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Use of Artificial Intelligence in the Identification and Management of Frailty: A Scoping Review Protocol

Sathya Karunananthan ,[1,2] Arya Rahgozar,[3,4] Ramtin Hakimjavadi,[2,5] Hui Yan,[2,5] Kunal A Dalsania,[1,2] Howard Bergman,[6] Bishwajit Ghose ,[7] Jim LaPlante,[8] Tess McCutcheon,[9] Daniel I McIsaac ,[10] Samira Abbasgholizadeh Rahimi ,[6] Nadia Sourial,[11,12] Manpreet Thandi,[13] Sabrina T Wong ,[13] Clare Liddy [4,9]

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For numbered affiliations see end of article.

Correspondence to
Dr Sathya Karunananthan; skarunan@uottawa.ca

ABSTRACT

Introduction Rapid population ageing and associated health issues such as frailty are a growing public health concern. While early identification and management of frailty may limit adverse health outcomes, the complex presentations of frailty pose challenges for clinicians. Artificial intelligence (AI) has emerged as a potential solution to support the early identification and management of frailty. In order to provide a comprehensive overview of current evidence regarding the development and use of AI technologies including machine learning and deep learning for the identification and management of frailty, this protocol outlines a scoping review aiming to identify and present available information in this area. Specifically, this protocol describes a review that will focus on the clinical tools and frameworks used to assess frailty, the outcomes that have been evaluated and the involvement of knowledge users in the development, implementation and evaluation of AI methods and tools for frailty care in clinical settings.

Methods and analysis This scoping review protocol details a systematic search of eight major academic databases, including Medline, Embase, PsycInfo, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Ageline, Web of Science, Scopus and Institute of Electrical and Electronics Engineers (IEEE) Xplore using the framework developed by Arksey and O'Malley and enhanced by Levac *et al* and the Joanna Briggs Institute. The search strategy has been designed in consultation with a librarian. Two independent reviewers will screen titles and abstracts, followed by full texts, for eligibility and then chart the data using a piloted data charting form. Results will be collated and presented through a narrative summary, tables and figures.

Ethics and dissemination Since this study is based on publicly available information, ethics approval is not required. Findings will be communicated with healthcare providers, caregivers, patients and research and health programme funders through peer-reviewed publications, presentations and an infographic.

Registration details OSF Registries (https://doi.org/10.17605/OSF.IO/T54G8).

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ In order to ensure systematic and transparent methods that are aligned with the most current guidance for scoping reviews, this protocol is guided by the Arksey and O'Malley methodological framework and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis extension for Scoping Reviews (PRISMA ScR) tool.
⇒ The use of integrated knowledge translation for the protocol development ensures that it will generate information that is relevant to knowledge users.
⇒ The research questions, search strategy and data charting methods are informed by an interdisciplinary team of clinicians, AI experts and systematic review methodologists.
⇒ Systematic methods have been described to identify and select studies, but their methodological quality will not be assessed.
⇒ This scoping review protocol is restricted to studies that explicitly use the terms 'frail' or 'frailty' to describe the study population, thereby excluding studies about populations living with frailty but not identified using these specific terms.

INTRODUCTION

Frailty is defined as a state of increased vulnerability to adverse health outcomes arising from multiple impairments in the physical, cognitive, psychological, nutritional and/or social domains.[1 2] Frailty can be conceptualised as a continuum with a series of intermediate stages that may be reversible.[3] With appropriate screening, identification and/or assessment of frailty, an upstream and proactive approach can be taken to prevent or delay decline.[4]

Though routine population screening for frailty has not been recommended,[5 6] there is evidence that case-finding strategies with appropriate tools could be beneficial.[7 8] The lack of agreement on an operational definition

for frailty,[9] however, has led to the development of many different measurement tools and identification criteria, hindering the evaluation of evidence-based interventions.[10–13] Given the time-intensive nature and substantial variability of the current methods for frailty identification,[14 15] healthcare providers often fail to identify frailty at the early stages, leading to missed opportunities for timely intervention and potential prevention of adverse health outcomes.[16 17]

The integration and analysis of electronic medical records and other digital data sources present the potential for early detection of frailty.[18–21] Leveraging the increasing availability of these data sources could provide benefits for a much wider group of people, by moving beyond reliance on the one-on-one interactions between the clinician and patient. Health service planning and community programming targeted towards those identified at the early stages could lead to improved functional status, thereby delaying progression of frailty and onset of adverse outcomes.[22] The use of artificial intelligence (AI) techniques may support early recognition of the signs and symptoms of frailty, which can help initiate care plans to address the needs of adults living with frailty in a timely manner to promote overall health and improve the quality of life for patients.[23–25]

