Sensor applications to measure health and movement among health care personnel at workplace: A scoping review protocol

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Protocol

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Abstract

Background

The well-being and health of health care personnel is becoming increasingly important in the delivery of high-quality healthcare. Monitoring technologies provide new opportunities for the objective measurement of activities and behaviours related to well-being and health. However, these possible technologies used by health care personnel have not been fully synthesised. The overall aim of this scoping review is to examine what technologies are available to monitor health care personnel's health, well-being and activities in workplace settings. More specifically, we want to explore how, by whom and for what purposes sensor applications have been used by health care personnel at different workplace settings.

Methods

This scoping review protocol will follow Arksey's and O'Malley's methodology, complimented by the approach of the Joanna Briggs Institute to scoping reviews. Peer-reviewed literature will be identified using a search strategy developed by a librarian, and a wide range of electronic datasets of medical, computer and information systems disciplines will be used. Eligibility of the articles will be determined using a two-stage screening process consisting of (1) a title and abstract scan, and (2) a full text review. Extracted data will be thematically analysed and validated by an expert of sensor technology and a group of nurses as stakeholders. Descriptive statistics will be calculated when necessary.

Discussion

This scoping review will examine what technologies are available to monitor health care personnel's health, well-being and activities in workplace settings. The results obtained from the review will inform the suitability of monitoring technology used in health care settings, what methods are already available for use in research and technology might still be needed for future innovations. Findings of the scoping review will be published in a peer-reviewed journal.

Systematic review registration

This review was submitted in Open Science Framework on 12 December 2020.

Background

Over 59 million health care personnel work in various health care settings all over the world.(1) Current improvements in the development of health care systems and technology have increased the costs and complexity of health services.(2, 3) Changes in the ecosystem of healthcare have raised expectations of competence in personnel to manage complex work environments.(4, 5) At the same time, the well-being of health care staff continues to be at risk due to changes in work environments,(6) which have contributed negatively to staff's physical and mental health.(7–9) Good evidence already exists that the

well-being of health care personnel should be on the agendas of health care organisations as well-being among staff is an important contributor to the quality of care.(7, 10–12)

Well-documented literature has shown a variety of risk factors associated with health and well-being among health care personnel, such as heavy workloads,(11, 13, 14) organisational problems(11, 13, 15, 16) and leadership styles(2, 17–20). Problems in social environments(11) and workplace violence and harassment(2, 21, 22) have also been identified as risks for the well-being and health of personnel. These problems have been documented as resulting in physical illnesses, psychological symptoms,(23) burnout,(8) low work satisfaction(7) and quality of life, and increased sickness absence(11, 19) among personnel. Despite the strong measurement trends, awareness of personnel health and well-being in the workplace is still not ubiquitous.

Various sets of instruments for self-reported measures have already been used to measure health and well-being.(24) The most common methods are subjective survey measures.(12) Although some of these measures may be considered outdated based on current standards, a few large-scale epidemiological cohort studies have captured detailed and long-term information on psychological and social factors in conjunction with rigorous assessment of health care personnel behaviour and health.(14) Still a variety of limitations of self-measures and survey measures have been identified. Subjective measures lay on individuals' interpretations,(25) which can be affected by multiple contextual factors.(22) Assessment results can also be vulnerable due to memory biases.(12, 22, 26) Cross-sectional survey instruments can only provide data depending on the timing of the data collection.(22) In addition, low response rates may cause limitations in results.(27) Because of these limitations, more usable and updated methods for assessing health and well-being among health care personnel are needed.

