategies or for systematic or other review types), or (iv) only assessed the benefit of combined search methods in which the isolated benefit of CT could not be extracted. We also excluded editorials, commentaries, letters, and abstract-only publications. Any type of literature review was excluded but was used to search for further primary studies (for details see below).

2.2 | Information sources

We searched MEDLINE via Ovid, CINAHL (Cumulative Index to Nursing and Allied Health Literature), LLISFT (Library Literature & Information Science Full Text) and LISTA (Library, Information Science & Technology Abstracts) via EBSCOhost, and the Web of Science Core Collection on October 26, 2020 (see Supporting Information S1). As supplementary search methods, we performed web searching via Google Scholar (on December 7, 2020) using search terms from our database search as well as direct forward and backward CT of included studies and pertinent review articles that were flagged during the screening of search results (on February 10, 2021). For forward CT, we used Scopus, Web of Science, and Google Scholar. For backward CT, we used Scopus and, if seed references were not indexed in Scopus, we manually extracted the seed references' reference list. We iteratively repeated forward and backward CT on newly identified eligible references until no further eligible references or pertinent reviews could be identified (three iterations; the last iteration on May 5, 2021). We also contacted librarians in the field of health sciences and information specialists through four mailing lists (Canadian Medical Libraries, Expertsearching, MEDIBIB-L/German-speaking medical librarians, and EAHIL-list) for further eligible studies.

2.3 | Search strategy

HE drafted the search strategies and JH checked them according to the Peer-Review of Electronic Search Strategies (PRESS) guideline.[19] We limited the strategy to text words due to a lack of adequate index terms. To determine frequently occurring terms for inclusion in the search strategy, we analyzed keywords in the titles and abstracts of potentially relevant publications retrieved from preliminary searches and similar articles identified via PubMed by using various text-mining tools (PubMed Reminer, AntConc, Yale MeSH analyzer, Voyant, VOSviewer, Termine, Text analyzer).[20] We restricted some text words to the title field in order to avoid retrieving systematic reviews that used CT. Translation of the original PubMed strategy to other syntax was done using the Polyglot Search Translator.[21] For topical restriction and reasons of feasibility, the retrieval from Web of Science was limited to pertinent Web of Science Categories and Research Areas. Final database-specific search strategies are reported in Supporting Information S1 and on searchRxiv (accessible via https://doi.org/10.1079/searchRxiv.2023.00109 [MEDLINE], https://doi.org/10.1079/searchRxiv.2023.00105 [CINAHL], https://doi.org/10.1079/searchRxiv.2023.00106 [Library Literature & Information Science Full Text], https://doi.org/10.1079/searchRxiv.2023.00107 [Library, Information Science and Technology Abstracts], and https://doi.org/10.1079/searchRxiv.2023.00108 [Web of Science Core Collection]).

2.4 | Data management

CAH conducted the database searches and CT, exported results to EndNote X9 (Clarivate), and eliminated duplicates using the Bramer method.[22] JH conducted the web search and contacted the experts. Citavi was used to manage the number of reference retrievals throughout the study selection process.[23] Additionally, we used specific tools for study selection that we describe below.

2.5 | Selection of sources of evidence

After an initial calibration phase of screening a random sample of 100 titles and abstracts separately and discussing divergent decisions (TN, JH, HE), two authors (JH, TN) independently screened titles, abstracts, and full texts using the web-app Rayyan.[24] Disagreements were solved by third author arbitration (HE or CAH). This applies to the results of the database search as well as of other searches.

2.6 | Data charting process

We used a prespecified data extraction spreadsheet (ONLYOFFICE, SWITCHdrive[25]) that was approved by consensus among the authors. We extracted bibliographic and geographic data (reference, publication year, and affiliated countries), design- and study-specific data (purpose of CT, health context, test sample, CT methods [e.g., backward CT, forward CT], terminology to describe CT, CT iterations, reported citation indexes, reported CT tools, outcome comparison[s] and measure[s]) as well as study results and authors' conclusions (Supporting Information S2). One author (JH, TN, CAH, or HE) extracted data and a second author (JH, TN, CAH, or HE) peer-checked the extraction. We solved disagreements by third author arbitration (one out of JH, TN, CAH, or HE).

2.7 | Synthesis of results

One author (JH, TN, CAH, or HE) narratively summarized and tabulated the study characteristics and results using numbers and percentages based on the data extraction. We aimed to provide a synthesis of any benefit of using CT. For operationalization, we checked authors' discussions and conclusions for clear statements of an added value or no added value. If clear statements were not present, we examined the study results: In studies where CT was used as a supplementary search method, we scored an added value if the use of CT compared to another search technique retrieved unique references. In studies where CT was used as a primary/stand-alone search method (i.e., instead of a database search, searchers would only conduct CT based on seed references from private collections or simplified database searches[26]), we scored an added value if CT identified more eligible references than the comparator search method or reduced the screening load. We additionally analyzed if an added value was brought into a specific context by the authors.

