

"Wearables only work on patients that wear them": Barriers and facilitators to the adoption of wearable cardiac monitoring technologies



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BACKGROUND Wearable technologies are increasingly popular. Yet their use remains low by older adults, who may stand the greatest benefit of use. While there is an abundance of research examining the performance, accuracy, specificity, and sensitivity of wearable devices, many barriers remain and need to be addressed to optimize uptake in clinical practice. There is a paucity of research exploring factors that help to understand barriers and facilitators to inform acceptance, adoption, wearability, and sustainability of use.

OBJECTIVES (1) To explore the perceptions and experiences of older adults and health professionals about using wearable cardiac monitoring technologies, and (2) to identify barriers and facilitators of acceptance and uptake of these devices in clinical practice.

METHODS A systematic review with a qualitative meta-synthesis was undertaken.

RESULTS A total of 7 original research studies were included.

Four interrelated themes emerged: (1) trust, including safety, and confidence; (2) functionality and affordability; (3) risks; and (4) assurance.

CONCLUSION There are many barriers and facilitators to the adoption of wearable devices based on experiences of older adults, health professionals, and carers. Most significant factors related to the design aspects of the devices, appropriate and timely feedback, user-friendly technology, and issues related to affordability and cost.

KEYWORDS Cardiac monitoring; Digital health; Older adults; Qualitative; Technology; Wearable

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Introduction

Wearable monitoring technologies are increasingly popular with clinicians and the patients they care for.¹ Yet, wearable monitoring technologies only work on patients that wear these devices, as recommended. Much of the research to date has focused on the performance, accuracy, specificity, and sensitivity of wearable devices. However, many issues remain and need to be addressed to enhance uptake.^{1,2} There is a paucity of research exploring factors that help

to understand barriers and facilitators to inform the acceptance, adoption, wearability, and sustainability of use.

Acceptability, adoption, and discontinuation of wearables

Studies examining the use of wearables in older people show varied results with regard to acceptability and adoption. Some studies report ease of use and comfort to be important factors influencing uptake. Increased confidence and awareness of physical activity are frequently reported outcomes. However, poor instructions or the lack of help to use are reported barriers or factors related to abandonment or discontinuation.^{3–6}

Wearables can be of benefit to older adults, yet remain underused within this population. In 2014, only 7% of older adults owned an activity tracker.⁷ Discontinuation and

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KEY FINDINGS

- Barriers and enablers exist to optimize the adoption of wearables for cardiac monitoring in older people.
- Wearables can empower patients and facilitate learning about their condition and support self-management while instilling feeling of confidence and assurance.
- Affordability and cost-related factors are important factors that impact adoption and continuation.

abandonment are common, with 1 in 3 adults discontinuing use within 6 months after purchase and adults aged 70 years or older ceasing use in only 2 weeks.^{7,8} Therefore, it is important to explore in older adults who are likely to gain the most benefit through use.

Adherence to wearing

Adherence with recommended monitoring may become problematic, particularly if requiring prolonged external monitoring. This may effect data quality, accuracy and impact diagnosis and treatment. A better understanding of wearability from the patient and provider perspective may assist to improve the overall data quality and contribute to enhanced detection of adverse events, such as atrial fibrillation. This could improve the diagnosis and treatment of underlying cardiovascular diseases and contribute to improved health outcomes. There have been several original qualitative studies that have explored barriers and facilitators of the adoption of wearables in cardiology, and in other conditions such as osteoarthritis or in the oncology setting.^{9,10} Yet, to date there has not been a meta-synthesis of these studies in the context of cardiac monitoring for older people. Evidence syntheses of qualitative research are important to help understand patient and health provider perceptions and experiences. These are useful to understand behavior, inform future interventions and design of new technologies, and inform policy and guideline recommendations.

Objectives

Objectives are (1) to explore experiences and perceptions of older adults and health professionals about using wearable cardiac monitoring technologies, and (2) to identify barriers and facilitators of acceptance and uptake of these devices in clinical practice.

