MAYO CLINIC

MAYO CLINIC PROCEEDINGS:
DIGITAL HEALTH

REVIEW

Expensive Ornaments or Essential Technology? A Qualitative Metasynthesis to Identify Lessons From User Experiences of Wearable Devices and Smart Technology in Health Care

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Abstract

This review sought to describe experiences of using wearable devices worn on the body for the purpose of tracking health status and movement and or using in-home health-related smart technologies. In this qualitative metasynthesis, five databases were searched from database inception to May 11, 2022. Included were qualitative studies of the experiences of using wearable or in-home sensors for monitoring health. The primary outcome was any study that reported experiences of using smart health technology using a wearable device or sensors in the home. Eighteen studies covering a range of technologies and health user groups were critically appraised, and data were extracted. Primary study themes were synthesized, and participant quotes across the studies were organized to construct broad themes and subthemes. The three themes included the following: technology as a motivator; reassurance from technology; and animosity toward technology. Technology was welcomed when participants experienced benefits such as reassurance that their health was being tracked and they were aware when problems arose. Participants appreciated the technology could motivate them to challenge themselves on the basis of feedback from the device. Some participants appeared to wish to avoid the technology but experienced resentment when they could not conceal the technology and still receive the other benefits. Data collected should be accessible to the technology user and the clinician together, to enhance transparency and reduce the power differential.

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Wearable devices and in-home sensors have been promoted as a solution for increased demands on health resources and in-home health, but will they be used as intended by the people that could most benefit? Or will they end up as expensive ornaments, sitting on shelves unused? An example of this was in 2012 when Google Glasses burst into the wearable market hyped as eyewear that both records images and projects information. The excitement was short-lived. The gadget was wiped from the market shortly after its debut owing to usability issues pricing (equivalent of USD$1900 today), prototypical technology, and users being labeled with a new colloquial term—glass holes—reflecting the social undesirability and privacy concerns associated with the product.[1] A parallel to the Google Glasses can be found in today's wearable medical assistance pendants. These are marketed on safety and reassurance for vulnerable people who live alone[2]; however, some studies report these devices to be completely unworn and placed out of sight by the users.[3]

There is evidence to suggest that wearable devices are not being used by populations who may benefit most from their health tracking

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ARTICLE HIGHLIGHTS

- Wearable devices are motivating for those who can see improvements in their health reflected in the technology, however the inverse is true for users whose efforts are undetected.
- Animosity towards technology was experienced by some users when devices reflecting their loss of health status were visible in their homes.
- Users appreciated the reassurance given by technology that their health status was being monitored and that they and or their clinician would detect any anomaly.

features. Although 30% of Americans use health wearable devices, only half of this group wears them daily.[4] Furthermore, the dominant users of wearable devices are primarily low-risk for health conditions—young, wealthy, educated, and technology literate individuals. The groups at high risk for health conditions, for example, older adults and the socioeconomically deprived, have low uptake of this technology.[4] Outstanding technology is worthless if the user is resistant to wearing the device, has difficulty navigating the technology, or forgets to wear it altogether. Without understanding user needs and experiences, services promoting the use of health technology risk following the path left by technology such as Google Glasses and falling into the glass hole, providing a product that is undesirable for the target user.

BACKGROUND

Smart technology, such as wearable devices (eg, smart watches and in-home sensors), in health have been lauded as a solution to ease demand for inpatient health care and monitor population health. The National Health Service (NHS) of the United Kingdom has prioritized a "digital transformation" to deliver the goals of health reform identified by the secretary of state. An example of the digital transformation was seen during the coronavirus disease 2019 (COVID-19) pandemic where health care delivery was transformed through home monitoring, virtual wards, and video consultation.[5] Data from wearable devices has been used to predict trends in influenza-like illnesses[6] and detect community COVID-19 infections.[7] The National Director of Transformation of the NHS audaciously expressed that "digital and data tools … can be as important as having the right medicines in our formularies" [Foreword by Dr Timothy Ferris, para. 1].[5] Although one of the key goals for the digital transformation of the NHS is to reduce health disparities, wearable technology is underused in high risk groups such as older adult groups and those who experience socioeconomic disadvantage.[4]

Improved health through implementing smart technology should be enticing; however, this usually requires a behavioral change and learning new technology, which can create a barrier to continued use. Human behavior can be notoriously difficult to change and is shaped by the internal factors of psychological and physical capability of changing behavior, motivation, and external factors of social and physical opportunity.[8] In some circumstances, the technology may be unused[3] or inconsistently used despite perceived benefits to the user. A recent review of wearable devices used during COVID-19 infections noted that participants in several studies removed the device when they were unwell, but the reasons for this were unexplored.[7] Passive infrared technology and cameras may overcome the issue of users remembering to wear the device but comes with other issues such as obtrusiveness, occlusion, multiple people in the scene, and privacy.[9]

The technology acceptance model (TAM)[10] provides some insights on factors that may promote the uptake of technology and has been validated in numerous health studies.[11] The TAM[10] presumes a mediating role between perceived ease of use and perceived usefulness in association between external variables (system characteristics) and actual system use. The TAM suggests that potential users of health technology must both perceive the technology as easy to use and useful to develop the behavioral intention to use the technology before actual use occurs. In accordance with the TAM, to promote actual use of smart technology in health, we must first understand the perceived usefulness, ease of use, and attitudes toward using these technologies. Examining user experiences (actual use) while using the technology from existing literature will in turn inform future developers and health care providers to develop and implement technology that meets the users need.

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Review Objectives

This study sought to determine patient and clinician experiences of using wearable devices (consumer devices worn on the body such as activity-tracking smart watches) and in-home health-related smart technologies (such as passive infrared technology positioned in the home to sense movement). Existing reviews in the area of wearable technology have included described methodological issues and device features,[12] evaluating research methods and reporting dimensions of engagement and acceptability,[13] usability in gait assessment,[14] and synthesized consumer reviews of Fitbits on Amazon.[15] None of these previous reviews have been concerned with synthesizing qualitative experiences of patients and clinicians.

Review question: What are patient and clinician experiences of patients being monitored using health-related smart technology?

METHODS

This qualitative metasynthesis included a systematic literature search and quality appraisal drawing on the Joanna Briggs Institute (JBI) qualitative systematic review methodology[16] and the 7-step meta-ethnography method.[17,18] Results were reported according to the framework of Enhancing Transparency in Reporting the Synthesis of Qualitative research.[19]

Inclusion

Full-text peer-reviewed articles were considered for inclusion if they were available in the English language and reported all types of qualitative studies of clinicians or health technology users aged 18 or older with any health or well-being focus where participants underwent remote noninvasive monitoring such as wearable devices (defined as devices worn on the body for the purpose of tracking health status) or passive infrared technology (static sensors that are positioned in the place of residence). We defined our primary outcome, patient experiences of using wearable devices, as any study that reported patient or clinicians' experiences of using smart technology using a wearable device or sensors in the home. No date limiters were applied.

