Review Article

DIGITAL HEALTH

DIGITAL HEALTH
Volume 10: 1–23

DOI: 10.1177/20552076241308439
journals.sagepub.com/home/dhj
Sage

A scoping review of the patient experience with wearable technology

Timothy Hoff[1,2], Aliya Kitsakos[3] and Jasmine Silva[4]

Abstract

Objective: This scoping review explores patients' experience with wearable technology. Its aims are to: (a) examine studies that contain empirical findings related to patients' experience with wearables; (b) compare these findings within and across studies; and (c) identify areas in need of greater understanding.

Methods: A Preferred Reporting Items for Scoping Review (PRISMA) guided approach was followed. Four databases of peer-reviewed articles (CINAHL, EMBASE, PubMed, and Web of Science) were searched for empirical articles involving patients' experience of using wearable technology. A standardized data abstraction form recorded relevant information on the articles identified. Data analysis included frequency counts for all abstracted categories; and itemized (by study) findings related to patients' wearable experience including satisfaction.

Results: Forty-six studies comprised the final review sample. The research literature examining patients' wearable experience is characterized by variety in terms of sample sizes, medical situations and wearable devices examined, research settings, and geographic location. This literature supports a positive patient experience with wearables in terms of satisfaction and usability, although the evidence is mixed when it comes to comfort. The moderate to higher satisfaction, usability, and comfort findings across studies do not suggest any sort of pattern with respect to the type of wearable, medical situation, or location.

Conclusions: The review findings suggest that health care organizations should view wearable technology as a viable complement to traditional aspects of patient care. However, from a patient experience standpoint, there is still much to know and validate in this regard, especially as the technology continues to advance.

Keywords

Wearable technology, patient experience, satisfaction, usability, comfort

Submission date: 25 July 2024; Acceptance date: 4 December 2024

Introduction

Patient care continues to incorporate the use of wearable technology for a range of different clinical purposes. Wearable technology includes a range of different devices and tools with the most common including patches and sensors that affix to patients externally for biometric and other forms of monitoring; and wristbands, bracelets, clips, and watches that collect and upload information to web-based applications. The U.S. wearable medical device market is expected to grow from 11 to 112 billion dollars over the next ten years[1] as physicians, hospitals, long-term care facilities, and other health providers embrace the technology as a means to help provide higher-quality care, real-time patient monitoring, and a better patient experience, and to potentially reduce health care costs by placing greater emphasis on prevention.[2,3] That said, current evidence that wearable technology positively impacts health outcomes is limited,[4,5] although recent

[1]D'Amore-McKim School of Business and School of Public Policy and Urban Affairs, Northeastern University, Boston, Massachusetts, USA
[2]Green-Templeton College, University of Oxford, Oxford, UK
[3]School of Public Policy and Urban Affairs, Northeastern University, Boston, Massachusetts, USA
[4]D'Amore-McKim School of Business, Northeastern University, Boston, Massachusetts, USA

Corresponding author:
Timothy Hoff, PhD, D'Amore-McKim School of Business, Northeastern University, 360 Huntington Avenue, Boston, MA, USA.
Email: t.hoff@northeastern.edu

review evidence suggests the use of wearables can be cost-effective and enhance quality of life years for patient populations.[6] At present, the use of wearable devices for home-based healthcare accounts for over 50 percent of market share, with remote patient monitoring accounting for 18% percent.[1]

Wearable technology is in its infancy. Still, it is important not only to understand its impact on clinical outcomes, but also to gauge the patient experience. This experience is multi-faceted and may include perceptions of overall satisfaction with using wearable devices, as well as levels of comfort given that these devices can be more or less intrusive on the person. In addition, the overall usability of wearable devices is part of the patient experience, in terms of dimensions such as ease of use and functionality. Patient adoption of wearable technology is an important factor in whether and how the health care industry implements it in various areas of patient care. Thus, while market growth projections may be ambitious, the realization of those projections is shaped by how much patients embrace wearable technology, given that patients will play a major role in making that technology work as intended.