Methods

Design and method

A systematic review qualitative meta-synthesis was undertaken guided by Noblit and Hare's principles.¹¹ This was conducted over 7 phases: (1) getting started (including scoping the depth of the proposed synthesis); (2) deciding what is relevant to the initial interest (including identifying relevant findings); (3) reading the studies (the repeated

reading of the accounts and the noting of interpretative metaphors); (4) determining how the studies are related (putting the various studies together); (5) translating the studies into one another; (6) synthesizing translations; and (7) expressing the synthesis, including reporting data according to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines.¹²

Search strategy

Wearable cardiac monitoring technology interventions were defined as *"a wearable item or a component of a multicomponent intervention of which an item is body-worn or carry on (to monitor the patient) for some time."* Interventions were included that used wearable, continuous, and passive monitoring, excluding interventions that included active logging of data by the patient. Wearables included in this definition measured a range of parameters such as physical activity, heart rate and rhythm, blood pressure, and oxygen saturation.

A systematic search of key electronic bibliographic databases was completed in February 2019. The databases searched included CINAHL, Medline, Embase, Cochrane, and IEEE Xplore using the key search terms of *"wearable"* OR *"device"* OR *"monitor"* AND *"telemetry"* OR *"mhealth"* OR *"telehealth"* AND *"older people"* OR *"aged"* OR *"aging"* AND *"cardiac patients"* OR *"heart failure"* OR *"atrial fibrillation"* AND *"perspective"* OR *"preference"* OR *"experience"* OR *"attitude."* The full search strategy is documented in the [Supplemental Material](#) in the [Appendix](#).

All original qualitative studies included in this review examined perceptions and experiences of older patients, providers, and/or carers were written in English and published in a peer-reviewed journal between 2000 and 2019. Conference proceedings and scientific abstracts, commentary, and protocols were excluded. Inclusion and exclusion criteria are summarized in [Table 1](#).

Results from database searches were screened via title and abstract through both Endnote and Covidence, an online screening platform.¹³ This was completed by 2 independent reviewers, and any disagreements were resolved by discussion and with a third reviewer. Full-text screening was completed by the 3 reviewers, as per the inclusion and exclusion criteria specified in [Table 1](#).

Studies were assessed for quality and bias using the 10-item CASP (Critical Appraisal Skills Programme) quality appraisal checklist¹⁴ ([Table 2](#)).

Data extraction and synthesis

Data extraction and synthesis were performed at multiple levels as established by similar studies in different fields.^{15,16}

Data (in the form of quotes) were extracted from the results and discussion sections of all included studies.¹¹ In the first level of data extraction and analysis 2 independent researchers read the studies and took notes of initial findings, including main themes and quotes, and came up with descriptive categories. Then, in the next level, data (in the form of quotes) were imported to NVivo software¹⁷ and a comprehensive

Table 1 Inclusion and exclusion criteria

Inclusion	Exclusion
2000 onwards	Conference abstracts
Published papers	Protocols or commentaries
English language	Any study with implantable or inserted devices
Qualitative studies	
Qualitative studies presented within mixed-methods studies	
Wearable technologies or devices	
Older patients, mean age over 65 years	

thematic data analysis was performed by grouping, coding, classification, and categorization of similar patterns. The final step involved interpreting concepts and developing the descriptive categories into main themes and subthemes (Table 3). This process allowed us to refine the meanings of concepts to address the aim of this meta-synthesis.¹⁸

Results

The initial search yielded 1939 citations. Removal of duplicates left 1456 citations remaining. Screening of title and abstract removed 1405 citations. The remaining 51 full-text articles were reviewed for eligibility and inclusion. Forty-four articles were deemed not relevant and excluded, resulting in 7 being included in this qualitative meta-synthesis. Study selection is illustrated in Figure 1.

Study characteristics

The 7 studies^{19–25} included in this meta-synthesis involved 141 individuals, both female and male adults. Data were based on individual interviews with patients primarily over the age of 60, health care professionals, and family caregivers. The included studies used devices to assess heart rate, blood pressure, oxygen saturation, and respiration and to monitor cardiac problems, such as heart failure. The equipment used by patients were tele-monitors such as mobile-based technology, and wireless heart rate monitors (electrocardiography sensors, belt or body area network) (Table 2).

Themes and subthemes

Four interrelated themes were identified: (1) trust, including safety, and confidence; (2) functionality, including affordability; (3) risks; and (4) assurance.

As shown in Table 3, each of these themes was supported by subthemes, which are elaborated on in the following sections.