3 | RESULTS

3.1 | Characteristics of included studies

Database and supplementary searches yielded 11,861 unique references. After title-abstract screening, we assessed 150 references in full text. Of these, we excluded 100 references due to various reasons, mostly wrong study aim, and finally included 47 studies[26,27–69,70–72] (Figure 1). For three of the studies,[42,71,35] we found related documents (erratum,[73] doctoral thesis,[74] and evidence summary[75]), yielding a total of 50 reports, two of which were conference posters.[51,46] Twenty-six reports (52%) were included from the results of the bibliographic database search and 24 (48%) from the supplementary search results (one from web searching, 14 from backward CT, six from forward CT, and three from contacting experts). Further CT iterations did not yield any additional records that met our inclusion criteria.

The 47 studies were published between 1985 and 2021; the median publication year was 2014. Most of the studies were nationally authored without international collaboration. More than 70% (34 studies) of the studies were conducted by authors from the United Kingdom or the United States. The unit of analysis in the included studies was mostly one or more systematic review(s) (32 studies, 68%) and dealt with a single medical field or health topic (35 studies, 74%) rather than various fields or topics (nine studies, 19%). Twenty-seven studies (57%) dealt with research questions that assessed interventions (Table 1).

3.2 | Benefit of citation tracking

Forty-five studies (96%) assessed the benefit of CT. Of these, 25 studies (56%) performed supplementary CT following prior database searching and 20 studies (44%)

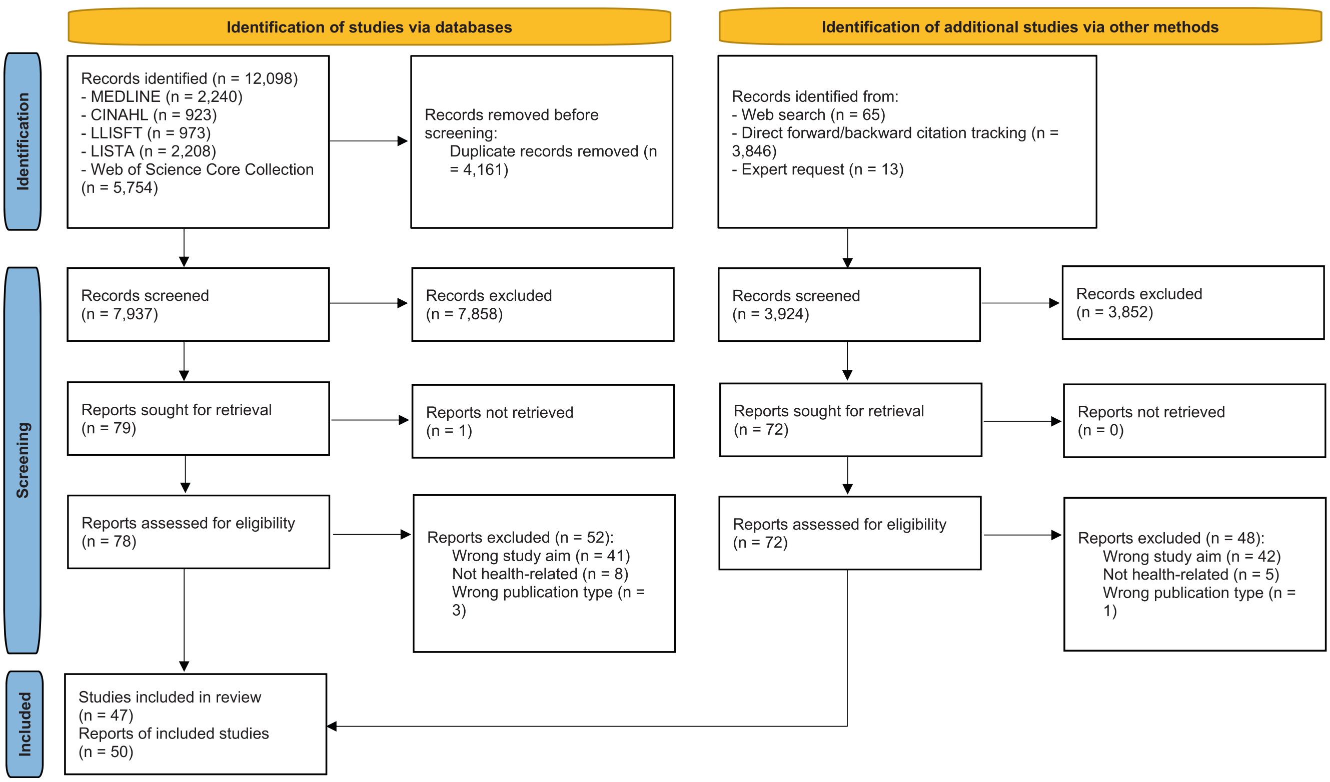

FIGURE 1 Literature search and study retrieval process (PRISMA 2020 flow diagram). CINAHL, Cumulative Index to Nursing and Allied Health Literature; LISTA, Library, Information Science and Technology Abstracts; LLISFT, Library Literature & Information Science Full Text; MEDLINE, Medical Literature Analysis and Retrieval System Online. [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Basic characteristics of the included studies ($n = 47$).