Exclusion

Articles were excluded if they reported participants aged younger than 18 years; discussion pieces that did not report original research; routine monitoring of health conditions (eg, telemetry); fitness-only intervention in a non-health population; a quantitative study; were a dissertation or thesis; or focused on an application with no accompanying wearable or in-home sensor.

Search Strategy (Step 1)

The search of electronic databases included Cumulative Index to Nursing and Allied Health Literature, Emcare, Medline, Scopus, and PsycInfo. Two reviewers independently screened all titles, abstracts, and full texts for inclusion on the basis of the specified inclusion and exclusion criteria. The search terms and associated index terms were as follows: *(home or community) AND (monitor* OR assess* OR detect* OR measure* OR recogni*) AND (tech* OR wearable OR sens* OR app OR smart* OR "human activity recogni*" OR HAR)*. For specific details, see Appendix A. The search strategy was developed with a university clinical sciences librarian who specializes in systematic reviews. The search terms were tested and refined several times to ensure a broad scope and to ensure known articles were collected.

Study Selection

All records identified from the search were uploaded into EndNote[20] and duplicates removed. The full texts and citations of potentially relevant articles were imported into the Covidence systematic review software and screened against the inclusion criteria by 4 reviewers (M.S., R.J., A.D., and L.C.) through title and abstract screening. The first 2 studies were screened against the inclusion and exclusion criteria by all reviewers to ensure the criteria were understood; then, the reviewers continued screening independently. Reasons for exclusion were reported. Disagreements on study inclusion at any stage of the screening were resolved through discussion and consensus between 2 authors (M.S. and R.J.). Search and study selection results are presented in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram.[21]

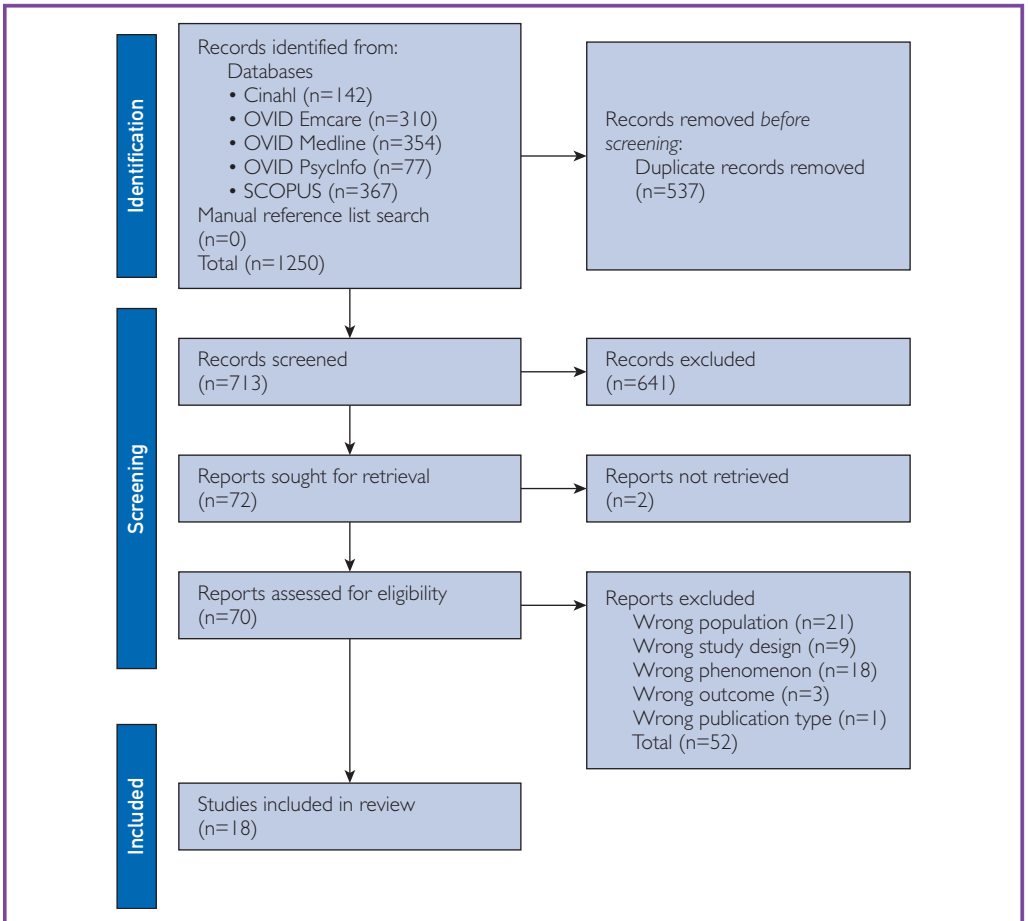

FIGURE. Study screening and selection flow chart.

Quality Appraisal (Step 2)

Critical appraisal of studies was undertaken independently by 2 reviewers (M.S. and L.C.) to determine the risk of bias. The JBI critical appraisal tool for qualitative studies was used by populating the custom risk of bias fields in Covidence. Reviewer conflicts were resolved through discussion. All studies were put forward for synthesis irrespective of quality.

Data Extraction

Data from eligible studies were extracted independently by 2 reviewers (M.S. and L.C.) according to the predetermined extraction fields: (1) study characteristics, for example, date, location, population, research design, research objectives, research aims, and outcome measures; and (2) study findings, such as population demographic characteristics and outcomes. Consensus was reached through discussion.

Data Abstraction

Reading and Localizing the Studies (Step 3). The final included studies were read by 2 researchers to gain an overview of themes and the experiences that users reported.

Data Synthesis

Determining the Relationships between Studies (Step 4). A stepwise approach[17,18] was used to guide development of the themes and metaphors of users' experience.

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The themes of the authors were read and reported.

Translating Studies into One Another (Step 5) and Synthesizing Translations (Step 6). Data were explored by 2 researchers (M.S. and K.R.) independently and organized by reviewers within Excel. Themes and metaphors were constructed across studies as a new understanding of users' experiences of smart technology was reached. Then, the 2 researchers (M.S. and K.R.) compared the themes they had constructed and further refined and synthesized content within themes and finalized naming.