Trust

Feelings of safety and trust were central points for patients and health providers. Study participants expressed their views and perceptions about telemonitoring devices and their impact on communication, health promotion, early detection of disease, and intervention. Four of the 7 studies emphasized the need for a user-centric design process in partnership with

end users.^{19,20,21,26} However, it is unclear from these studies with end users were not conducted prior in the development of the technologies and not published. Partnership with end users may enhance trust through consideration of the issues related to, and abilities of, older adults. Participants believed that telemonitoring facilitated and enhanced communication and reliable interaction between patients and health providers.^{19,20,22,23} The trust-based relation and continuity of care by the same health provider increased the regularity and effectiveness of communication.^{20,25}

“Telehealth works better when you know the patient because you can look at the information, you’d know roughly what’s been happening with that patient over the last week. If you don’t know that it can lead to decisions being made that perhaps are not the best decisions.” (Health Professional)²⁵

“Well his [her husband] condition has improved because of the equipment because the surgery [health professional’s office] has contacted him and he’s seen the doctor again and again and they’ve come up with something to improve his health.” (Health Professional)²⁰

Some people believed that reducing the number of face-to-face interactions is an advantage of using telemonitoring devices.²⁰ In contrast, others believed that such online communication should never replace face-to-face interaction.^{19,20}

“But I would hope they would still do their person-to-person contact [and] that they wouldn’t just forget, you’re on a machine that’s it...It’s alright that they’re looking at machines... but it would be nice, once in a while for them to come and say... you’re doing okay, just the little bit of encouragement.” (Patient)²⁰

Safety

The use of telecommunication was considered a supportive aid for early detection of disease and intervention.^{19,20,23,25} Participants believed that telemonitoring is supportive in alerting them to danger signs and gave them a sense of reassurance of availability of services and facilities in case of emergency.^{20,25} The regularity and routine use of equipment provided patients and providers with the opportunity to track symptoms and react promptly.^{19,20} Clinicians also believed that these devices are beneficial for short-term use; however, in the long term it would increase the dependency of patients on health providers and patients may deny their responsibility in their health care.^{23,25} For example:

“I know if there is something wrong, they are going to pick it up right away... if something goes wrong, they’ll phone me. [It’s a] safety net.” (Health Professional)²⁵

“...it encourages more of the sick dependency role... I don’t think it’s something that you would want to continue

Table 2 Summary table of included studies

Author/Date	Aim	Design and synthesis methodology	Sample	Method	Intervention/ monitoring device	Key findings	CASP Quality appraisal
Bratan et al 2005	To explore features, feasibility, and acceptability of monitoring in community settings	Qualitative evaluation	N = 8 interviews with staff from 3 different residential and nursing homes (2 doctors, 4 managers, 1 carer, and 1 nurse)	Two sets of semi-structured interviews	Telemonitors measuring several variables, including 7-lead ECG, blood pressure, oxygen saturation, heart rate, temperature and respiration	The equipment was considered easy to use and enabled early detection of deterioration; a number of potential patient benefits although technical issues were frequent. Patient acceptance was good, and gave peace of mind to residents and families.	5/10
Cajita et al 2018	To identify potential facilitators and barriers to the use of mHealth or mobile devices in older adults with heart failure	Qualitative, descriptive, exploratory study	N = 10 participants from the inpatient population of a large urban teaching hospital. 6 were smartphone owners. Age range 66–83 years. 7 male, 3 female. 50% identified as white, 50% as black. Five were married. Varied educational attainment and annual household income.	Semi-structured interviews in hospital patient rooms	No actual intervention, reporting on hypothetical use of mHealth, intention to use	Facilitators included previous experience with mobile technology, willingness to learn mHealth, ease of use, presence of useful features, adequate training, free equipment, and doctor's recommendation. Barriers included lack of knowledge regarding how to use mHealth, decreased sensory perception, lack of need for technology, poorly designed interface, cost of technology, and limited/ fixed income.	9/10
Ehmen et al 2012	To evaluate the usability and acceptance of long-term monitoring system for older people	Qualitative Prospectively designed, randomized, and monocentric study (experimental)	N = 12 from the hospital and the sport health park of the Evangelisches Geriatriezentrum Berlin (EGZB) (4 female; 8 male, mean age 71 years, age range 55–90 years)	Structured interview with participants Observational evaluation of participants use of monitoring belt by a physiotherapist. Participant questionnaire.	Four different belts (2 heart rate monitors and 2 ECG devices): 1. Polar wear link coded 2. Garmin premium heart rate monitor 3. Corscience CORBELT 4. Zephyr bioharness BT	Participants found usability complex, struggles with clips and adjusting belts (poor fine motor skills). Issues with comfortability and constrictiveness were voiced about the belts (material not breathable and rough). Six participants preferred the Garmin Premium Heart Rate Monitor, whereas 5 chose the Polar WearLink and only 1 the Zephyr Bioharness BT.	8/10