		n (%)
Publication decade	1980s	5 (11)[53,59,62,63,70]
	1990s	5 (11)[44,52,54,60,61]
	2000s	10 (21)[27,37,45,47,48,55,56,58,68,69]
	2010s	19 (40)[28,30,31,33–35,39,42,46,49–51,57,65,67,26,71,72,64]
	2020s[a]	8 (17)[36,29,32,38,40,41,43,66]
Authorship[b]	Internationally authored	4 (9)[33,36,40,57]
	Nationally authored	43 (92)[26–32,34,35,37–39,41–56,58–72]
Affiliated countries[b]	UK	17 (36)[27,37,52,54,55,58,64–66,69,70,72,35,49,45,51,39]
	US	17 (36)[33,38,48,56,59–63,30,31,41–43,50,53,67]
	Germany	5 (11)[57,46,71,36,40]
	Canada	3 (6)[36,32,68]
	Austria	2 (4)[33,57]
	Netherlands	2 (4)[29,44]
	Switzerland	2 (4)[40,57]
	Australia	1 (2)[34]
	Denmark	1 (2)[47]
	Korea	1 (2)[28]
	Romania	1 (2)[57]
	Tunisia	1 (2)[26]
Unit of analysis in included studies (with number included in each)	Systematic reviews ($n = 1$ to $n = 250$[c])	32 (68)[28,37,46,69,38,56,64,58,27,55,71,54,52,32,33,35,51,41,50,49,39,45,29–31,68,44,43,67,65,57,42]
	Systematic and nonsystematic reviews ($n = 20$)	1 (2)[34]
	Overviews of reviews ($n = 86$)	1 (2)[36]
	Scoping review ($n = 1$)	3 (6)[40,72,66]
	Search strategies ($n = 1$ to $n = 89$)	6 (13)[47,48,26,60,61,53]
	Set of references ($n = 111$ to $n = 1331$)	4 (9)[62,63,59,70]
Medical field/health topic of sample studies	Mental or cognitive health/psychology	9 (19)[71,38,46,40,70,72,41,35,66]
	Orthopedics	6 (13)[56,26,32,58,47,27]
	Gastroenterology	3 (6)[33,59,63]
	Hematology/Oncology	3 (6)[28,69,48]
	Cardiology/Angiology	2 (4)[44,45]
	Endocrinology	1 (2)[51]
	Infectiology	1 (2)[34]
	Pulmonology	1 (2)[62]
	Health decision/policy making	4 (9)[50,55,39,37]
	Health diagnostics	3 (6)[54,49,65]
	Health communication/education	2 (4)[64,52]
	Various medical fields/health topics	9 (19)[30,31,67,68,36,42,43,57,53]
	Not reported	3 (6)[60,61,29]
Intervention characteristic of sample studies[d]	Clinical intervention	21 (45)[44,51,59,63,33,69,52,50,54,65,34,71,38,46,56,26,27,30,31,67,68]
	Non-clinical intervention	6 (13)[64,37,35,66,72,58]

(Continues)

TABLE 1 (Continued)

		n (%)
	No intervention	10 (21)[45,28,48,39,55,49,40,70,41,32]
	Various	6 (13)[47,36,42,43,57,53]
	Not reported	4 (9)[29,60–62]

Abbreviations: UK = United Kingdom; US = United States (of America).

Note: Non-clinical intervention: Health-related measures on organizational or health policy and research level, health-related measures on patient/population-level not focusing on specific diseases (e.g., common health behavior). No intervention: Studies that do not assess interventions (e.g., epidemiological, prognostic, methodological or descriptive studies). Various: Mix of at least two of the three characteristics "clinical intervention," "non-clinical intervention," and "no intervention." Not reported: No information provided in the eligible study.

[a]Note that database and supplementary searches were performed between October 2020 and May 2021.

[b]Considering all affiliated authors and countries.

[c]Number per included study is reported in the raw data, see supporting information S2.

[d]Clinical intervention: Health-related measures on a patient/population-level (e.g., diagnosis, therapy, care, prevention) focusing on specific diseases.

primary/stand-alone CT, including four studies that used primary/stand-alone CT for a review update.[41,51,28,45] Mostly, the performance of CT was compared to a search in multiple databases (21 studies, 47%). Typical outcome measures were the number of retrieved eligible articles (27 studies, 60%), unique articles that were only identified by CT (8 studies, 18%), and/or retrieved articles that were not checked for eligibility (7 studies, 16%). A benefit of CT was usually ascribed by the authors if the results of CT significantly contributed to these outcome measures or if methodological efficiency of evidence retrieval (i.e., the relevancy and precision of the output) was increased (Table 2 and Supporting Information S2). Notably, while only two (4%) studies that assessed the benefit of CT found no added value of the use of CT,[71,72] 40% of those authors that stated an added value brought it into a specific context. Thus, particular study designs (observational, prognostic, or diagnostic test studies) or research topics such as non-pharmacological, non-clinical, public health, or alternative medicine, which may be regarded as complex, broad, fringe, or difficult-to-locate, were proposed to benefit most from CT (Table 2).

3.3 | Methods, citation indexes, and tools used for citation tracking

With respect to CT methods, 33 studies (70%) assessed backward CT, whereas forward CT was somewhat less frequently assessed (29 studies, 62%). Indirect CT methods were assessed in 7/47 studies (15%) for co-cited and 6/47 studies (13%) for co-citing CT (Table 3).