Reflexivity

The researchers regularly met and explored what preconceived expectations related to the research, the research questions, and analysis may be. It was acknowledged that the researchers conducting the analysis had insider knowledge[22] of health consumers through work as an occupational therapist (K.R.), registered nurse (M.S. and R.J.), and clinical psychologist (M.S.). Rigor was enhanced through peer review and debriefing to support the conceptualization of themes[23] and exploring the potential influence of the researchers' experiences on the research.[22]

RESULTS

Search Outcome (Step 1)

The study search took place in May 2022. Database searches yielded 1250 articles, and after the removal of duplicates, 713 remained. After abstract screening, the full texts of 72 articles were screened, of which 18 met the selection criteria.[24–38] Figure illustrates the search and screening process.

The primary reason for exclusion in the abstract and title screening was the study not reporting the experiences of users. The reasons for studies excluded at the full-text screening stage were the wrong population (eg, healthy people with a fitness focus), study design (quantitative), or phenomenon (eg, speculative opinions of potential users). Inter-rater reliability was 94% for title and abstract screening and 82% for full-text screening.

Study Characteristics

Studies were undertaken primarily in European countries in home, hospital, or workplace settings. Most studies that reported their methods used semistructured interviews and analyzed the data using a thematic analysis but did not necessarily report following a named methodology. Sample sizes ranged from 6 to 32 participants, mostly with chronic health conditions (eg, osteoarthritis, stroke survivors, and cognitive impairment) or were of advanced age. Devices studied were wearable activity trackers (n=8), in-home sensors (n=4), wearable camera (n=1), and smart pillboxes (n=2). Ages, culture, and sex of participants were not consistently reported, and no study specifically described the experience of indigenous populations (Table 1).[39,40]

Quality Appraisal (Step 2)

The JBI critical appraisal checklist for qualitative research was used.[41] No study met all quality appraisal items; the most commonly met items were congruity between the research methodology and the research questions (3), ethical approval by an appropriate body (9), and relationship of conclusions to analysis (10). Most authors did not engage in reflexivity or locate themselves theoretically. Although most studies described their methods, these were often incompletely described and vaguely linked to a methodology. Lower quality studies were retained owing to the dearth of studies exploring user experiences. Findings of the quality appraisal are reported in Table 2.

Abstraction and Synthesis (Steps 3-5)

Primary Study Authors' Themes. Five themes were identified through synthesizing the original authors themes and interpretation (Table 3): acceptability, privacy, benefits, barriers, and use of technology. These author themes provide an overview of the original study findings.

Secondary Analysis of Participant Quotes from Primary Studies. Participant quotes were analyzed, experiences explored, and 3 themes constructed, each with 3 or 4

TABLE 1. Characteristics of the Primary Studies Included in the Analysis

Reference, year	Title	Phenomenon of interest	Country	Context	Methodology/theoretical framework/data collection	Participants	Technology
Andersen et al,[24] 2020	Experiences with wearable activity data during self-care by patients with chronic heart disease: qualitative study	Patient experiences of wearable device	Denmark	Outpatient, participants' homes or other location they chose	Qualitative, longitudinal/ thematic analysis with abductive reasoning logic/ semistructured interviews	27 patients with chronic heart disease and an implantable cardioverter defibrillator	Fitbit
Asfaw et al,[25] 2018	Barriers and facilitators of using sensored medication adherence devices in a diverse sample of patients with multiple myeloma: qualitative study	Patient perceptions of illness, illness management, and medication devices with sensors	United States	Outpatient academic medical center	Qualitative, cross-sectional/ thematic analysis with framework method/ semistructured interviews	20 patients with multiple myeloma receiving oral treatment	Smart pill containers
Beukenhorst et al,[26] 2020	Engagement and participant experiences with consumer smart watches for health research: longitudinal, observational feasibility study	Patients experiences of wearable device	United Kingdom	Participants' homes	Mixed methods, longitudinal/ grounded theory analysis/ semistructured interviews	26 patients aged over 50 y with knee osteoarthritis	Smart watch with application
Bradford et al,[27] 2018	Watching over me: positive, negative and neutral perceptions of in-home monitoring held by independent-living older residents in an Australian pilot study	User experiences of in-home monitoring devices	Australia	Participants' homes	Qualitative, longitudinal/ content analysis/ semistructured interviews	8 older adults living in independent-living units	Sensors attached to medical devices and motion sensors. Smartphone application connected to the family
Brickwood et al,[28] 2020	Older adults' experiences of using a wearable activity tracker with health professional feedback over a 12-mo randomized controlled trial	Patient experiences of wearable device with health professional support	Australia	Participants' homes	Qualitative, cross-sectional/ thematic descriptive analysis/semistructured interviews	20 older adults living with chronic illness who completed a structured lifestyle intervention	Jawbone UP24 fitness tracker
Burrows et al,[29] 2018	Privacy, boundaries, and smart homes for health: an ethnographic study	Ethnographic understanding of people's relationship with their homes including how they manage health and technologies	United Kingdom	Participants' homes	Mixed methods, cross-sectional/thematic analysis/ semistructured interviews; home tour; "cultural probes"	19 adults in the community	Range of telecare devices such as wrist worn, pullcord, and smart energy

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TABLE 1. Continued

Reference, year	Title	Phenomenon of interest	Country	Context	Methodology/theoretical framework/data collection	Participants	Technology
Debard et al,[30] 2020	Making wearable technology available for mental health care through an online platform with stress detection algorithms: the Carewear project	User experiences of wearable device and online platform	Belgium	Participants' homes	Mixed methods, cross-sectional; qualitative data collection and analysis methodology not reported	6 "healthy" students	Empatica E4 wearable (wrist); accelerometer, physiological measures such as skin temperature
Elnaggar et al,[31] 2021	Applying mobile technology to sustain physical activity after completion of cardiac rehabilitation: acceptability study	Patient experiences perceptions of mobile health tools including wearable device	United States	Participants' homes	Mixed methods, cross-sectional/thematic analysis/ semistructured interviews	7 older adults who had participated in cardiac rehabilitation randomized controlled trial	Fitbit or Movn mobile application
Gelonch et al,[32] 2019	Acceptability of a lifelogging wearable camera in older adults with mild cognitive impairment: a mixed-method study	Patient experiences of wearable device	Spain	Adult day centers	Mixed methods, cross-sectional/thematic analysis/ socioconstructivist focus groups, self-report questionnaire	18 in total: 9 patients diagnosed with mild cognitive impairment and 9 caregivers	Lifelogging wearable camera
Hjelm and Hedlund,[33] 2022	Internet-of-Things in health care and social services—experiences of a sensor system for notifications of deviant behaviors in the home from the users' perspective	Patient experiences of in-home monitoring devices	Sweden	Participants' homes	Qualitative, cross-sectional/ content analysis/ semistructured interviews	12 in total: 3 adults with functional disabilities living in serviced accommodation; 3 older adults living in residential care, 5 health care staff, and 1 relative	Sensor system installed in the home
Keogh et al,[39] 2020	Comparing the usability and acceptability of wearable sensors among older Irish adults in a real-world context: observational study	User experiences of wearable devices	Republic of Ireland	Participants' homes or place of work	Mixed methods, cross-sectional/deductive content analysis with a realist approach/semistructured interviews	8 "healthy" adults, aged over 50 y	Numerous sensors such as Actigraph, Actibelt, Actiwatch, Biovotion, Hexoskin, and Wavelet