The use of sensor technology is growing as it provides new opportunities for more objective, accurate, updated and ongoing measurements of real-life situations.(28–30) Technological innovations have enabled the monitoring of different tasks and activity levels more effectively and efficiently.(30) Other benefits in sensor technologies are their ability to use large sample sizes with lower costs.(29) However, adaptation of new technologies in health care settings requires positive attitudes toward technology, new skills in health care personnel, and appropriate support, especially for those who are less-motivated technology users(31) or those who belong to older generations.(32)

To avoid redundancy and to ensure the value of the current review,(33) we performed a comprehensive search for earlier systematic reviews of the JBI Database of Systematic Reviews and Implementation Reports, PubMed, and the Cochrane Database of Systematic Reviews, and found only 5 reviews that were related to personnel in any professional group. Khakurel et al.(34) described a recent trend in wearable technology, and assessed both its potential in the work environment and challenges concerning the utilisation of wearables in the workplace. They identified a total of 359 articles found, of which 34 met the selection criteria. The authors concluded that wearable technology can be used in the work environment for activities including monitoring, augmenting, assisting, delivering and tracking. Another review compared device-measured physical activity, sedentary behaviour and health across occupational

groups, including healthcare workers.(35) Two other reviews described physical activity at the workplace using both subjective and objective methods including research-grade accelerometers (e.g., activPAL™, Actigraph™, GENEActiv™), smartphone-integrated accelerometers, accelerometer-inclinometers, and activity monitors (e.g., Fitbit®, Tractivity®).(36, 37) Further, Chappel et al.(38) assessed in their review with subjective and objective measures nurses' occupational physical activity levels. The objective measurements used in the studies included heart rate monitoring, accelerometry, pedometry, and direct observation.

We also screened ongoing reviews registered in the International Prospective Register of Systematic Reviews (PROSPERO) and found two ongoing systematic reviews on monitoring practices in workplace settings. Sands et al.(39) are focusing on best practices using wearable technologies to promote workplace physical activity, while Bustos et al.(40) aim to summarise progress in the development of physiological monitoring systems for occupational applications. However, we did not find any ongoing reviews focusing on different monitoring technologies used by health care personnel in the workplace. The gap in existing and ongoing review topics provides justification for a new review.(33)

There are already numerous sensoring applications that offer potential benefits in health care settings.(34) However, little is known about how these devices could be used to continually collect large-scale data to monitor health care personnel's health and well-being. Therefore, the overall aim of this scoping review is to examine what technologies are available to monitor health care personnel's health, well-being and activity in health care settings. More specifically, we want to explore what type of monitoring technology has been used to sensor healthcare personnel in various healthcare settings, as well as how and for what purposes it was used. As we will identify certain characteristics of sensor technology and offer an overview of the nature and diversity of the knowledge available(41), a scoping review is the best method of doing so.(42) Introducing a categorised framework and the different purposes of technological devices already used in practice could help us identify which types of devices are suitable for specific purposes and specific target groups, and thereby facilitate the adoption of wearable devices in the workplace.(34) The results of this scoping review will also be used to identify existing research gaps(43) and provide evidence on the best practice for how sensoring methods could be used in future studies.

Methods

Aim

The overall aim of this scoping review is to examine what technologies are available to monitor health care personnel's health, well-being and activity in health care settings. More specifically, we want to explore what type of monitoring technology has been used to sensor healthcare personnel in various healthcare settings, as well as how and for what purposes it was used.

Research questions

In this review, we will address the following research questions:

1. What types of sensor technology have been used to measure health, well-being, physical activity and mobility among health care personnel in the workplace?
2. How have sensor applications been used to measure health, well-being, physical activity and mobility among health care personnel in the workplace?
3. For what purposes have sensor applications been used to measure health, well-being, physical activity and mobility among health care personnel in the workplace?

Protocol registration

Systematic review registration was submitted in Open Science Framework on 12 December 2020 (https://osf.io/smbxc/).

Design

In this study, a scoping review design will be used to form a conception of the use of monitoring technology among health care personnel in health care settings. As the foundation for the review, we will modify the framework of Arksey and O'Malley's(44) for scoping reviews for our purposes. It fits into our review because it enables mapping the range of research data available in the topics not earlier reviewed and identifies gaps in the existing literature. Further, the updated framework by JBI(42) will compliment Arksey's and O'Malley's(44) approach with six stages: 1) identifying the research question; 2) identifying relevant studies; 3) selecting studies; 4) charting the data; 5) collating, summarising and reporting results; and 6) consulting with stakeholders. In reporting the scoping review, we will use the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR).(45) The checklist of the PRISMA-ScR is attached as an online supplementary (File 1).