Five studies reported comparisons of different CT methods.[37,46,64,30,28] In three studies, backward CT retrieved more eligible references than forward CT.[37,52,46] In two studies, forward CT retrieved more eligible references than backward CT[45,64] (Supporting Information S2). The relative performance of indirect CT methods is reported in a separate paragraph (see below).

Although the associated reporting was unclear, most studies definitely (12 studies, 26%) or at least probably (29 studies, 62%) omitted CT iterations and performed only one round of CT (Table 3).

Seventeen studies (36%) performed CT (mainly backward) without the use of a citation index. Of the 30 studies that used at least one citation index, only seven used and compared different citation indexes.[28,46,49,50,64,66,72] By far the most popular citation indexes were Science Citation Index/Science Citation Index Expanded (SCI, 22 studies) and Social Sciences Citation Index (SSCI, 19 studies) that were used by themselves or in context of the Web of Science Core Collection (12 studies). Other citation indexes included Scopus (eight studies) and Google Scholar (five studies) (Table 3). Authors that compared CT indexes found that, compared to Scopus or Web of Science, the use of Google Scholar for forward CT is associated with a high administrative and time cost,[49,72] which led other authors to exclude Google Scholar results "for practical reasons."[46] In terms of yield of forward CT, Scopus was reported to be superior to Web of Science.[66] Likewise, the forward CT results from Scopus were more precise than those from Web of Science or Google Scholar when searching for a specific diagnostic test[50] (Supporting Information S2).

Several studies designed or applied software tools for CT (Table 3).

3.4 | Performance of indirect citation tracking

Relatively little evidence exists regarding the utility of indirect CT for health-related evidence retrieval. Nonetheless, the replication of 14 Cochrane reviews

TABLE 2 Study focus of included studies ($n = 47$) and purpose of CT, comparator, outcome measure, and added value of CT in studies assessing the benefit of CT ($n = 45$).

		***n* (%)**
Study focus ($n = 47$)[a]	Benefit of CT	45 (96)[27,29–33,35–48,50–69,26,70–72,28]
	Technical uses of CT	8 (17)[34,33,28,29,66,72,49,50]
	Different methods of CT	5 (11)[46,28,37,64,30]
Purpose of CT in relation to database search ($n = 45$)	Supplementary search	25 (56)[27,32,36–38,40,44,46–48,52,54,56–58,60,64–66,68–72,55]
	Primary/stand-alone search	20 (44)[59,61,62,45,29–31,33,39,41–43,50,51,53,67,26,63,35,28]
Comparator ($n = 45$)	Multiple database search	21 (47)[36–38,40,41,46,48,50,51,53,56–59,62–65,69,70,72]
	Multiple database search and supplementary search methods[b]	5 (11)[27,52,54,68,71]
	Single database search	9 (20)[32,39,44,45,47,60,61,26,28]
	Supplementary search methods	1 (2)[55]
	Multiple search methods[c]	9 (20)[55,30,31,29,35,33,42,43,66,67]
Outcome measure ($n = 45$)[a]	Number of retrieved eligible articles	27 (60)[59,63,29,47,36,46,53,58,64,65,70,27,54,52,71,42,67,55,60,44,56,69,37,51,33,39,28]
	Number of unique articles	8 (18)[38,40,35,45,32,66,72,48]
	Number of retrieved articles that were not checked for eligibility	7 (16)[60,62,41,32,41,43,60,68,29,62]
	Other[d]	6 (13)[57,30,50,61,31,26]
Added value of CT ($n = 45$)	Yes	43 (96)[26–33,35–48,50–70]
	No	2 (4)[71,72]
If added value, added value brought into specific context by the authors ($n = 17$)	Diagnostic test studies	2 (4)[51,65]
	Observational studies	2 (4)[48,45]
	Complex research questions[e]	2 (4)[37,46]
	Health services and public health	2 (4)[55,58]
	Depending on the topic	1 (2)[27]
	Disciplines and topics in which citations are numerous	1 (2)[30]
	Broader scope	1 (2)[60]
	Fringe areas	1 (2)[62]
	Non-published and difficult to locate studies[f]	1 (2)[69]
	Prognostic studies	1 (2)[32]
	Non-clinical research	1 (2)[70]
	Non-pharmacological interventions	1 (2)[57]
	Alternative medicine	1 (2)[44]

Abbreviation: CT, citation tracking.
[a]More than one category possible.
[b]For example, hand-searching, contacting experts.
[c]Potentially multiple search methods used which were not described in detail, for example, "Cochrane review methods" without providing details.
[d]For example, time, relevancy, precision (see Supporting Information S2 for details).
[e]For example, as those undertaken for management and policymaking questions.
[f]For example, conference abstracts, technical reports.

by combined CT methods suggested that co-cited references may offer better coverage of relevant literature compared to cited, citing, or co-citing references.[30] Independent work, which led to the development of the CT software CoCites,[43] also documented the effectiveness of co-cited references for health-related evidence retrieval.[42] Moreover, the studies on indirect CT revealed and pioneered the necessity for various relevancy ranking methods to prioritize and reduce the abundant output of indirect CT (Supporting Information S2).[42,67,30,31]

TABLE 3 Methodological characteristics of the included studies (n = 47).