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TABLE 1. Continued

Reference, year	Title	Phenomenon of interest	Country	Context	Methodology/theoretical framework/data collection	Participants	Technology
Kong and Woods,[3] 2018	Smart eldercare in Singapore: negotiating agency and apathy at the margins the margins	Participants' interactions with and perceptions of in-home monitoring devices	Singapore	Participants' homes	Qualitative, cross-sectional/in-depth interviews; analysis methodology not reported	26 in total: 22 older adults, a subset of SHINESeniors project, 3 SHINESeniors caregivers, and 1 Singapore Management University staff member	Medication box, panic button, SHINE sensors "in-home smart technology"; wearable panic button
Leese et al,[40] 2021	Experiences of wearable technology by persons with knee osteoarthritis participating in a physical activity counseling intervention: qualitative study using a relational ethics lens	Patient experiences of wearable device as part of physical activity intervention	Canada	Participants' homes	Qualitative, cross-sectional/phenomenographic analytical methods with a relational ethics lens/preexisting semistructured interview data	21 patients with osteoarthritis	Fitbit
Mercer et al,[34] 2016	Acceptance of commercially available wearable activity trackers among adults aged over 50 and with chronic illness: a mixed-methods evaluation	Patient experiences of wearable device	Canada	University	Mixed methods, cross-sectional/thematic analysis/surveys; focus groups	32 patients living with chronic illness, aged over 50 y	Fitbit, Pedomitor, Jawbone, Misfit, and Withings Puke
Naslund et al,[35] 2016	Wearable devices and smartphones for activity tracking among people with serious mental illness	Patient experiences of wearable device and smartphones	United States	Community mental health center	Mixed methods, cross-sectional/rapid content analysis/surveys; semistructured interviews	11 adults with severe mental illness and obesity	Fitbit and smartphone application
Rogerson et al,[36] 2020	The feasibility and acceptability of smart home technology using the Howz system for people with stroke	Patient experiences of in-home monitoring devices	United Kingdom	Participants' homes	Mixed methods, cross-sectional/semistructured interviews; analysis methodology not reported	19 stroke survivors	Howz smart home; sensor light, temperature, and movement
Ummels et al,[38] 2020	Measure It Super Simple (MISS) activity tracker: (re)design of a user-friendly interface and evaluation of experiences in daily life	The (re)design of the MOX activity tracker and user experiences' of wearable device	The Netherlands	Outpatient physiotherapy	Mixed methods using "the double diamond method"/interviews; observation. Qualitative data collection and analysis methodology unclear	28 older adults	MISS activity tracker (steps)

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TABLE 1. Continued

Reference, year	Title	Phenomenon of interest	Country	Context	Methodology/theoretical framework/data collection	Participants	Technology
Ummels et al,[37] 2020	Patients' experiences with commercially available activity trackers embedded in physiotherapy treatment: a qualitative study	Patient experiences of wearable device as part of physiotherapy treatment	The Netherlands	Outpatient physiotherapy	Qualitative/framework analysis/ surveys; focus group; interviews	29 patients living with chronic illness	Activity trackers such as Activ8, Digi walker, Fitbit, Lumo back up 24, and Walking styleX

subthemes. Participant quotes are reported that strongly represent each theme.

Theme 1. Technology as a motivator: "It lets me feel as though I'm accomplishing something every day … I feel pretty happy … and then it's kind of fun to see how much more I can do" [Daenerys, p.7].[40] The motivation theme was strongly represented throughout in the study.

Participants reported a range of experiences reflecting the influence of the technology on their motivation. For some, they challenged themselves to beat previous step targets and to become more active than before. Others felt the technology made them more aware of their lack of ability and their health deterioration, which was unhelpful to their self-esteem.

1.1 **Self-challenge:** "…I try and I compete with myself and I know that I sit or lie down much too long. But when you're over 80 I think that's excusable" [woman, 85, Group 1, p.10].[34] Most frequently, participants reported the value of challenging oneself to increase activity on the basis of the feedback of the device. Participants' spoke of increasing incidental activity, such as walking around the house more. Participants considered their activity levels on a day-to-day basis and compared it with before, which allowed them to either increases or maintain activity levels and intervene early when there was a lapse.

1.2 **Demotivator/ambivalence:** "I know I cannot do physically very demanding exercises. I have come to terms with that. So, I have not received any new extra information via Fitbit" [P1, p.7].[24] For some participants, seeing that they are not able to do things that they could was unhelpful and raised their awareness of things that they would rather not be reminded of.

1.3 **Unwanted information:** "I actually think it is a little unhealthy to measure oneself all the time. It comes to take up a lot, in my life, and I don't think it is that important" [P18, p.9].[24] Participants lost some of their ability to choose what information they had and consequently felt some intrusion and loss of the freedom of not

knowing. Some participants disliked information that they had little control over, such as the amount of sleep they had.

1.4 **Monitoring health markers:** "I like that it's all in one central location and I like the data I get from it with the charts to see my progress or if I'm struggling I could see on the graph what it looks like."[35] Participants enjoyed having an overview that enabled them to analyze what they were doing and make adjustments. Features such as dashboards were helpful to bring together information.

1.5 **Gain independence:** "Yes, it can become better when you don't have to hear nagging from the staff" [R1, p.8].[33] A small subgroup of participants felt technology enabled them to be free from interference from staff and family.

Theme 2. Reassurance from technology: "Being able to see my heart rate is normal creates a sense of security because I'm not able to feel when my heart rate rises. A normal rhythm means that there is nothing to be afraid of—no danger is underway" [P11, p.8].[24] Participants felt reassured and safe through having some form of monitoring that allowed them and/or a clinician to evaluate their health status and adjust treatment plans in response or in an emergency have an alert sent.

2.1 **A sense of safety:** "I feel safe to have this sensor and to have this button…" [Uncle Leong, 80, English, p7].[3] Participants were able to maintain a sense of autonomy and able to have an unobtrusive monitor that was there if they needed it but were otherwise able to go about their daily lives uninterrupted.