The utilisation of AI is currently being explored by healthcare payers, providers and numerous health-related industries in a variety of ways,[26 27] most commonly to support diagnosis, monitoring, care, patient engagement and adherence, and medical administrative activities. The recent advances in deep learning, inspired by biological computing and brain-like capabilities of neural networks, have opened the door to new opportunities in addressing complex clinical challenges.[28–31] AI methods are being developed, tested and implemented to individual patient data generated either through the monitoring of their activities or through digital health information, with the objective of improving efficiency in the early identification or management of frailty.[32 33] By providing healthcare professionals with supplemental information about their patients' needs, these AI applications can enable better informed decision-making, thereby promoting more proactive, patient-centred care.

A growing number of studies are focusing on the classification and prediction of frailty through the application of AI to various types of patient data.[34] A cursory PubMed search combining the terms AI and frailty reveals an exponential increase in the number of publications on this topic over the last 5 years (figure 1). However, due to the inconsistencies in the conceptualisation of frailty,[35] there exist significant disparities in the methods and results across studies. Similarly, the range of AI approaches may also be extremely broad, with important potential differences in terms of their objectives and methods. Moreover, it is unclear whether and how knowledge users including clinicians, patients and caregivers and policy makers, have been engaged in this emerging area to ensure that it meets their needs. To address these gaps, this protocol describes a scoping review that aims to provide a comprehensive overview of current evidence regarding the development and use of AI technologies for the identification and management of frailty. Specifically, we will focus on clinical tools and frameworks of frailty used, the outcomes assessed and the involvement of knowledge users.

To our knowledge, no systematic literature review on the topic of AI and frailty has been conducted to date.