		***n* (%)**
CT methods used[a]	Backward (direct)	33 (70)[26,27,29–31,33–37,39–46,48,52,54–59,64,65,67–69,70,71]
	Forward (direct)	29 (62)[30–32,35,37–43,45,46,50–53,59,63,60,61,64,66,67,26,71,72,28,49]
	Co-cited (indirect)	7 (15)[30,31,41–43,67,26]
	Co-citing (indirect)	6 (13)[29–31,47,67,26]
	Unclear	1 (2)[62]
CT iterations	Definitely yes	5 (11)[29,39–41,44]
	Probably yes	1 (2)[26]
	Definitely no	12 (26)[27,28,30,31,42,43,45,46,53,65–67]
	Probably no	29 (62)[32,33–38,47–52,54–64,68–72]
Number of citation indexes used	None	17 (38)[27,32,35,36,44,48,54–56,58,59,62,63,65,68–70]
	Single[b]	23 (47)[28,30,31,33,34,37–43,45,47,51–53,57,60,61,67,26,71]
	Multiple	7 (15)[28,46,49,50,64,66,72]
Citation indexes used[a]	Web of Science	12 (26)[29,31,39,42,43,46,47,50,51,66,26,72]
	SCI	22 (47)[26,29–31,37,39,42,43,45–47,49–53,60,61,64,66,71,72]
	SSCI	19 (40)[29,31,37–39,42,43,46,47,49–53,64,66,26,71,72]
	Scopus	8 (17)[28,33,40,50,57,66,67,72]
	Google Scholar	5 (11)[46,49,50,64,72]
	Microsoft Academic Search	1 (2)[34]
	CINAHL	1 (2)[64]
	PubMed Central	1 (2)[28]
	NIH Open Citation Collection	1 (2)[41]
Tools used[a]	CoCites	2 (4)[41,43]
	Science of Science Tool	2 (4)[30,31]
	SciMacro	1 (2)[29]
	VOSviewer	1 (2)[26]
	CitNet Explorer	1 (2)[26]
	ParsCit (modified)	1 (2)[34]

Abbreviations: CINAHL, Cumulative Index to Nursing and Allied Health Literature; CT, citation tracking; n, number; SCI, Science Citation Index and Science Citation Index Expanded; SSCI, Social Sciences Citation Index.

[a]More than one category possible.

[b]Indexes that are part of Web of Science/Web of Knowledge (e,g., SCI, SSCI) were counted as one.

3.5 | Terminology used for citation tracking methods

We extracted the terminology that was used in the 47 studies for CT methods and for seed references. As documented in Table 4, terminology was heterogeneous and, in some instances, ambiguous.

4 | DISCUSSION

We provide the first comprehensive analysis of the use and benefit of CT in systematic literature searching. Focusing on health-related literature, we identified 47 methodological studies. CT is a research method that has been used for systematic literature searching for almost 40 years. Nevertheless, detailed methodological guidance for its use and reporting in evidence retrieval is largely missing. The present scoping review which maps the current evidence on CT is the first milestone in a larger research endeavor to develop such guidance.[11]

Of the 47 methodological studies that we identified, 45 assessed the benefit of CT and 43 of these found added value of CT for evidence retrieval. It is tempting to conclude from this that CT is paramount for systematic evidence synthesis in health-related topics. However, these

TABLE 4 Terminology used for citation tracking methods, ordered by frequency.

Citation tracking methods[a]	Terminology used	n
Umbrella term [citation tracking]	Citation searching[b]	7[41,43,47,30,31,35,66]
	Citation tracking[b]; tracking citations	5[40,45,71,41,43]
	Citation-based searching/techniques	4[41,43,31,67]
	Snowballing[b]	4[37,55,26,39]
	Using/mining a citation network/relationship/link	3[29,30,47]
	Citation chasing	1[35]
	Citation mapping	1[26]
	Citation mining	1[30]
	Citation method	1[30]
	Retrieval of the citation space of the seed article	1[67]
	Extracting citations and reference lists	1[41]
	Applying citation discovery tools	1[28]
	Gleaning references	1[56]
	Bidirectional citation searching	1[39]
	Citation search strategies	1[53]
	Using citation search methods	1[31]
Finding cited references [backward citation tracking]	Searching/checking/examining/gleaning/scanning/reviewing/extracting reference lists	23[27,30,31,33,34,36,37,39,41,43,46,48,52,56–58,64–66,68,69,71,72]
	Checking references; reference checking	5[44,36,65,72,64]
	Backward citation tracking; tracking backward citations	4[45,40,71,43]
	Reference tracking	4[37,39,64,65]
	Backward citation searching	3[39,49,66]
	Backward searching /searching backward	3[38,32,34]
	Checking/following citations	3[44,70,29]
	Reference searching	3[32,38,52]
	Using/retrieving cited references	3[63,26,31]
	Citation tracking[b]/tracking citations	2[34,33]
	Identifying references cited; searching cited references	2[59,70]
	Pursuing references of references	2[37,33]
	Snowballing[b]	2[33,34]
	Reviewing/checking bibliographies	2[48,49]
	Backward chaining	1[47]
	Backwards citation chasing	1[35]
	Checking citation lists	1[36]
	Checking the citations of papers	1[55]
	Citation retrieval[b]	1[69]
	Hand searching references	1[54]
	Reference harvesting	1[49]
	Reference retrieval	1[67]
	Reviewing publication references	1[48]
	Tracking down items cited in the bibliographies	1[60]
	Using backward citations	1[31]