Information sources and search strategy

This scoping review will combine existing knowledge based on the published empirical studies. A comprehensive literature search will be carried out using the following relevant bibliographic electronic databases: Web of Science (provides cross-disciplinary research on social science, science, technologies, humanities and the arts), PubMed, Medline, and PsycINFO in EBSCO, ScienceDirect (provides access to papers and articles on science and technology journals), Google Scholar, Cochrane, IET Electronic Library, the IEEE Xplore (a digital database of scholarly and technical literature, which provides the abstracts and complete texts of papers on computer science, electrical engineering and electronics), and Elsevier/Engineering Village. These databases were selected as they cover scientific and technical literature and provide extensive insights into researchers' efforts in a wide range of relevant disciplines.

Search terms (or equivalent index terms and free-text words) for each database will be used to ensure a broad coverage of published studies in our review. A keywords search will be combined into a phrase including Boolean (AND, OR) terms. An example of the search terms to be used in PubMed is presented in Table 1. A manual search will also be conducted with additional references by screening the reference lists of the included articles. In addition, specific journals related to the topic (e.g., JMIR) will be searched

manually. Grey literature will not be used in this review. EndNote X7 software will be used to find and remove duplicates.

Table 1
Examples of the search terms to be used in PubMed

#	#Suchfrage
#1	"health personnel"[mh] OR "health personnel"[mh]
#2	health care personnel[tiab] OR health personnel[tiab]
#3	(delivery of health care[tiab] OR (Health Care Provider*[tiab]) OR (Healthcare Worker*[tiab])
#4	(#1 OR #2 OR #3)
#5	"Electrical Equipment and Supplies"[mh] OR "Wearable Electronic Devices"[mh]
#6	"Monitoring, Physiologic"[mh]
#7	"Monitoring, Ambulatory"[mh]
#8	"Telemedicine*"[mh]
#9	("Assistive Technology"[tiab]) OR ("Assistive Technologies"[tiab]) OR ("Telecare"[tiab])
#10	("Tele-health"[tiab]) OR ("Telemedicine"[tiab]) OR ("telehomecare "[tiab]) OR ("tele-medicine" [tiab])
#11	("ehealth"[tiab]) OR ("e-health"[tiab])
#12	("vital signs monitoring"[tiab]) OR ("vital-signs monitoring"[tiab]) OR ("vital signs"[tiab]) OR ("vital-signs or monitoring"[tiab])
#13	("mobile phone"[tiab]) OR ("cell phone"[tiab]) OR ("personal digital assistant"[tiab]) OR ("personal smart assistant"[tiab])
#14	(“Inertial sensor technology“[tiab] OR "motion sensor*" [tiab] OR movement sensor*" [tiab])
#15	(“Sensoring“ [tiab] OR "Biosensing Techniques" [mh])
#16	((#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15))
#17	"wellness"[tiab] OR "well-being"[tiab]
#18	"quality of life"[mh] OR "Health Status"[mh] OR "Personal Satisfaction"[mh]
#19	"quality of life" [tiab] OR "Health Status" [tiab] OR "Personal Satisfaction"[tiab]
#20	(#17 OR #18 OR #19)
#21	Activit*[tiab]
#22	"physical activit*”[tiab] OR "activities of daily living”[tiab] or "physical* activ*”[tiab] OR "free-living activity”[tiab]
#23	(#21 AND #22)
#24	Mobilit*[tiab]
#25	"motor activit*”[tiab] OR "social mobilit*”[tiab]

#	#Suchfrage
#26	"Social Mobility”[mh]
#27	"exp locomotion”[tiab] OR "running or walking”[tiab] OR "ambulation or functional mobility”[tiab] OR "movement”[tiab]
#28	(#24 OR #25 OR #26 OR #27)
#29	#4 AND #16 AND (#20 OR #23 OR #28)

Eligibility criteria

The review will be limited to texts published in English, with an abstract available with no time restrictions. Only peer-reviewed, published papers using a variety of designs and research methods will be included as long as the paper includes a tested monitoring method. Papers describing the design process of the sensor technology, theoretical papers, statistical reviews, books or book chapters, letters, dissertations, editorials, and study protocols will be excluded. Grey literature will not be considered for inclusion. More specifically, the review will be limited to certain studies as follows.