2.2 **Oversight from a clinician:** "It is comforting to know somebody is keeping an eye on you and good for lonely people" [P7, p.150].[36] Some participants felt reassured where data were being monitored by a clinician. The availability of a clinician as a backup to the device was seen as positive by participants, particularly when it enabled them to maintain their autonomy and have fewer intrusions.

2.3 **A reality check:** "Now I get certainty. Is something wrong or not" [P12, p.8].[24] Participants used their data to determine whether to react to unusual body sensations such as increased heart rates or to let it go.

2.4 **Trusting the data:** "I don't trust the readings" [participant identifiers not provided, p.1386].[27] Participants recognized a mismatch between their activity and what was recorded on their devices, with both overestimation and underestimation of activity being sources of frustration.

Theme 3. Animosity toward technology: Participants recorded mixed experiences with technology. Although they liked receiving the benefits of technology and being able to access the collected data in 1 place, they found it problematic when they believed there were inaccuracies in what the devices were registering. They disliked needing to rely on others to operate the device; however, many participants could use it independently. Aspects such as lights flashing and reminders were an annoyance, and discreet means of collecting data were preferred. Participants saw that the technology enabled them some privacy from having others check in on them.

3.1 **It is annoying:** "I turn them off at night … the light in there annoys me because I can nearly see it from my bed" [participant identifiers not provided, p.1386].[27]

Although some participants did not mind the visibility of the device, discrete and unobtrusive ones were preferred, and most went on with their usual life without feeling interference from the devices. A number of participants felt uncomfortable with the interference and intrusion from being observed, particularly in bathroom areas. Some participants felt that there were no longer places where they could find solitude or be away from observation or free from electronics. Lights and sounds gave participants awareness that they were being monitored and were annoyed by this.

3.2 **Surveilled:** "It makes you feel a bit uneasy, everybody can see everything" [Patient 02, Focus group 1, p.7].[32] Some participants commented that they felt they were being watched and had lost some of the privacy they would otherwise enjoy in their home. Areas particularly problematic were bathrooms and

TABLE 2. Quality Appraisal of Studies

Reference, year	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Andersen et al,[24] 2020	NA	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Asfaw et al,[25] 2018	NA	Yes	Yes	No	Yes	No	No	Unclear	Yes	Yes
Beukenhorst et al,[26] 2020	Unclear	Yes	Yes	Yes	Unclear	No	No	Yes	Yes	Unclear
Bradford et al,[27] 2018	NA	Yes	Yes	Yes	Unclear	No	No	Yes	Yes	Yes
Brickwood et al,[28] 2020	NA	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Burrows et al,[29] 2018	NA	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Debard et al,[30] 2020	NA	Unclear	Unclear	No	No	No	No	No	Yes	No
Elnaggar et al,[31] 2021	Unclear	Yes	Yes	Yes	Yes	No	No	Yes	Unclear	Yes
Gelonch et al,[32] 2019	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Unclear
Hjelm and Hedlund,[33] 2022	NA	Yes	Yes	Yes	Yes	No	No	Unclear	Yes	Yes
Keogh et al,[39] 2020	NA	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Kong and Woods,[3] 2018	NA	N/A	N/A	N/A	N/A	No	No	Yes	Unclear	Yes
Leese et al,[40] 2021	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes
Mercer et al,[34] 2016	Unclear	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Naslund et al,[35] 2016	NA	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Rogerson et al,[36] 2020	NA	Unclear	Unclear	Unclear	Unclear	No	No	Unclear	Yes	Yes
Ummels et al,[38] 2020	Unclear	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Ummels et al,[37] 2020	Unclear	No	Yes	Yes	Yes	No	No	No	Yes	Yes
No. of studies (n=18) with criteria met	2	14	15	14	12	2	0	13	16	15

Quality appraisal tool[41] questions were as follows: (1) Congruity between the stated philosophical perspective and the research methodology; (2) congruity between the research methodology and the research question or objectives; (3) congruity between the research methodology and the methods used to collect data; (4) congruity between the research methodology and the representation and analysis of data; (5) there is congruence between the research methodology and the interpretation of results; (6) locating the researcher culturally or theoretically; (7) influence of the researcher on the research, and vice versa, is addressed; (8) representation of participants and their voices; (9) ethical approval by an appropriate body; and 10) relationship of conclusions to analysis, or interpretation of the data.

bedrooms where there would be a usual expectation of privacy. Some participants balanced this with outlining there were some personal benefits.

3.3 **Ease of use:** "It's too technical for me" [participant identifiers not provided, p.1386].[27] Several participants felt that it was difficult to operate the technology. They preferred technology that was simple and that they could operate independently, with a number commenting that they waited for assistance from family to start using the device.

DISCUSSION

Expressing the Synthesis' Theoretical Underpinnings and Discussion (Step 7)

This is the first qualitative metasynthesis to investigate users' experiences of wearable and in-home sensors in a health and well-being context. Eighteen studies that described the experiences of patients and clinicians of using health-related smart technologies were synthesized, and 3 themes were constructed. Studies reported the experiences of users of activity trackers, in-home sensors, smart pill boxes, smart watch with applications, and lifelogging cameras. Although participants experienced benefits to their well-being and life experiences from using the technology, considerable animosity to the technology was reported. The findings across studies extended those reported in the primary studies and reflected the complexity of sustaining health-related behavior change.[8] Although the relationships participants had with their clinicians formed part of their reported experiences, there was little by way of direct social effect from these technologies reported.

TABLE 3. Author-Reported Themes From Primary Studies

Reference, year	Findings	Subthemes/additional data
Andersen et al,[24] 2020	Three themes	
	Knowing: gaining insight and evoking doubts	Learning that heart disease increases one's average resting heart rate Learning that medication influences the heart rate Learning that activity improves one's average heart rate Using activity data to monitor heart pumping ability No new learning: sensing is more useful than activity data Doubting heart rate data When doubt becomes mistrust
	Feeling: being reassured and becoming anxious	Feeling safe through Fitbit reassurance Reassurance prompts activity Both insights and doubts can introduce new anxieties
	Evaluating: promoting improvement and exposing failure	Being nudged and getting praise Recognizing a nudge but not knowing what to do about it Not getting the proper reward: the invisibility of "good" activities Self-disappointment with poor numbers Ignoring or resisting nudges
Asfaw et al,[25] 2018	1 broad category	
	Perspectives/attitudes toward medication devices with sensors that identified concerns that could limit the willingness of some to engage with the technology	Subthemes were not reported Patients were classified, half reacting positively and half reacting negatively, with the same features being viewed as helpful and by others as invasive Privacy concerns, difficulty using technology, and ease of use of the containers themselves were considered drawbacks
Beukenhorst et al,[26] 2020	2 categories	
	Interaction with the watch: experience and usability	Some participants expressed concerns in the preliminary interviews about successfully operating the smart watch At follow-up, all participants stated they found the watch easy to use Engagement with the watch was affected by other activities Battery life significantly influenced patterns of engagement
	Self-tracking	Increased focus on activity levels and challenged existing assumptions regarding their activity and pain Not all participants found [features] useful Some participants expressed concerns regarding accuracy of the watch
Bradford et al,[27] 2018	5 concepts	
	The silent watcher	Participants were most concerned with the perception that someone was watching what they were doing