Fairbrother et al 2014	To understand views on acceptability and usefulness of telemonitoring in the eyes of health professionals and patients	Qualitative design using Framework approach	N = 18 patients who were telemonitored by GP or CHF nurse service and n = 5 health professionals involved in telemonitoring service. (Patient characteristics: 61% male, mean age 75 years, range 50–80 years) (Family members contributed in 4 of 23 interviews) GP-led telemonitoring (n = 15) Nurse-led telemonitoring (n = 3)	Semi-structured interviews	Telemonitoring service including the Intel Health Guide, which measures oxygen saturation, heart rate, blood pressure, and weight. Daily assessment with an online questionnaire.	Patients found the service easy to use and felt reassurance that they had continuous practitioner surveillance. Did not encourage self-management and the need for formalized education was discussed. Patients and practitioners would prefer monitoring by practitioners that already knew about their condition. Practitioners wished the service would encourage more self-management from patients. Increased communication. Constant technological difficulties and lack of interoperability was a major concern. The need to determine the criteria for patient applicability to telemonitoring.	9 /10
Fensli et al 2010	To evaluate patient satisfaction of using wireless ECG-based BANs	Mixed methods Phenomenological study	N = 36 participants from a cardiac outpatient clinic (11 evaluating wireless ECG BAN and 25 evaluating Holter monitor) (23 female, 13 male, mean age 48 years, range 11–77 years)	Follow-up interviews	Comparison between Holter monitor and wireless ECG-based BAN; body-worn wireless ECG sensor and hand-held device.	Positive experiences with ECG BAN, comfortable and not limiting with physical activity and daily living. Feelings of safety increased. Important issues of stigmatization, need for feedback from the system, need for feedback from health personnel, and patients expressed confidence when using the wireless ECG BAN.	8/10

(Continued)

Table 2 (Continued)

Author/Date	Aim	Design and synthesis methodology	Sample	Method	Intervention/ monitoring device	Key findings	CASP Quality appraisal
Middlemass et al 2017	To explore patients' experiences and perceptions of telemonitoring equipment in their homes	Qualitative Instrumental, collective case study	N = 21 participants with long-term multimorbidities, COPD, and 1 other heart-related condition. (Age range 60–99 years)	Interviews at 2 time points: after installation and at the end of the study	Telemonitoring at home: ResmonPro, Wristclinic, and Touch screen symptoms questionnaire	Strong concerns regarding health professional access and attachment; heightened illness anxiety and desire to avoid continuation of the “sick-role.” A means to validate symptoms and decline. Able to detect trends in health status. Health professionals have questions about accuracy of information.	10/10
Seto et al 2010	To assess the attitudes of heart failure patients and health professionals to the use of mobile phone-based remote monitoring	Mixed methods Conventional content analysis	N = 36 participants (20 heart failure patients and 16 clinicians). (n = 94 completed a quantitative survey, 79% male, 21% female, mean age 55 years) No demographic characteristics provided of qualitative subset)	Semi-structured interviews	Mobile phone-based remote monitoring system includes wireless (Bluetooth-enabled) weight scale, blood pressure monitor, and single-lead ECG	A number of benefits were identified, including clinical care improvement, self-care improvement, increased reassurance/accountability, reduced clinic visits, and ability to monitor health even when patients are away from home. Barriers included the system not being suitable for all patients, clinical workflow challenges, medicolegal issues, inappropriate automated instructions, and security/privacy.	8/10

BAN = body area network; CASP = Critical Appraisal Skills Programme; CHF = chronic heart failure; COPD = chronic obstructive pulmonary disease; ECG = electrocardiogram; GP = general practitioner.