Participants

Any health care personnel, of any age and gender, with a variety of professional training, who are working in any health care area in patient care will be included in the review. Studies will be excluded if staff members did not have a role in patient care.

Intervention

Sensor applications can be used either in active or passive sensoring. They can be, for example, mechanical (e.g., accelometers, gyroscopes), optical (e.g., fibre optic), or semiconductor sensors (temperature sensors) to assess different domains (healthcare, wellness, or environmental domains) and networks (personal area, ambient/pervasive sensor networks, wide area networks). Sensor deployments may include physiological monitoring using telehealth, telemonitoring using body-worn assessment applications (wearable or body-worn devices, physiological sensors, smart watches, etc.). Other types of sensors can be ambient sensing, user touch point, or consumer sensing applications.(46)

Context

We will include studies including monitoring devices in any health care setting (primary health care, acute care, rehabilitation units, specialist services, etc.) as long as the sensoring system has been used during working hours. We will exclude any publications focusing on free time only (hobbies, running, nutrition monitoring, etc.).

Outcomes

We will include any sensor applications used to measure health and well-being-related physiological outcomes at work, including vital signs, heart rate, blood pressure, temperature, respiratory rate, breathing

rate and depth, energy expenditure, blood oxygenation or skin temperature. Physiological monitoring can include obesity and weight management or assessing sleep as long as they are related to the work environment. Any studies involving invasive applications used to assess health related physiological outcomes will be excluded.

To describe movement, we will include applications sensors, for example, motion, body motor activity, sedentary behaviour, body posture, step count, physical activity, geospatial activity, location variance, or mobility in the workplace. Applications related to free time or hobbies will be excluded as long as they are not related to work.

Selection of sources of evidence

The initial search will be performed to find articles related to the topic. Additional articles will be found using a manual search, e.g., looking at the reference list of each article. After checking for duplicates, titles and abstracts will be first screened by two authors (HK, JC) for relevance to the topic and to see if they meet the inclusion criteria. In case of any discrepancy regarding inclusion or exclusion of a specific study, a third author (MV) will be consulted for a decision. Based on this process, potential full-text articles will be obtained. Second, a full-text review will be conducted to assess whether they meet inclusion criteria. This two-step process will also be carried out by two authors (HK, JV). In case of any discrepancy, the situation will be resolved by one author, depending on the specific question and expert area needed (MV, XG, WMS).

Data charting

All studies will be categorised using a two-step process using the following steps. First, author, year, country, research setting, design, participant group, and sample size will be extracted to describe the characteristics of the study. Second, to answer each research questions, the following information will be extracted from the included study according to the research questions: 1) What technologies are used to monitor well-being, physical activity and mobility among health care personnel? 2) How are the technologies used? and 3) For what purposes are the technologies used?

Included full-text articles will be extracted by two authors. In case of any discrepancy, the questions will be resolved by a third author (MV). If there is any uncertainty related to the monitoring method used, it will be discussed with an expert in geoinformatics (WMS). Information and data collection relevant to answer the research questions will be determined by the reviewers collectively.

Data synthesis

The data will be collated by combining numerical and thematic information in the data to summarise the background information of the studies. To answer the research questions, a thematic analysis in narrative format will be conducted. The reviewers will collectively produce an analysis process from the text data, and the themes will be formed according to the extracted tables.