(Continues)

TABLE 4 (Continued)

Citation tracking methods[a]	Terminology used	*n*
Finding citing references [forward citation tracking]	Citation searching[b]	12[52,59,63,60,61,64,72,49,50,53,55,65]
	Citation retrieval[b]	7[62,59,63,60,61,67,53]
	Forward citation tracking; tracking forward citations	6[34,40,45,71,72,43]
	Forward citation searching	6[27,39,46,49,51,66]
	Citation tracking[b]	5[32,72,37,39,46]
	Forward searching; searching forward	3[38,32,34]
	Forward citation chasing	2[51,66]
	Cited reference searching	2[71,50]
	Retrieving citing documents	2[66,30]
	Forward tracking	1[37]
	Searching documents that cite key documents	1[31]
	Using forward citations	1[31]
	Using the 'cited by' citation discovery tools	1[28]
	Providing a list of articles that cited the article of interest	1[28]
	Identifying studies that cited a prior identified study	1[38]
	Following citations	1[29]
	Forward chaining	1[47]
Umbrella term for indirect citation tracking	Co-citation searching[b]	1[31]
	Co-citation retrieval	1[40]
	Using co-citation network analysis	1[26]
Finding co-cited references [co-cited citation tracking]	Co-citation searching[b]/clustering; using/retrieving co-citations	8[41,43,42,31,62,63,61,53]
	Retrieving/identifying co-cited papers/articles/documents; obtaining co-cited articles/document clusters	6[30,67,42,63,62,53]
	Retrieving documents co-cited with the key documents	1[31]
Finding co-citing references [co-citing citation tracking]	Bibliographic coupling	7[30,31,43,42,61,63,47]
	Co-citing papers/articles retrieval	2[30,67]
	Citation cycling	1[47]
	Retrieving documents co-citing the key documents	1[31]
Relevant articles known beforehand [seed references]	Key; Key papers/articles/sources/documents/references/citations/older works/publications; access/search keys	13[59–63,30,31,37,53,54,42,72,33]
	(Known) relevant resources/papers/documents/references/publications/studies/items; paper known to be relevant	12[49,33,31,34,39,60,59,62,47,43,41,72]
	Seed papers/articles/documents/references	7[60,61,63,67,47,30,31]
	Source articles/documents/papers/items/files/records	4[59,63,66,53]
	Query set/articles	2[41,43]
	Reference set	1[36]
	Base set	1[49]
	Initial set (of papers)	1[26]
	Pertinent papers	1[48]
	Accepted papers	1[52]
	Primary references	1[26]
	Pearls	1[39]
	Core set	1[49]

TABLE 4 (Continued)

Citation tracking methods[a]	Terminology used	*n*
Iterative repetition of a citation tracking method [citation tracking iterations]	Repeating the process/steps/(citation) search	5[30,34,39,43,41]
	Iterations/iterative (citation) searching/search methods	5[30,32,39,43,47]
	Citation searching to completion	1[39]
	Snowballing	1[39]
	Starting another round	1[40]
	Re-running the (citation) search	1[41]
	Stepwise checking of references	1[44]
	Consequent checking of references	1[44]
	Applying algorithm to the documents obtained at the prior level	1[29]

Abbreviation: CT, citation tracking.

[a]Square brackets denote the terms that were used in our protocol and final review report.

[b]Term was used ambiguously.

numbers should be interpreted with caution: First, included studies displayed highly heterogeneous methodological and topical characteristics that could influence the benefit of CT (e.g., unit of analysis in included studies, quality of comparator search method, health topic, CT methods used, number of CT iterations, or citation indexes and tools used). Second, studies not finding a clear benefit of CT (2/45 in our study) may be underrepresented due to publication bias. Researchers who applied CT but did not find an added value may be less likely to publish their results in a methodology paper.

Based on these considerations, it is important to highlight the specific features and conclusions of the two studies that reported no added value of CT.[71,72] Westphal et al. conducted a systematic review of randomized controlled trials on the efficacy of psychotherapeutic, pharmacological, and combined interventions in the treatment of chronic depression. They searched seven bibliographic databases and identified 2417 unique records. The authors also performed a variety of supplementary search methods yielding >27,000 records. They concluded that hand-searching contents of relevant journals and screening reference lists of related systematic reviews were effective but backward and forward CT on included records using SCI and SSCI was not because it did not lead to any further inclusion of primary studies.[71] Wright et al. performed six sensitive database searches yielding almost 22,000 records on interventions targeting change in at least two risk behaviors. Their scoping review searches were complemented with laborious forward CT on the 40 included papers in Google Scholar, Scopus, Web of Science, and Ovid MEDLINE. This elaborate CT search found only one eligible paper that was not previously identified by database searching. The authors concluded that "citation searching as a supplementary search method for systematic reviews may not be the best use of valuable time and resources."[72]