Table 3 Thematic data analysis

Trust, safety, and confidence	Functionality and affordability	Risks	Assurance
<ul style="list-style-type: none">• Facilitating learning and health promotion• Communication and interaction• Early detection and protection	<ul style="list-style-type: none">• Design• Cost• Usefulness	<ul style="list-style-type: none">• Medical compliance• Interplay of stress and anxiety• Self-management	<ul style="list-style-type: none">• Unforeseen technical issues• Assurance of data• Timely feedback/ workload

for years in a stable patient. I think some patients benefit from it for a short period, but then you hope that they'll check their weight, be aware of their symptoms, whereas the machine tends to do that for them..." (Health Professional)²⁵

Confidence

Patients and their caregivers believed that the use of telemonitoring could empower them by educating, engaging, and informing them about their health.^{19,20,22,23,25} Patients who had familiarity with technology such as mobile technology considered telemonitoring devices as a facilitator to learning about health-related issues and they were willing to use such devices in the future. For instance, the use of health-related applications via mobile phones helped patients to gain more knowledge and be more informed on how to manage their health-related issues such as diet, weight, and blood pressure.^{22,25} As a 50-year-old patient mentioned:

"...the doctors kept saying to me that you can self-medicate with fluid tablets. And I would think 'oh no [laugh], I don't know what I'm doing here, so I'm not going to do that...' But then the [telemonitoring staff] at the other end said to take another fluid tablet... And then gradually, I started to realise that when I felt unwell I was able to think 'oh, you know, take another tablet or half a tablet.'" (Patient)²⁵

Another patient believed that the use of telemonitoring devices helped him verify his knowledge about his symptoms:

"You know to me, from the point of view that I'm not allowed oxygen because I haven't got a blood oxygen level that's low enough. But at certain times of the day, I believe my blood oxygen level is low enough to warrant it but I've never been able to prove it, this equipment might help me either prove or disprove it." (Patient)²⁰

Functionality

The most significant concerns under functionality and affordability were related to design, efficiency, and the cost of the wearable devices.^{19–25}

Comfort and ease of use impacted the use of telemonitoring devices. It is important that devices can be adapted to address individual needs, ensuring that users can complete their daily activities independently.^{19–22,24,25} For example:

"Once you start going to the older generation, there are the people who are likely to have these heart problems, also be visually impaired and hearing impaired, if you

do not have the two systems it could be a barrier." (Patient)²²

Supportive characteristics in the design of wearable devices—for example, visibility with large icons, use of contrasting text color, automated transfer of data, and voice feedback—were indicated as assisting factors that encourage patients to be more engaged and achieve better health outcomes.^{20,22,24,25} For example:

"Something to remind me so that I won't forget to take my medicine, something that goes 'beep beep' and lights up, and it's got to light up because I can't hear." (Patient)²²

Older people who cannot perform their daily activities independently often have difficulty using technology and some of them felt physically uncomfortable wearing the devices. In one study, patients found it challenging to adjust belts or straps (such as wireless heart rate monitors) or fasten a device behind their back, or experienced skin roughness or breathability issues while wearing the device.²¹ In another study, patients found it difficult to wear the device while undertaking physical activities.²⁴ Some patients' statements illustrate these difficulties:

"Adjusting the length [of belt] is very difficult," "I think the belt may slide down," "Transmitter is too heavy," "The width of the belt is too small," "You feel constricted because of straps," or "The material feels non-breathable." (Patient)

However, appropriate training and technical support from family and friends would tackle some of these challenges and improve the confidence of patients to use the devices.¹⁹

Health providers believed that the design of the devices should motivate the patients to be better informed about their health and support them to be self-sufficient in complying with medical advice, including physical activity and diet.²⁵

"It might be useful if the [telehealth system] would give [patients] prompts like: 'have you taken your medications today?'; 'have you watched how much salt is in your diet?'; 'have you taken any exercise today?' The questions [in the Intel® Health Guide] aren't geared for self-management... and that's why I personally don't think it actually encourages them to self-manage..." (Health Professional)

Affordability

Three of the 7 manuscripts described both the patient and clinician perceptions for cost considerations or implications.^{19,25,26} These findings also emphasized the