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Mayo Clin Proc Digital Health ■ XXX 2023;1(3):311-333 ■ https://doi.org/10.1016/j.mcpdig.2023.05.006
www.mcpdigitalhealth.org

TABLE 3. Continued

Reference, year	Findings	Subthemes/additional data
	Medical devices contribute to health autonomy	Devices described as straightforward, understandable, easy to use, fast, convenient, and, for 1 participant, frustrating The motivational value of the devices was identified
	Grandchildren drive iPad skill development	Many felt out of their depth with the new technology Despite the difficulties, residents liked the concept Most residents sought further informal training of their own volition from their grandchildren
	Issues of annoyance	Frustration experienced when data did not upload to the application, sensors took up space or power points, lights from the sensors were annoying, and concern about electricity use
	Benefits for relatives	Relatives felt alert features would be useful if available to them to improve communication and make alternative plans for care and safety
Brickwood et al,[28] 2020	4 themes	
	Increased sense of awareness of activity levels is related to motivation	Most participants reported using the activity tracker made them more aware of their physical activity levels and sedentary behaviors For most of the participants, increased awareness led to increased motivation
	The level of engagement with the activity tracker influences the user experience	Engagement with the activity tracker differed between participants and was influenced by a previous experience with technology, accuracy of the activity tracker, and design of the activity tracker
	The role of feedback from a health professional in providing ongoing support	Additional support provided by accredited exercise physiologist enhanced overall user experience
	The role of habits in supporting long-term behavior change	Toward the end of the follow-up period, participants felt they had established some effective activity level habits and no longer felt they needed an activity tracker
Burrows et al,[29] 2018	2 themes	
	Boundary work and a sense of agency	The physical properties of health care and assistive devices were clear factors that influenced how people used/not able to use various rooms in their homes because of the limitations of the technology (boundaries) Participants described being able to negotiate visibility/integration of technology to address perceived stigmatization
	Reasoning about experiences and sharing information	All participants believed that privacy was essential, but privacy meant different things to different people Participants unclear about the concept of data/ implications of data use

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TABLE 3. Continued

Reference, year	Findings	Subthemes/additional data
Debard et al,[30] 2020	Findings not reported as themes	Users reported discomfort from wearing owing to how tight it must be worn to get measurements without artifacts Difficulty transferring data from device to platform, delays to user feedback, and doubts about accuracy of measurement and recording of events
Elnaggar et al,[31] 2021	4 themes	
	Technology use increased motivation to be physically active	Participants reported that digital technology has strong potential to promote physical activity because it provides a sense of continuity to cardiac rehabilitation by providing motivation, enjoyment, insight, and commitment
	Technology use served as a reminder to be physically active	Technology [as] mainly for increasing motivation and a reminder to maintain physical activity, allows for self-monitoring through immediate feedback
	Recommendations for technology to improve user experience	Obstacles and barriers identified: eg, not waterproof limiting physical activities, text size on device too small to read, and limited sensitivity of heart rate
	Desire for personal feedback	Some technical challenges and difficulties due to health condition (ie, limited fine motor skills) Need for more personalized goal setting and guidance
Gelonch et al,[32] 2019	3 categories	
	Learning to wear the camera	Participants found the camera easy to use during the test Participants identified training was required to become familiar with the technology
	Reluctance to use the camera	Some participants felt embarrassed or were worried about the comments that the camera might provoke Concerns relating to the threat to privacy
	Evaluating the acceptability of the camera	Most regarded recording their daily life as useful despite the inconvenience
Hjelm and Hedlund,[33] 2022	4 themes	
	Having control over the situation	The care recipients expressed they felt safe that the staff had control over the situation and could see when they got out of the bed, or if they had fallen, and could get help if needed The most important factor was that the staff reacted and cared when the sensor indicated an unusual event
	Being more independent	Reminded users to engage in day-to-day tasks, which resulted in "less nagging" from the staff with reminders Praise from staff when tasks completed improved

Continued on next page

Mayo Clin Proc Digital Health ■ XXX 2023;1(3):311-333 ■ https://doi.org/10.1016/j.mcpdig.2023.05.006
www.mcpdigitalhealth.org

TABLE 3. Continued

Reference, year	Findings	Subthemes/additional data
		the relationship between staff and care recipients
	Feeling monitored (security and surveillance)	Mostly positive feelings of security, but some negative feelings of intrusion into privacy and integrity Some participants felt that they were under surveillance
	Well-functioning systems	Care recipients said it was important that the system worked well and was user-friendly (ie, that the alarm did not disturb them) Care recipients felt it was essential that it was a secure system and that nobody else could access it or watch them
Keogh et al,[39] 2020	4 categories	
	Comfort of devices	Wrist-worn sensors were reported as the most versatile and easy to use
	Ease of use of devices	Devices that required little to no interaction from participants were considered the easiest to use Long battery life was essential
	Perceived usefulness of devices	The best devices were those they felt they received the most feedback from Participants seemed willing to compromise on small annoyances if they were personally getting something from the device Participants were prepared to wear their device to help others through research
	Likelihood of wearing a device during a trial	Purpose of use is a key enabler for long-term adherence For most devices, participants reported that they would only wear them if it was necessary Use of these devices would be born out of adherence rather than a specific, intrinsically motivated intention
Kong and Woods,[3] 2018	4 types of expectation using theoretical model of uptake by Golant.[42]	
	Expectations of understanding	Trialists were unanimous in the view that technology was largely incompatible with themselves, and most did not have a clear understanding of how the SHINE Seniors technologies worked Language played a prominent role Fear of technology along with it being perceived as expensive, gave rise to a fear of them breaking it through (mis)use
	Expectations of response	When smart technologies did not work as expected, the most commonly articulated as the inability to receive help when it was (urgently) needed Participants expressed fears over the loss of privacy