This scoping review explores the patient experience with wearable technology. Its specific aims are to: (a) examine studies in the literature that contain empirical findings related to patient satisfaction, usability, and comfort with wearable technology; (b) assess and compare the findings on satisfaction, usability, and comfort within and across studies; and (c) identify areas in need of greater study and understanding for this literature as a whole moving forward. We focus the review only on studies that examine wearable technology in the context of the monitoring and management of specific medical conditions or specific risks such as falls (e.g., falls risk among seniors). To our knowledge, this review is the first of its kind in terms of focusing on the patient experience with wearable technology.

Methods

We performed the initial literature search during January 2024, and included peer-reviewed articles published up to that time. A Preferred Reporting Items for Scoping Review (PRISMA-ScR) guided approach was followed for performing the review (Figure 1). Four databases of peer-reviewed articles (CINAHL, EMBASE, PubMed, and Web of Science) were searched for empirical articles that contained results involving patients' experience of using wearable technology as part of their care (e.g., monitoring sensors, smart watches and bracelets, medication dispensers). The PubMed and Web of Science databases have extensive collections of peer reviewed articles from 20,000 journals. CINAHL covers a narrower field of interdisciplinary health-related topics. Embase is a large biomedical and health care article database which indexes 8500 journals.

Using these four article databases for our scoping review allowed for a comprehensive search to find relevant empirical studies examining the wearable experience among patients, and to explore the various findings in a nascent literature while identifying additional opportunities for future research. The terms "wearables", "wearable technology" and "wearable devices" were each used in separate searches followed by the Boolean operator "AND" and each of four respondent terms ("patient satisfaction," "patient experience," "user satisfaction", "user experience"). Duplicates within and across the four databases were identified and removed prior to moving to the next step in the filtering process. We excluded articles published prior to 2000.

Eligibility criteria and study selection

Once all duplicates were removed, article abstracts and, where necessary, the full text of articles were reviewed to identify and filter out articles: (a) that were in non-English journals; and (b) which did not contain an empirical finding related to patients' wearable experience. Two of the co-authors performed this step and the third co-author reviewed any article abstracts and full-text articles where there was uncertainty as to whether a relevant empirical finding was present. Empirical findings could include anything ranging from a univariate to multivariate result for specific aspects of the experience such as satisfaction, usability, and comfort. The three co-authors met to resolve any disagreements. After non-empirical or non-relevant articles were identified and filtered out through either abstract or full article review, a total of 46 studies comprised the final review sample (Figure 1).

Data abstraction & analysis

A standardized data abstraction form created in Microsoft Excel was used to record relevant information on the 46 articles. The following information was abstracted from the articles: geographic (country) setting of study; research setting (e.g., home, hospital, other remote location); sample size (number of patients); time period of study (if identified); medical conditions examined (e.g., Parkinson's Disease, Diabetes); type of wearable device; and specific patient experience findings (e.g., satisfaction).

The data abstraction process was performed in the following manner. The three co-authors independently abstracted the above information for a group of the same five articles, then met and compared their results. This helped calibrate the abstraction approach across the co-authors. Subsequently, two of the co-authors each independently reviewed half the articles and abstracted the above information into the Excel spreadsheet. The third co-author reviewed these abstractions, double-checking a select number of original data abstractions made by the two co-authors. Any discrepancies in abstracting were resolved as a team.