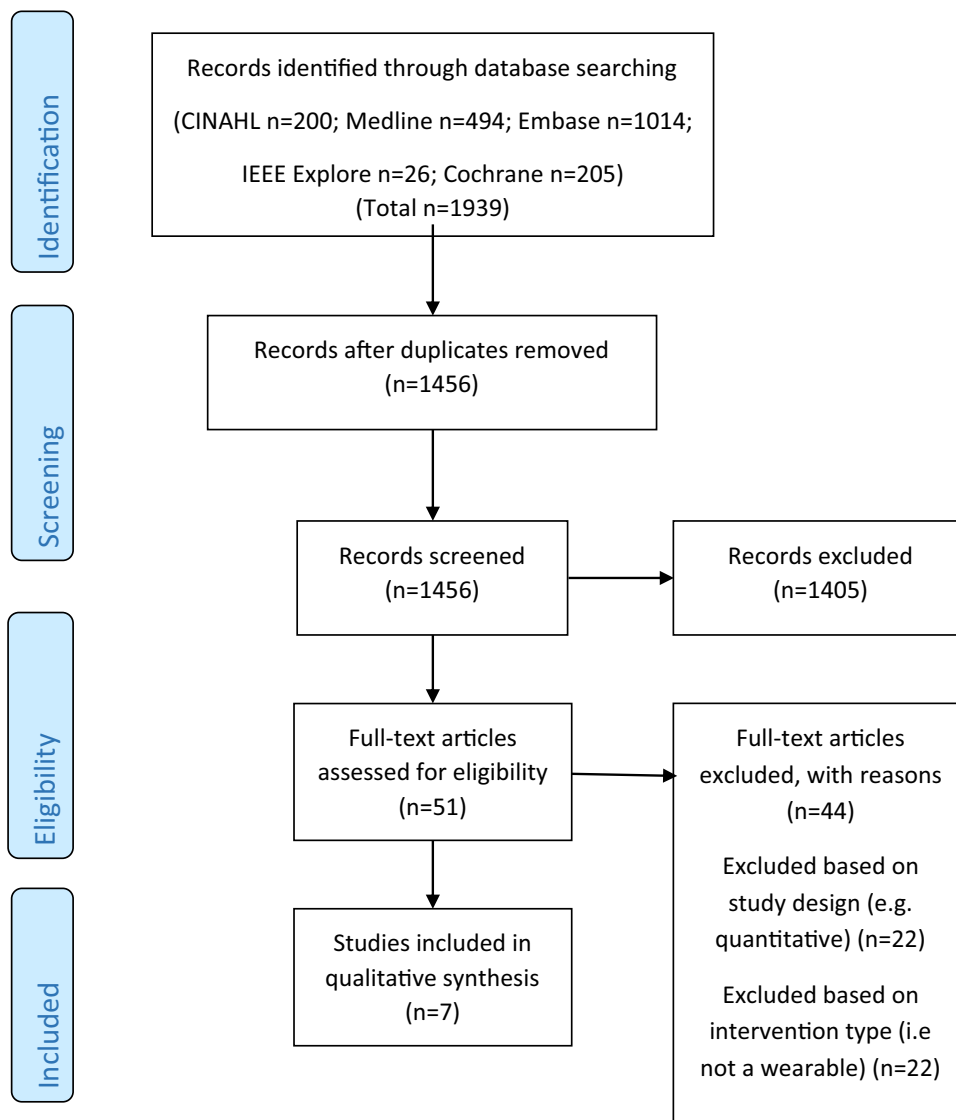


Figure 1 PRISMA flow diagram of study selection.

cost-related barriers and expenses that would affect discontinuation or effective use of the telemonitoring devices.^{19,22,25} The high costs of devices were considered a financial burden, especially for those on a limited income. However, this is likely dependent on global region and health care system models of remuneration.

“It’s going to come down to cost, like I said, I’m on Social Security so that’s a big factor. It would depend upon the amount of money really if can afford it or not is the key question. I mean, I would certainly be willing to buy all of these things if I could afford them.” (Patient)²²

Risks

The synthesis of data indicated that there are different perceptions among participants about the risks and benefits of using wearable devices. Respondents agreed that they weigh up

their health and safety over the social stigma and the discomfort of wearing such devices. One study in this review reported that some participants wished to hide and disguise the devices from the public; however, such stigmatization had no impact on the use of the device.²⁴ Most studies addressed the effect of wearable devices on their health outcomes, management of anxiety, and self-efficacy.