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TABLE 3. Continued

Reference, year	Findings	Subthemes/additional data
	Expectations of adherence	Problematic when users did not engage with smart technologies in the ways they are expected to Most problematic were technologies that required active user engagement (ie, panic button and sensor-enabled medicine box)
	Expectations of appreciation	Trialists expressed a passive sense of appreciation for what the SHINE Seniors project was trying to achieve Appreciation was often compromised by an overarching sense of antipathy toward the technologies
Leese et al,[40] 2021	3 categories	
	Making choices about physical activity with or without a wearable	Participants experienced their wearable as a motivating or nagging influence to be more active Motivation was contingent on how freely they were able to make autonomous choices about their everyday physical activity
	Emotional dimensions of adding awareness about physical activity	Participants felt a sense of accomplishment from seeing progress in their wearable data Accomplishment fueled their motivation and accountability
	Reviewing wearable data with the study physiotherapist: issues of accountability and trust	Sharing wearable data helped participants build mutual trust in their relationship with the study physiotherapist Participants also expressed there was potential for sharing wearable data to undermine this trust, particularly if these data were inaccurate
Mercer et al,[34] 2016	4 themes	
	Adoption within a comfort zone	Perception that navigation of devices and applications requires technological know-how that is often absent in the older adult population
	Self-awareness and goal setting: knowing where you are and where you want to be	Greatest advantage participants identified was the device helped them become more aware of their activity levels
	By the numbers: purposes of data tracking	Participants less interested in being motivated by the activity tracker and more interested in being motivated by the self-awareness gained from data collected by the tracker
	The future of wearable activity trackers as health care devices	Identified the need for the health sector to promote activity trackers to improve health and provide data to health professionals to monitor health markers
Naslund et al,[35] 2016	3 categories	
	Motivating, encouraging, fun to use, and other benefits	Positive experiences reported were activity tracking and setting daily step goals Experiencing a sense of accomplishment from being more active and collecting more steps

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Mayo Clin Proc Digital Health ■ XXX 2023;1(3):311-333 ■ https://doi.org/10.1016/j.mcpdig.2023.05.006
www.mcpdigitalhealth.org

TABLE 3. Continued

Reference, year	Findings	Subthemes/additional data
		Increasing awareness of physical activity Providing tangible data in the form of steps as proof of being physically active
	Other things that Fitbit can do	Several participants used different features on the Fitbit companion mobile application in addition to tracking steps and were enthusiastic about being able to see their own data on the mobile application Not all features of the Fitbit mobile application were considered useful because they were perceived to be distracting/misleading
	Technical difficulties, challenges, and recommendations for improvement	No challenges related to using the actual Fitbit device, except remembering to wear it each day Some participants expressed the need for more instruction for using the smartphone/accessing the companion mobile Fitbit application
Rogerson et al,[36] 2020	3 predetermined categories	
	Views on using technology	Mixed views about using technology, but none found the idea of using technology off-putting
	Views about privacy and intrusion	Sensors were not perceived as intrusive and did not cause worry about others having information about their activity
	Views on the Howz application	All participants found the application easy to use and would recommend it to others with stroke • Participants identified that the application increased communication with family members
Ummels et al,[38] 2020	7 predetermined categories	
	Purchase of the activity trackers	Participants wanted to buy the MISS activity tracker from a health care setting that has expertise in the activity trackers
	Instructions and use	Manual was clear and the helpdesk reassuring
	Characteristics of the activity tracker	Described as easy to use, including specific details
	Correct functioning	Description of how the MISS worked
	Sharing data and privacy	Participants did not report privacy concerns
	Use of the activity tracker	Participants checked their data and used it to gain insight into their activity and communicate with health professionals Participants expected the health professional would use the data for planning health care
	Interest in feedback	Participants felt the tracker provided insight into their activity level and would be motivating if they were not active enough
Ummels et al,[37] 2020	7 predetermined categories	
	Purchase of the activity trackers	Participants were unfamiliar with activity trackers and concerned about costs Participants wanted more information on their use and the interface with their existing technology

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TABLE 3. Continued

Reference, year	Findings	Subthemes/additional data
	Instructions and use	Participants wanted more information from their physiotherapists to support their independent use Participants required additional information from family members to use the device owing to limited technical abilities
	Characteristics of the activity tracker	Participants experienced difficulty navigating the technology, which was demotivating Participants expressed concerns about waterproofing, comfort when sleeping, visibility to others, and battery life Helped gain insight to activity levels
	Correct functioning	Participants' experience of validity and reliability of tracker data varied
	Sharing data and privacy	Participants were positive about sharing their data with family and health professionals and found this motivating Participants did not want their data to be shared with the manufacturer or other companies
	Use of the activity tracker	Some participants forgot to wear the tracker over time They liked discussing their activity with the physiotherapist but did not want this prioritized over their usual treatment Participants did not perceive the tracker to add value to their treatment They found unrealistically high goals demotivating
	Interest in feedback	Participants saw the feedback from the activity tracker as positive, except when there was a decline in health The feedback was a motivator and increased their awareness of activity

Three themes were constructed: (1) motivation—where participants expressed their increased awareness of their health from using the technology, this in turn challenged themselves to make progress, but, for others, their lack of ability was highlighted and had a demotivating effect; (2) reassurance—participants felt comforted by having accurate health data that were connected to a clinician and being able to self-check when they had concerns; and (3) animosity—participants felt annoyed by the intrusion of the technology into their personal space both through the visibility of the device and the sense of being observed. The discomfort also came from experiencing difficulties using the technology, leading to some users wanting to abandon the device. This may reflect lower digital literacy of some participants as the lack of digital literacy is a barrier to use, as is low self-efficacy regarding digital technology particularly in the older adult age group.[43] These findings supported the TAM[10] because participants in this synthesis discussed the perceived usefulness and perceived ease of use of the technology as influencing their engagement with the devices. In the TAM, usefulness and ease of use are mediators to actual use of technology.

The motivation theme reflected factors such as participants feeling encouraged from knowing a clinician was overseeing their use of the device. The relationship with the clinician was also reflected in the second theme of reassurance, whereby participants felt safe because they were connected to an external

Mayo Clin Proc Digital Health ■ XXX 2023;1(3):311-333 ■ https://doi.org/10.1016/j.mcpdig.2023.05.006
www.mcpdigitalhealth.org

help. This aligns with the findings from a previous meta-analysis whereby the patient-clinician relationship had a small but statistically significant effect on health care outcomes.[44] The role of the clinician in supporting engagement with wearable devices is a potential area for future research, particularly in the context of the TAM.[10] Participants were motivated through challenging themselves to increase step counts and reaching personal bests. This motivational component aligns with the recent systematic review and meta-analysis that found the use of activity trackers led to a sustained increase in physical activity over time.[45] Some participants in this synthesis felt discouraged by seeing their poor health status reflected in their statistics. This is a significant finding when considering the target users for health technology are often those experiencing poor health.