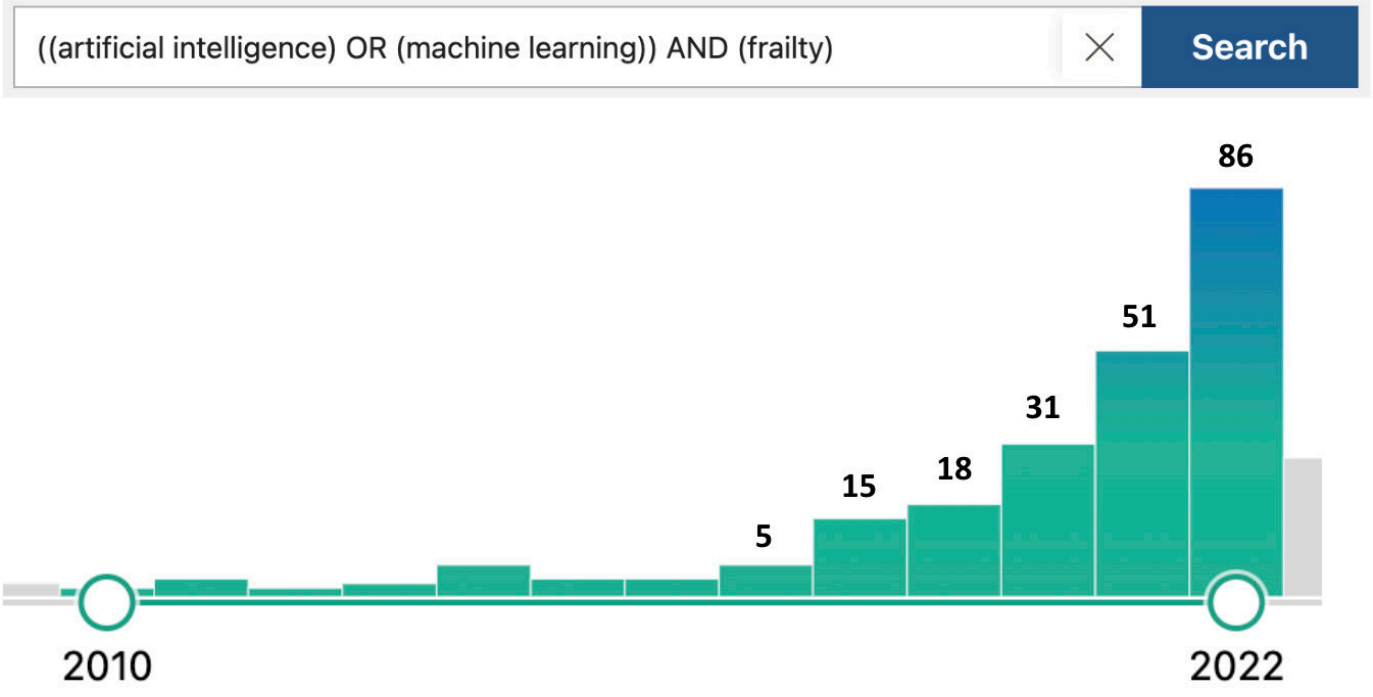

Figure 1 Number of publications related to artificial intelligence and frailty indexed in Medline between 2010 and 2022.

In a recent narrative review examining machine learning methodologies for frailty screening, Oliosi and colleagues summarised the results of six publications on the topic and identified notable heterogeneity in the frailty definitions and AI methods used.[36] Building on this recent work, we are adopting a scoping review methodology which will cover a much broader range of topics from the literature on AI and frailty. Our review will include a systematic search of published and grey literature, thereby including many more references and a more comprehensive overview of the literature in this area than what was presented in Oliosi *et al*'s narrative review.

We anticipate that the proposed synthesis will inform researchers, healthcare providers, policy makers as well as patients and their caregivers in understanding the current scope of work in the intersecting fields of AI and frailty. By offering insights into the current state of research and applications, this proposed review will facilitate informed decision-making and guide future work in this field. In this protocol, we provide detailed methods for the scoping review on the use of AI for the identification and management of frailty. A separate publication will present the review outcomes once the review has been completed.

METHODS AND ANALYSIS

Patient and public involvement

We have adopted an integrated knowledge translation approach for the conduct of this scoping review protocol. Our team is comprised of a core writing group which includes the lead author (SK) and three other team members (KAD, RH, HY), along with a team of coauthors who are content area experts and knowledge users, including a caregiver partner, primary care providers, medical specialists, medical trainees, leads of health service data systems being analysed using AI as well as AI and frailty researchers. All team members provided input on the research questions, the scope of the study and the protocol. They are all coauthors on this protocol and will continue to remain involved throughout the data collection, analysis, interpretation and dissemination phases of this work. We will report on knowledge user involvement using the GRIPP2 Short Form.[37]

Protocol design

This scoping review protocol is registered in Open Science Framework (OSF) (https://doi.org/10.17605/OSF.IO/T54G8).[38] The approach established by Arksey and O'Malley,[39] which was further extended by Levac *et al*[40] and the Joanna Briggs Institute,[41] will guide the scoping review protocol methods. We have modified the six-stage methodological framework by incorporating knowledge user engagement at every stage of the process (figure 2). Furthermore, bidirectional arrows are used to indicate the iterative nature of scoping review methods. The study activities have been planned to take place between July 2023 and August 2024.

Stage 1: Identifying the research questions

During the project's inception, a meeting of all coauthors was held, during which the core writing group presented an overview of the motivation for conducting a literature review on AI and frailty. The team members agreed on the impetus for this review, as well as the overarching aim of describing the extent and nature of the literature on AI and frailty and the use of scoping review methodology to accomplish this. During the meeting, they proposed and discussed specific research questions of interest for the review. Subsequently, the writing group summarised the comments and formulated three questions based on the meeting discussion. These questions were circulated by email for feedback, refinement and approval by the