Patients and providers both were agreed that use of wearable device altered the behavior toward chronic diseases and most patients are more aware of the long-term impact of heart diseases and aging issues, and therefore perceived it as a safer option to use wearable devices.^{19,20,24,25}

“Patients would adhere to taking daily measurements long-term if they perceived clear tangible benefits from using it...they would monitor their weight, blood pressure, and other factors more closely if their heart condition ever worsened.” (Health Professional)²⁶

Lack of familiarity with the devices, not knowing how to use them, and low levels of health literacy exacerbated stress and anxiety in patients; and owing to fear, they may not continue using the devices.^{20,22,23,25}

"I have to say I am one of these people who do worry about things. I do get concerned about myself...and I just thought this is silly. This is reminding me every day, then I should think I wonder what my reading is, how good it is, or how bad it is and I thought no, get away from an illness you know. Every time as soon I started thinking about it, I started thinking about my illness..." (Patient)²⁰

Participants believed that telemonitoring give them a sense of responsibility to be involved in their own care^{21-23,25}; however, some believed that health providers are primarily responsible for the management of their condition.²⁵

"I felt quite happy to be involved...instead of just being a vegetable that sat back and swallowed things." (Patient)²⁵

In contrast, some participants believed that using technology is not necessary for them to self-manage their condition.

"Many of these things I do already and I don't see the necessity for having to use technology to get there. I mean, I record my weight every day; I record my blood pressure using a pencil and paper. And I, uh, I record my blood pressure when I go to the doctor. So it's all written, not computerized." (Patient)²²

Assurance

Both patients and health professionals believed that the regular use of wearable telemonitoring devices provides a reliable insight into patients' condition and a way of assessing and measuring the symptoms.^{19-23,25}

"I think it felt like having somebody coming in every day, just checking my stats and everything...I feel more comfortable knowing that somebody's checking it all the time, you know they're looking at it every day...I feel as if there's somebody there, although they're not here, it's just machinery. But I know that the phone can ring if I'm not very well...it's fantastic." (Patient)²⁰

"[telemonitoring] has allowed me a greater confidence in patients who I thought would maybe not, for example, tolerate a beta-blocker...If they're on telehealth, I might think 'well, let's have a go' because I can daily monitor...I can see the stats there so I would know if they're not tolerating the drug...it has encouraged me to be a bit more proactive with medications with some patients." (Health Professional)²⁵

Despite that the use of the devices gives a sense of assurance and safety, health providers were frustrated and consider

it an extra workload. Issues such as managing patients outside of standard clinic hours, while there is a lack of health workforce and inadequate readiness of the health system's infrastructure, and attitudes of patients and health professionals toward remote monitoring were contributing factors toward their frustration. Some believed that the use of telemonitoring increased the number of home visits or communications in response to device data while there is a lack of workforce.^{19,25} For example,

"I think certain people at health board level think this is going to be great at reducing [home visits] and you're going to be able to just sit in your office and look at everybody, but these patients still need to be seen...When you're managing a heart failure patient it's not just about the pulse and blood pressure. There's a lot of general management, psychological management, and support...to put everybody in the same box because they've got a long-term condition and think you're going to reduce admissions...it's not necessarily going to be able to do that." (Health Professional)²⁵

Most studies reported the low efficiency of such devices owing to technical problems or management issues. For example, some studies reported that doctors were not involved in the project and they did not know how to use the monitoring system, or owing to infrastructure issues, wireless data did not transfer properly.^{20,23} Lack of patients' technological literacy created obstacles toward effective use of data. In some instances, patients were not able to position the sensor correctly and that affected the functionality and accuracy of data.^{21,22,25} On other occasions, as a result of technical problems, the system was slow to use and therefore there were delays in giving feedback.²³ Timely feedback is believed to be a source of encouragement for patients to manage their conditions.^{22,24} In contrast, health professionals felt they were legally liable for poor outcomes if there was a delay in providing timely feedback.¹⁹

"You can do it a few days on the run and you're not getting no [any] response and you think, it feels like a non-entity really..., you think what's the point?...the questions that are asked are easy and basic...it's a straight-forward yes or no answers but you're not getting no [any] response." (Patient)²⁰