Consulting with stakeholders

A stakeholder group including four nurse leaders working in health care settings has been formed for the scoping review. Their opinions will be consulted in different phases of the review process. First, the relevance of the topic of the review was confirmed before registration of the protocol. Second, the stakeholder group will participate in the study selection(47–49) and supplement the data collected in the literature search by providing their experimental data(49) or informing about any known unpublished studies.(47) Third, these stakeholders will review emerging findings (47) and provide input when interpreting the findings. (47–49) Fourth, the stakeholders will provide preliminary feedback on the manuscripts,(47, 49) help identify key messages and relevant recommendations for practice and policy makers. Last, they will guide us in identifying the next steps toward future research.(49) The opinions and feedback from the stakeholders will be collected through meetings, workshops, electronic surveys, and focus group interviews.(49)

Discussion

Although the health and well-being of health care personnel has received much research attention, there is still for future assessment of these crucial factors associated with burden in health and well-being that is carried out in a timely, ongoing manner and with a large objective dataset. This study will generate evidence that will help in the exploration of what type of devices could be used in monitoring psychological and physical trajectories for health risk in the workplace. New sensor technologies could offer less intrusive and burdening methods for assessing well-being and more objective methods for assessing physical activity.

Findings from RCT studies improving personnel health and well-being in the workplace have shown that trajectories affecting well-being at work are related to personnel life situations,(14) which is difficult to capture retrospectively using survey forms only.(12, 22, 26) However, measures to increase our understanding of the roles of specific events, emotional atmosphere and individuals' feelings or burden caused at work have not been given much attention. Muaremi et al.(50) have concluded that the use of wearable devices and smartphone applications can ensure better results than asking people about their moods in interviews or having them fill out questionnaires retrospectively. Therefore, one can argue that an ongoing data collection that records events and emotions in real time could be much more informative.

This review can help researchers select appropriate data collection methods for addressing the problem in focus. In clinical practice, effective and efficient health-promoting interventions that prevent and control risks for health problems in the workplace also need more attention. Findings from this study can contribute to the body of knowledge on well-being and health among personnel, which will have a positive impact on clinical practice, research, and policy making in the area of health promotion in the workplace.

Due to the paucity of objective data, we intend to address any technologies used in any health care professional groups. We argue that the findings from this scoping review can play a vital role in selecting

measures to support health promotion in the workplace. Our scoping review may also identify aspects of a future empirical study aiming to increase work efficiency, improve workers' physical well-being and reduce work-related injuries.(34) Using objective measures is even more important in the current COVID-19 situation when feasible and objective measures are needed to assess well-being of health care personnel at their work place.

A List Of Abbreviations

EBSCO Elton B. Stephens Company

IEEE Institute of Electrical and Electronics Engineers

IET The Institution of Engineering and Technology

JBI Joanna Briggs Institute

JMIR Journal of Medical Internet Research

PRISMA-ScR the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews

PROSPERO the International Prospective Register of Systematic Reviews

RCT Randomized Controlled Trial

Declarations

Ethics approval and consent to participate

For this scoping review, neither research ethics approval nor consent to participate will be required.

Consent for publication

Not applicable

Availability of data and materials

Not applicable. After the completion of the study, the datasets used and/or analysed are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

MV: conception (generator of the review) and responsible for the study design, screening the abstracts and full papers, data analysis and writing the manuscript; KH: searching preliminary literature for the background, screening the abstracts and full papers, writing the manuscript; JC: screening the abstracts and papers, writing the manuscript; XH: search strategy for papers, screening the abstracts and papers, writing the manuscript; JG: screening the abstracts and full papers, writing the manuscript; MSW: search strategy for papers related to monitoring devices, screening the abstracts and full papers, writing the manuscript.

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Tables

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Click here to enter text.
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Click here to enter text.
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Click here to enter text.
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Click here to enter text.
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Click here to enter text.
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Click here to enter text.
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Click here to enter text.
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Click here to enter text.
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Click here to enter text.

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Click here to enter text.
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Click here to enter text.
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Click here to enter text.
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Click here to enter text.
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Click here to enter text.
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Click here to enter text.
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Click here to enter text.
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Click here to enter text.
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Click here to enter text.
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Click here to enter text.
Limitations	20	Discuss the limitations of the scoping review process.	Click here to enter text.

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Click here to enter text.
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	Click here to enter text.

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.