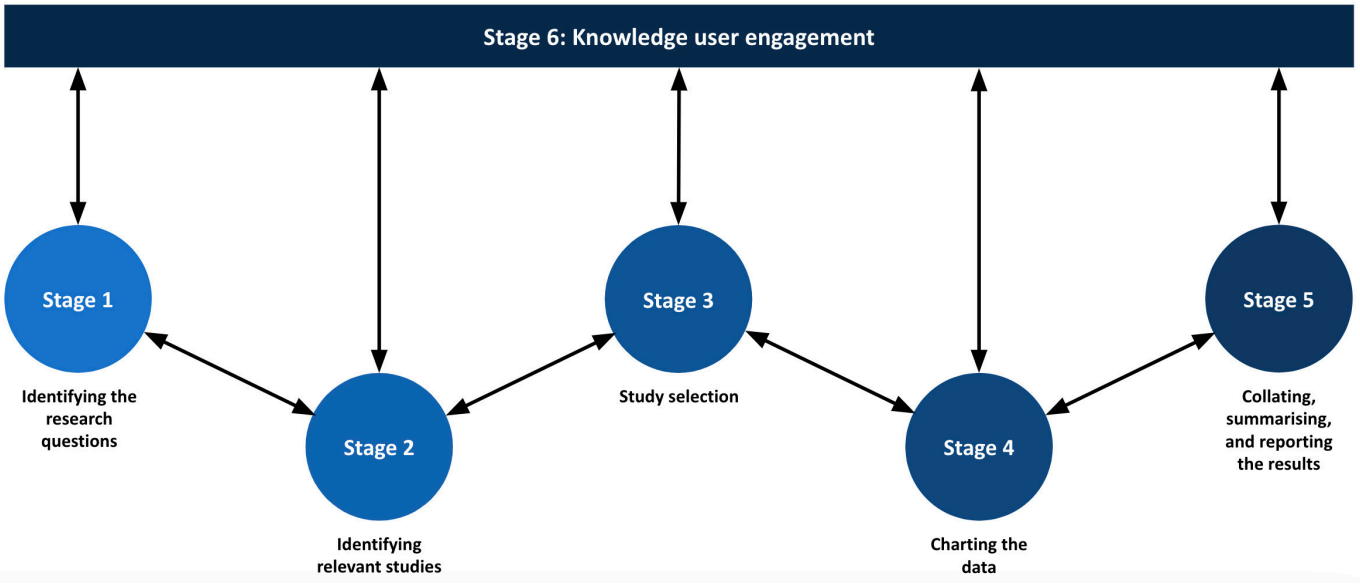

Figure 2 Six stages of the scoping review, adapted from the Arksey and O'Malley framework.

whole team. Through this process, the following questions were agreed on by the team:

1. What clinical tools or conceptual frameworks of frailty are being used as reference standards in training AI algorithms for use in clinical settings?
2. What outcomes are assessed when applying AI to frailty identification and management in clinical settings?
3. In the development and evaluation of AI for frailty in clinical settings, which knowledge users have been engaged and how?

While these questions provide the general direction for our scoping review protocol, team members expressed interest in exploring other areas within the literature on AI and frailty, including:

- Barriers to the use of AI for frailty
- The type of information used (biomedical, social, behavioural)
- Nature of the dataset (eg, size, data cleaning or preparation methods)
- Measures of predictive accuracy used in the evaluation of AI for frailty
- Bias in training AI models with narrowly conceptualised definitions of frailty
- Geographical distribution of AI applications for frailty
- Areas of healthcare delivery for applications of AI and frailty
- Application of privacy legislation and patient/caregiver permission
- Possible ageism created or perpetuated through applications of AI for frailty

These topics will be included as items in the data charting form and presented as findings of the scoping review. In addition, given the iterative process of formulating research questions for scoping reviews, the proposed questions may be expanded or modified at later stages of the scoping review, as indicated by the bidirectional arrows in figure 2.

Stage 2: Identifying relevant studies

Definitions

There is no consensus on the definition of frailty.[13] Since one of the objectives of this review is to document the tools and conceptual frameworks used in training AI algorithms, we will include all definitions and conceptualisations of frailty where authors use the term 'frail' or 'frailty'. Related concepts such as functional limitations, disability, vulnerability and specific conditions related to frailty such as sarcopenia will only be included if authors explicitly use the term 'frail' or 'frailty' in their research questions or objectives or in the description of their study population.

Likewise, AI technologies in medicine can exist in many forms.[42] Here, we are adopting a definition of AI proposed by the Council on Artificial Intelligence of the Organisation for Economic Co-operation and Development (OECD)[43] and endorsed by the World Health Organization's first global report on AI in health[44] as our operational definition: 'An AI system is a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy'.

Literature searches

The core writing group, guided by existing systematic and scoping reviews related to AI[45] and frailty[12 46–49] and in consultation with a health sciences librarian at the University of Ottawa, collaboratively developed the search strategy and inclusion/exclusion criteria. The larger team of researchers and knowledge users provided input to further refine the searches and selection criteria to ensure alignment with our research topic and specific questions. Given the exploratory nature of scoping reviews, the search strategy and eligibility criteria may be refined iteratively as we explore and learn more about the landscape of the literature.

The following eight electronic databases will be searched: Medline, Embase, PsycInfo, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Ageline, Web of Science, Scopus and Institute of Electrical and Electronics Engineers (IEEE) Xplore. These databases were selected in consultation with the health sciences librarian to ensure that the breadth of medical-related and technology-related concepts pertinent to the review (ie, frailty and AI) were adequately covered.