Discussion

This review provides evidence of perceived barriers and facilitators in the acceptability of wearable devices based on experiences of the older adult, health professionals, and caregivers. The most significant factors that impact the uptake of such devices are related to the design aspects of the devices, appropriate and timely feedback, user-friendly technology, and issues related to affordability and cost. Further, it highlights that patients and health professionals recognize the critical need to integrate the user-centric design process, in partnership with end users, into the development of devices

and services. Co-design is a practical process that supports engagement with patients; it involves patients in the design of devices and care processes intending to improve their health outcomes. These findings are anchored in the literature that supports assessments of wearable devices to include the availability of resources, patient education, and the time required to process the data to make clinical decisions.²⁷

The findings from patients and caregivers indicate that the use of wearable devices could improve self-management, medical adherence, and health literacy. This meta-synthesis highlights that patients' motivation and acceptance of telemonitoring devices depends on their understanding of technology, means of communication, and visual aspects of the devices such as video-conferencing and using mobile applications. Participants who had low technological and health knowledge raised the importance of education and health literacy to gain confidence in the use of technology before commencing uptake of telemonitoring devices.

Similar to other evidence, our review findings suggest that when a patient has difficulty in reading or seeing the messages properly or talking to their health providers they are less likely to adhere and fully engage with their care and their medical advice.²⁷⁻²⁹ While embedding technological components of care for effective communication can improve patient engagement in decision-making, face-to-face conversations may be preferred by patients and clinicians to support physical assessment or development of a therapeutic relationship.³⁰

This review extends our understanding of patients' engagement in the design of wearable monitoring devices and its direct association with improving efficiency, quality, and safety of health care. We suggest that the design of wearable devices through engaging patients should be combined with other innovative interventions that are targeting behavioral change and economic affordability. Patients described the use of telemonitoring devices as a satisfying experience that increased their level of awareness about their illness and taking responsibility for self-management and decision-making.

In contrast, health providers are more focused on the reliability of clinical data and are concerned with workload or data burden as barriers to using telemonitoring programs. Health providers perceived that using telemonitoring devices caused patients to be less self-sufficient in managing their health and, as a result, increased the burden of responsibility and legal liability for health providers.¹⁹ Patients' satisfaction is critical to their acceptability and uptake of telemonitoring devices, as evidence showed being with family at home or any other familiar environment and coping with daily routines would reduce anxiety and improve positive experiences.³¹ Day-to-day self-management of cardiovascular disease provides patients a sense of flexibility, confidence, and freedom. Engagement in planning and decision-making is considered to be empowering for patients and may help to improve their self-management.³² This may help contribute to improved patient outcomes and overall satisfaction with care. It is important, when integrating wearables into clinical practice, that these are considered as a component of a model of care and that

this is designed with a strong behavioral science theoretical underpinning. Wearables alone may not have greatest effect when used in isolation; however, when combined with a care approach that focuses on behavior change, they may contribute to better health outcomes. Adjunct behavioral strategies such as symptom logging, goal setting, education, personalized messages, motivational interviewing, prompting or reminders, gamification, feedback, nudges, and incentivization may be helpful. Lastly, affordability and cost are key considerations for older adults. Exploration of new models for remuneration and their impact on uptake and adoption is warranted. This includes remuneration for the patient at point of purchase, but also from the perspective of the provider for remote monitoring or follow-up with a practitioner, if required.

Limitations

Our review has some limitations. Firstly, the sample size ($n = 141$) is small, yet provided rich and valuable insights into patients, caregivers, and health professional experiences and perceptions. Sample characteristics were often briefly provided in the studies included, and the ethnic, educational, and economic diversity remains unknown. These are important factors to consider when interpreting findings. Secondly, 3 of the 7 studies included in this review were published more than 10 years ago. These are older devices that may have been quite large or cumbersome to wear in the past. More recently produced technologies may adopt more user-centric design process.

Conclusion

This review provides evidence examining patient acceptance of wearable cardiac monitoring technologies. Barriers and facilitators impact the acceptability and uptake of wearable devices. Most significant factors related to the design aspects of the devices, appropriate and timely feedback, user-friendly technology, and issues related to affordability and cost.

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Disclosures

The authors have no conflicts of interest to declare.

Ethics statement

Ethics statement is not applicable for this meta synthesis (review paper).

Patient consent

Patient consent is not applicable for this meta-synthesis (review paper).

Guidelines statement

The review was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines.

Authorship

All authors attest they meet the current ICMJE criteria for authorship. All authors read and approved the final manuscript.

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Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.cvdhj.2021.02.001>.

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