The theme of reassurance suggests that participants may have experienced a degree of anxiety because reassurance seeking is a common coping behavior—associated elevated anxiety.[46] For example, a person with anxiety from a chronic cardiovascular illness may seek reassurance through checking their heart rate on their wearable device frequently. By contrast, a person coping with the same illness may use avoidance to decrease their anxiety. Avoidance may manifest in not using a device that records heart rate or use it but not access the data gathered. Both coping strategies regarding health anxiety can become problematic.[46] It is possible that in the studies extracted, participants sought or achieved a balanced sense of reassurance from technology. Examples of this included participants reported a feeling of safety from knowing that if an adverse health event occurred, the data gathered would allow them or their clinician to understand the event further. Participants were also reassured that there was passive data collection occurring so that a clinician would be alerted should they be unable to do so themselves or if an event went otherwise undetected. Regarding the TAM, technology anxiety has been found not to affect their perceptions of usefulness or ease of use in the general population[47] or older adults.[48] The relationship between health anxiety and the TAM may be relevant when considering health technology.

The theme of animosity included subthemes relating to lack of control over how technology was visible or present in participants' life. This could relate to the inability to avoid the technology because it drew attention to the users' impaired health and potentially increased their anxiety. This theme highlighted the balance smart technologies must strike between facilitating and supporting the users' independence, with functionality that may reduce the users' sense of privacy. By contrast, although the use of a panic button should provide reassurance to the user, the predominant behavior observed was avoidance whereby all participants rendered it useless by hanging the pendant on the wall or placing it in a drawer.[3] The frustration participants reported when they perceived discrepancies in their data may reflect an increase in anxiety because they no longer felt reassured by the technology. Animosity toward technology may be also due to drawing attention to unwelcome information, as observed in the motivation theme where a subset of users disliked seeing their statistics as they already knew they were deteriorating.

Limitations

The quality of studies in the metasynthesis varied, with some reporting limited detail in their methods and methodology. Owing to the dearth of research in user experiences and the need for timely information, lower quality studies were included. Future studies in user experiences could be strengthened by adopting methodologically rigorous designs and addressing barriers to high quality research, such as by positioning the researcher in the context of the study. No study included reported indigenous experiences, and few described the experiences the socioeconomically disadvantaged. These are important considerations because these groups are at higher risk for poor health outcomes than the groups that have been identified as the primary users of wearable devices—younger people from high socioeconomic groups.[4] This research focused on qualitative studies written in English; consequently, some survey-based and non-English articles that reported experiences might have been omitted. The choice of home-based or community-based users enabled this review to focus on independent

and self-regulated users of wearable, as opposed to hospital-based users under a clinician's oversight. It is possible that the selected search terms and databases used might have omitted articles; however, this was mitigated by comprehensively testing terms across databases with the support of an experienced research librarian.

Recommendations

The themes reported in this review offer guidance for the developers of health technology and clinicians to support the uptake of smart technology and reduce the barriers for users and their families. In accordance with the TAM and subsequent recommendations, efforts should be undertaken to increase the perception of usefulness and ease of use to facilitate adoption of the technology. Actions recommended during implementation include increasing the digital literacy and self-efficacy of users by ensuring users understand the purpose and benefits of the technology, the scope of it (eg, what it can and cannot see and do), what type of data are collected, and who may access this. Users may feel an increased sense of confidence and self-efficacy when they were able to independently use the technology to meet their needs, and this included being able to access their health data independently. Participants enjoyed interpreting their health data in the context of their own experiences. Features such as dashboards may improve accessibility for users, particularly when guidance is provided on how to interpret the data within their own context. Dashboards that are open to be accessed by both clinicians and the health service user enhances transparency and trust because the consumer can see what information is gathered, and this may alleviate concerns around privacy. A co-design process at the development stage may support the future uptake of new technology by capitalizing on user experience and identifying designs, features and functionality that would entice them to use the product.[49] This should include determining how to increase acceptability for groups who are experiencing deteriorating health and, in our study, reported this as unwelcome information. The co-design process in turn may increase the perceived ease of use and perceived usefulness of wearable devices and in-home sensors in health.

CONCLUSION

Although end-user engagement is critical to support the uptake of new technologies, only a few studies have explored the experiences of users of smart technology in health. To the best of our knowledge, this was the first study to analyze and interpret user experiences across multiple primary studies regarding wearable devices and in-home sensors in health. Although older adults are targeted for health interventions regarding wearable devices and in-home sensors, this area was under researched. Furthermore, older adults have been underrepresented in the consumable wearable market. This research found that the ease of use of technology was related to uptake and continued use of the device. Although there were perceived benefits such as increasing motivation and being able to track health status, the technology was quickly cast aside when it became difficult or was perceived as being less than accurate. When a device reminded a user of their limitations, their motivation and engagement dropped, and animosity increased. Using principles of participatory co-design and behavioral change theories could enhance uptake of new products.

POTENTIAL COMPETING INTEREST

Anna Dawson is an employee of Vigil Care, a technology company working with remote monitoring of workers and health consumers.

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Abbreviations and Acronyms: **COVID-19,** coronavirus disease 2019; **JBI,** Joanna Briggs Institute; **NHS,** National Health Service; **TAM,** technology acceptance model

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Appendix A

EBSCO CINAHL

(monitor* or detect* or measure* or sens* or tech* or app) and (health*)

AND (wearable or smart* or "human activity") n3 (experience or experiences or percept* or preference* or acceptab*)

SCOPUS

TITLE-ABS-KEY (monitor* OR detect* OR measure* OR sens* OR tech* OR app) AND

TITLE-ABS-KEY (health*) AND

TITLE-ABS-KEY (wearable OR smart* OR "human activity") W/3 (experience OR experiences OR percept* OR preference* OR acceptab*)

OVID Medline and Emcare

(monitor* or detect* or measure* or sens* or tech* or app) AND

(health*) AND

(wearable or smart* or "human activity") adj3 (experience or experiences or percept* or preference* or acceptab*).af. Limited to English only

Ovid PsycInfo (n=77)

(monitor* or detect* or measure* or sens* or tech* or app) AND

(health*) AND

(wearable or smart* or "human activity") adj3 (experience or experiences or percept* or preference* or acceptab*). ab,ti,hw,mf.