While it would be desirable for researchers to know exactly in which situations a possible added value of CT would or would not outweigh the increased workload that comes with it, a clean categorization is currently not possible. But analyzing the contexts of the eligible CT studies, we may have found other factors that could play a role. For instance, CT may be less beneficial in situations where researchers operate with clearly defined clinical interventions as part of Participant-Intervention-Comparison-Outcome (PICO)-questions than with hard-to-search-for topics such as non-clinical interventions or policymaking questions.[37] Concerning potential correlations between research topic and added value of CT, we realized that "CT for systematic literature searching" was a hard-to-search-for topic when we composed the search strings for this scoping review. Thus, sensitive versions of database search strings would have returned far too many results, necessitating pragmatic search decisions (see section limitations). Consistent with the above observations, 40% of our included studies derived from applying CT as a supplementary search method and critically added value to our work. But taking a bird's eye view and as outlined by Horsley et al.,[76] it is currently challenging for reviewers to recognize situations when database searches are not sufficiently exhaustive and should be supplemented by CT methods.

CT was conducted as a primary/stand-alone search approach instead of a supplementary search method in almost half of the methodological studies collected in this scoping review. Using CT as a primary/stand-alone method rarely finds as many relevant articles as using a database search as the primary method.[30,43,42,39,45,50,51,53,62,67] This leads us to the conclusion that primary/stand-alone CT appears not to be sensitive enough for systematic reviews and scoping reviews or their updates. Having said that, optimized primary/stand-alone CT methods may prove an interesting alternative to database searching for narrative, rapid, or systematized reviews and for researchers composing research-in-context assessments or grant applications. For complex topics that are unamenable to subject searches (see above), primary/stand-alone CT techniques could also be considered as a pragmatic workaround search approach.

Concerning different CT methods, we found that almost five times as many methodological studies assessed direct as indirect CT. Out of direct CT assessments, about as many studies as have assessed forward have also examined backward CT. Since backward CT is the oldest CT method and used far more frequently than forward CT,[15] we were surprised that there were not more methodology papers assessing it. It is likely that reviewers who apply backward CT do not usually analyze the results of it in a separate methodology paper. Indirect CT showed great potential for health-related evidence retrieval.[30,42,43] However, since all of the included studies that evaluated indirect CT evaluated it as a primary/stand-alone method, we propose further research on its use as a supplementary search method before developing recommendations for applicability and conduct.

Furthermore, while some outputs of forward and backward CT can be extraordinarily high depending on the number of seed references and their citations, the problem of a potentially unfeasible number of results is clearly aggravated by using indirect CT methods. While there are currently some tools that allow for ranking by number of shared citations or relevances,[42,67,30,31] we are not aware that there is currently a commonly accepted approach that allows researchers to omit some of the screening load. Such omissions could be part of the retrieval (e.g., articles with fewer shared citations will be omitted from the results) or part of the subsequent screening (e.g., after excluding a certain amount of relevancy-ranked consecutive ineligible articles, screening stops and remaining articles will be omitted). Ranking methods and stopping rules require further research and probably a paradigm change from having to screen everything to well thought-out omission of some articles.

Almost all included studies used only one citation index for CT, most commonly SCI and SSCI. However, studies that used multiple citation indexes in parallel found that the results of the different indexes complemented each other.[72,49,66] Collecting CT results systematically from several citation indexes therefore enhanced the coverage of citations which is somewhat reminiscent of the complementary effect of using multiple databases for searching. This applies to both forward and backward CT. Backward CT is still frequently being performed manually by screening reference lists. However, performing backward CT using electronic citation indexes in combination with reference management software is preferable, since it allows deduplication of the references against each other and against the results of the primary search as well as effective title and abstract screening.[33,77]

Only a minority of systematic reviewers perform CT iterations. Three of the included methodological studies that performed CT iterations reported unique relevant publications that were identified only during the second or third CT iteration.[39,44,41] In our scoping review, we performed three CT iterations. The first iteration yielded 20 papers. Although the second iteration, based on those did not yield any new eligible references, it did identify a SuReInfo chapter[78] and a precursor paper of one of our includes[53] that so far escaped our searches and were used as seed references for a third CT iteration. The third iteration yielded no more relevant papers. Thus, there is evidence that conducting CT iterations can contribute to the comprehensiveness of a systematic search.

Only a few identified methodological studies reported specific software tools for CT automation. While CT automation could be more time-saving and practical in general, detailed assessments would be needed to measure time-savings, recall or potential costs. During the finalization of this scoping review, two new and publicly available tools have been published: the *citationchaser*[79] for automated forward and backward CT and the *Citation Cloud* PubMed extension[80] for automated forward, backward, co-cited, and co-citing CT. Since such tools are born from the digital advancements of recent years which keep improving, there may be more tools and respective studies in the future.