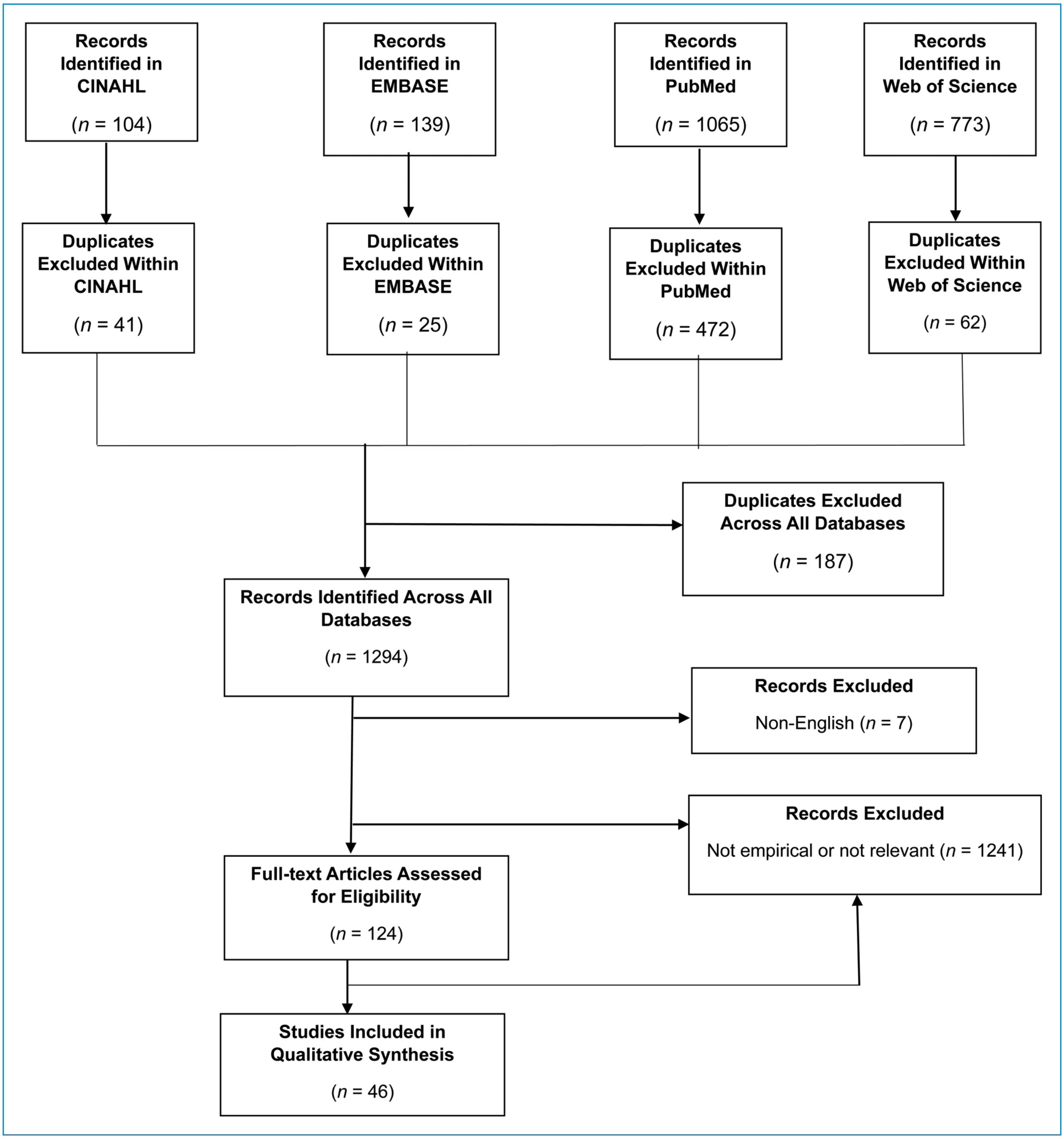

Figure 1. Preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow diagram.

Further analysis of data was also collaboratively performed by two of the co-authors. This analysis included frequency counts for all abstracted categories; and itemized (by study) findings related to patients' wearable experience (e.g., satisfaction, usability, comfort). Consistent with the scoping review intent, we attempted to identify any patterns in the findings that might help clarify the patient experience with wearable technology at the present time, as well as identify key gaps in understanding that should be filled empirically moving forward to enhance our knowledge of how patients perceive the use of wearable technology in their care.

Results

The overall research literature examining patients' wearable experience is characterized by variety in terms of sample sizes, types of medical conditions and wearable devices examined, research settings, and geographic location (Table 1). Sample sizes ranged from 6–115 patients, with most studies in the review (31/46) including fewer than 30 patients. Medical conditions examined included Parkinson's Disease, Huntington's Disease, orthopedic rehabilitation, epilepsy, cardiac/stroke rehabilitation, heart conditions, diabetes, and fall prevention. Research settings included wearables used at home only, at the hospital only, in both settings, and in other non-home remote settings. Eighteen studies were conducted in European countries and ten were conducted in the United States. Other countries where studies were performed included South Korea, India, Taiwan, Canada, and Cambodia. In twelve study instances, the country setting was not explicitly stated.