The search strategy has been developed in Medline (Ovid) and translated for other databases (see Appendix A in online supplemental material 1 below). When available, subject headings such as MeSH and Emtree terms will be used. In this scoping review protocol, the major concepts are 'Artificial Intelligence' and 'Frailty'. These concepts will be used to select subject headings as well as keywords. Table 1 and Appendix B in online supplemental material 1 provide lists of subject headings and keywords.

We will also search the grey literature (eg, theses and dissertations, research and committee reports, government reports, conference papers). Sources of grey literature will include dissertations, databases,[50–52] websites of governments and health organisations (eg, StatCan, World Bank database), GreyNet International (https://www.greynet.org/) and OpenGrey (OPENGREY.EU), the largest grey literature database for biomedical and social sciences.

We will implement a dedicated search plan to incorporate the grey literature sources, adapting the methods outlined by Godin *et al*.[53] When searching sources that provide search functionalities and filters, such as grey literature databases, the same search terms used in the academic database search (Appendix B in online supplemental material 1) will be modified to fit the grey literature source. To find relevant websites of governments and health organisations to browse, we will solicit recommendations from content experts and knowledge users within our research team.

Table 1 Subject headings related to artificial intelligence and frailty

Artificial intelligence	Frailty
Artificial Intelligence	Frailty
Machine Learning	Frail Elderly
Deep Learning	
Supervised Machine Learning	
Support Vector Machine	
Pattern Recognition, Automated	
Unsupervised Machine Learning	
Sentiment Analysis	
Computer Heuristics	
Expert Systems	
Fuzzy Logic	
Knowledge Bases	
Natural Language Processing	
Neural Networks, Computer	
Robotics	
Medical Informatics Applications	
Decision Making, Computer-Assisted	
Diagnosis, Computer-Assisted	
Therapy, Computer-Assisted	

Stage 3: Study selection

Articles returned by the academic searches will be imported and deduplicated in Covidence.[54] Titles and abstracts will be screened independently by two reviewers based on inclusion and exclusion criteria. Full texts will be retrieved for titles or abstracts that meet inclusion criteria, as well as those for which there is doubt about eligibility. The full-text reports will then be independently screened by two reviewers to assess their relevance, and disagreements will be resolved through discussion. When the reviewers are not able to agree, a third reviewer will be consulted, until a complete consensus is reached.

Experimental, observational and qualitative study designs will be considered for inclusion in our review. The eligibility criteria for study inclusion are presented in table 2. These criteria were developed by the core writing group, in consultation with the full author team and based on prior reviews in the areas of frailty[55 56] and AI.[45] Once data collection begins, modifications may be made to these criteria to ensure they adequately capture relevant reports.

Prior systematic reviews of frailty have used varying age cut-offs to define the study populations.[12 46] Given that frailty can be prognostically important at both early and later stages of life, we will include studies of adult populations aged 18 years and above.[57]

Relevant results of the grey literature search will be exported to an Excel spreadsheet, and duplicates will be excluded through the built-in 'remove duplicates' function. Items from different sources will be kept separate on different sheets of the Excel spreadsheet. The titles of all items will be screened independently by two reviewers in Excel using the same eligibility criteria (table 2). Abstracts, executive summaries or tables of contents of items will be considered when available.[53] Discrepancies will be resolved through discussion and in consultation with a third reviewer as needed.

Stage 4: Charting the data

We have created a data charting form based on the research questions and areas of interest put forward by our team of knowledge users (Appendix C in online supplemental material 1). The form is also informed by previous scoping reviews in the areas of AI and frailty.[12 45 46] The data charting form will be piloted by three reviewers using two relevant studies to ensure clarity of the items and good agreement between reviewer extractions. Additional piloting will be done if agreement between reviewer extractions is poor or important modifications to the form are needed. If new areas or items of interest emerge during the literature review, they may be added to the form. Two reviewers will chart the data independently and discuss discrepancies that arise. If discrepancies between reviewers cannot be resolved, a third reviewer will be consulted.