On a more general note, we found that the reporting of CT methods is frequently unclear and far from standardized. A possible reason for this could be the lack of specific guidance for the conduct and reporting of CT as current gold-standard guidelines for systematic reviews are relatively lax as far as CT is concerned.[2,15,81] High heterogeneity is also reflected by the obvious nonuniformity of CT terminology. Several terms are used ambiguously, and it is often unclear what they stand for. For example, "citation searching," "snowballing," or "co-citation searching," are sometimes used for the methodological umbrella term but also for a specific method such as backward or forward CT. Furthermore, CT methods can be used for more than retrieval of studies for evidence syntheses. For example, bibliometric research also uses CT methods to explore citation networks based on authors, institutions, countries, or topics.[47,81–83] These alternative user scenarios may partly explain the existence of various terms that can be used for CT methods.

A rich albeit heterogeneous evidence landscape exists regarding the use of CT in health-related systematic literature searching which spans decades of common practice. The present scoping review is a first attempt to systematically synthesize this evidence. Our results make a strong case for the urgent need for evidence-based and researcher-approved guidelines for the use of CT.

4.1 | Limitations

Our scoping review has several limitations. First, we did not consider articles that were at preprint status at the time of study selection,[84] which would have led to the inclusion of further studies,[85] nor did we exhaustively search for unpublished studies. Second, during the work on this review, we became aware of "bibliographic coupling" as a relevant term that was missing from our search strategy, which possibly led to the omission of eligible articles and should be reconsidered for updates of this review. Third, our decision to limit the Web of Science search to pertinent Web of Science Categories and Research Areas was pragmatic and potentially incompatible with systematic retrieval. Fourth, we did not assess the quality and sensitivity of the database searches in included studies. This could be considered in future studies since the quality and sensitivity of database searching as a primary or comparator search method may indirectly influence the effectiveness of CT. Fifth, the dichotomous way we scored "added value yes/no" from heterogeneous data as a composite outcome of author statements and our own definition of added value neither reflected the size of that value (e.g., how many more (unique) eligible references does CT find than the comparator?) nor its usefulness (e.g., does finding these extra studies change the results of meta-analysis?). Sixth, we restricted eligibility to methodological studies with a focus on CT as an evidence retrieval method. This almost certainly led to the neglect of (systematic) reviews with an implicit evaluation of the benefit of CT, for example, as indicated by the detailed documentation of article retrieval sources.[86] Seventh, as our scoping review's eligibility was restricted to health sciences, we neglected the methodological studies of other fields that assessed CT. While the benefits of CT could differ between fields (as it likely does between topics), our main reason for this restriction was feasibility, for example, to reduce the massive amounts of search results. Hence, the list of identified methodological studies and software tools is clearly not exhaustive.[87,88] Finally, we did not request information about the isolated results of CT from authors who applied and evaluated several supplementary search methods together. This might have led to the inclusion of a few further studies[89–91] and should be considered for updates of this review.

5 | CONCLUSIONS

Our scoping review features a broad body of studies investigating the use of CT as a literature search method for health-related topics. We found large heterogeneity regarding its application, terminology, and reporting. Despite CT adding value in most of the identified studies, that value was relative to each individual situation and its extent could not be assessed with certainty. However, the usefulness of CT seems to depend on multiple factors including the research topic and feasibility/appropriateness of a primary database search. Our results support the use of multiple citation indexes in parallel and the conduct of several CT iterations but discourage from primary/stand-alone CT in systematic literature searching. Indirect CT methods show great promise but require further research on refinement to be feasible. Based on our results and conclusions, we plan a Delphi study to develop consensus recommendations for the use and reporting of CT.[11]

6 | REQUIRED SECTION

6.1 | What is already known

Citation tracking (CT) is an umbrella term and can be sub-categorized into direct and indirect CT methods. The added value of any form of CT to systematic literature searching is not clear.

6.2 | What is new

The benefit of CT likely depends on multiple factors that could not be assessed with certainty by synthesizing the collected evidence. Ample methodological heterogeneity among CT studies exemplifies the strong need for approved guidelines for conduct and reporting of CT.

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

For systematic reviews and other study designs aiming at a comprehensive retrieval of available evidence, the use of forward and backward CT on eligible articles should be considered as supplementary search methods. For non-systematic literature retrieval, any form of CT as a primary/stand-alone search approach that is based on articles that are already known can be a valuable strategy.

AUTHOR CONTRIBUTIONS

All authors made (1) substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data, (2) drafted the article or revised it critically for important intellectual content, and (3) finally approved the version to be published.

CONFLICT OF INTEREST STATEMENT

None declared.

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DATA AVAILABILITY STATEMENT

Data analyzed in this review is contained in the manuscript, its supporting information (raw data set, see journal online content), or available on searchRxiv (database-specific search strings, accessible via https://doi.org/10.1079/searchRxiv.2023.00109 [MEDLINE], https://doi.org/10.1079/searchRxiv.2023.00105 [CINAHL], https://doi.org/10.1079/searchRxiv.2023.00106 [Library Literature & Information Science Full Text], https://doi.org/10.1079/searchRxiv.2023.00107 [Library, Information Science and Technology Abstracts], and https://doi.org/10.1079/searchRxiv.2023.00108 [Web of Science Core Collection]).

ETHICS STATEMENT

Not necessary for this study.

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