Stage 5: Collating, summarising and reporting the results

Results will be summarised descriptively and thematically while adhering to the PRISMA-ScR guidelines for reporting.[58] Descriptive findings will include demographical characteristics of the sample populations, country of research and bibliometric information such as

Table 2 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Addresses the identification or management of individuals with living frailty	Published in a language other than English or French
The term frailty is defined and used in the statement of the research question or purpose or in the description of the study population	Application of artificial intelligence is in settings outside the clinical setting (eg, monitoring patients' function in their homes)
Relates to the development, implementation and/or evaluation of artificial intelligence in a clinical setting	
Study population includes adults only	

publication year and number of citations. We will report on the reference standard for frailty used to define the population, description of the AI method, nature of the dataset (eg, size, data cleaning or preparation methods), the outcomes assessed, knowledge user engagement, healthcare setting of the study or intervention and other variables listed in Appendix C (online supplemental material 1) or identified iteratively as we review the literature. Depending on the volume and interconnectedness of included studies, additional bibliometric analysis may be conducted to explore cocitation networks among authors and countries, using the open-licence software VosViewer.[59]

We will also provide a thematic summary of the included studies to highlight key themes emerging from the literature. This will be achieved through inductive thematic analysis as outlined by Braun and Clarke.[60]

Stage 6: Knowledge user engagement

This step allows for knowledge user participation, resulting in insights that go beyond what has been described in the literature. Using an integrated knowledge translation approach, this scoping review protocol was codesigned by a multidisciplinary team, with ongoing involvement of knowledge users at every stage described above. Knowledge users, including a caregiver partner, healthcare providers and AI developers, are actively involved throughout the review process, starting from the development of the research questions to the review of the study methods, the interpretation of the findings and the dissemination of the results.

DISCUSSION

The use of AI in medicine is revolutionising healthcare.[42 44] However, applications of this emerging technology in frailty are still in the early stages and have not been comprehensively described. Given the lack of agreement on a definition of frailty, applications of AI for frailty may be particularly diverse compared with those for other health conditions. Summarising the rapidly emerging research in this area will provide important insights into the approaches that are being used, the gaps and limitations of this work and avenues for future research.

Ethics and dissemination

Given that this is secondary research based on publicly available information, ethics approval is not needed. The findings of this review will be communicated with healthcare providers, caregivers, patients, as well as research and health program funders, primarily through peer-reviewed publication in a scientific journal and presentations at conferences.

Author affiliations
[1]Interdisciplinary School of Health Sciences, University of Ottawa, Ottawa, Ontario, Canada
[2]Bruyere Research Institute, Ottawa, Ontario, Canada
[3]The Ottawa Hospital Research Institute, Ottawa, Ontario, Canada
[4]Department of Family Medicine, University of Ottawa, Ottawa, Ontario, Canada
[5]Faculty of Medicine, University of Ottawa, Ottawa, Ontario, Canada
[6]Department of Family Medicine, McGill University, Montreal, Quebec, Canada
[7]Faculty of Health Sciences, University of Ottawa, Ottawa, Ontario, Canada
[8]Care Partner, Ottawa, Ontario, Canada
[9]C.T. Lamont Primary Health Care Research Centre, Bruyère Research Institute, Ottawa, Ontario, Canada
[10]Anesthesiology and Pain Medicine, The Ottawa Hospital, Ottawa, Ontario, Canada
[11]Department of Health Management, Evaluation & Policy, Université de Montréal, Montreal, Québec, Canada
[12]Research Center of the Centre Hospitalier de l'Université de Montréal, Montreal, Quebec, Canada
[13]Centre for Health Services and Policy Research, University of British Columbia, Vancouver, British Columbia, Canada

Twitter Samira Abbasgholizadeh Rahimi @RahimiSamira

Contributors SK led the development of this study. All coauthors (SK, HB, KAD, RH, JL, CL, DIM, TM, AR, SAR, NS, MT, STW, HY, BG) contributed to the conception of the objectives. SK, BG, KAD, RH and HY developed the research methods and design, with comments and feedback from HB, JL, CL, DIM, TM, AR, SAR, NS, MT and STW. All coauthors read and approved the final version of this manuscript.

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Competing interests Authors of this review may also be authors of eligible studies. When that is the case, they will not have any role in the screening and selection of those studies. There are no additional conflicts of interests to declare.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

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ORCID iDs
Sathya Karunananthan http://orcid.org/0000-0002-4247-4752
Bishwajit Ghose http://orcid.org/0000-0003-4461-3821
Daniel I McIsaac http://orcid.org/0000-0002-8543-1859
Samira Abbasgholizadeh Rahimi http://orcid.org/0000-0003-3781-1360
Sabrina T Wong http://orcid.org/0000-0002-9619-9012
Clare Liddy http://orcid.org/0000-0003-0699-5494

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