Findings related to patient satisfaction with wearable technology

Twenty six of the 46 studies in the review sample contained a general satisfaction finding of some kind with respect to wearable technology (Table 2). In 20/26 of these studies, moderate to higher levels of patient satisfaction were identified. These included higher patient satisfaction with the use of a FitBit and software application to assess perioperative activity in urologic surgery[7]; moderate to higher satisfaction with wearing a miniature eye camera to assist with visual impairments[8]; higher satisfaction with ingestible and patch sensors that connect to a smartphone app to monitor medication adherence to help manage uncontrolled hypertension[9]; and higher satisfaction with an electrocardiogram (ECG) device worn by hospital patients on the chest, with accompanying wristband, for continuous atrial fibrillation detection.[10]

In only four studies were patient satisfaction levels identified as lower, and across the studies there were no discernable patterns identified in terms of patient location (e.g., home vs. hospital); type of wearable device; or medical situation/condition. The studies which had the highest levels of patient satisfaction were equally split between more serious medical conditions (e.g., lung transplant monitoring during Covid vaccinations; blindness; stroke rehabilitation; atrial fibrillation) and more routine ones (e.g., diabetes; hypertension).

Findings related to patient usability with wearable technology

Twenty four of the 46 studies in the review sample contained a usability finding of some kind with respect to wearable technology (Table 3). In 21/26 of these studies, moderate to higher levels of patient usability were identified. These included higher perceived usability with a wearable leg sensor that provided biofeedback for orthopedic injury rehabilitation[13]; higher usability with smart wristbands used during pregnancy to monitor heart rate and steps[29]; moderate to higher perceived usability with finger-worn sensors uploading temperature, heart rate, and muscle tension information to a web-based application[31]; and higher perceived usability with three body-worn sensors that provide information on the scope and severity of symptoms for patients with Parkinson's Disease.[51]

In only three studies, patient usability levels were identified as lower. Across these studies there were no similarities in terms of patient location (e.g., home vs. hospital); type of wearable device; or medical situation/condition. For the studies which had the highest levels of usability, a majority focused on wearable use in the home setting. Similar to the satisfaction findings, studies reporting higher levels of usability were equally split between more serious medical conditions (e.g., Parkinson's Disease; stroke and spinal cord injury sleep/gait monitoring) and more routine ones (e.g., orthopedic rehabilitation after knee replacement; overactive bladder; pregnancy monitoring).

Findings related to patient comfort with wearable technology

Fifteen of the 46 studies in the review sample contained a comfort finding of some kind with respect to wearable technology (Table 4). In 11/15 of these studies, moderate to higher levels of patient comfort were identified. These included higher perceived comfort with a belt device using a 3D camera and vibrating mechanism to make up for peripheral vision loss[19]; moderate to higher comfort with smart wristbands used to monitor heart rate and steps during pregnancy[29]; higher comfort with Google smart glasses worn by autistic children to help with social skill development[34]; and moderate comfort associated with a waist belt and electronic bracelet serving as a virtual cane for visually impaired patients.[15]

Three studies reported lower patient comfort levels. Across these studies there were no similarities in terms of patient location (e.g., home vs. hospital); type of wearable device; or medical condition. The studies which had the highest levels of patient-reported comfort each addressed different medical conditions and involved different wearable technologies.

Comparing satisfaction, usability, and comfort findings across studies

Only one study in the review (i.e., Bhatlawande et al. 2014[15]) reported moderate or higher levels across all three dimensions of the wearable experience, i.e., satisfaction, usability, and comfort (Table 5). In part, this was due to the fact that several studies only examined one or two of the three dimensions. Six studies found moderate or higher levels of wearable usability combined with similar levels of patient satisfaction. Four of these six studies involved serious medical conditions such as Parkinson's Disease, blindness, spinal injury, and organ transplantation. None of the wearable technologies examined across the six studies was similar. In four separate studies, moderate or higher levels of wearable comfort were identified with similar levels of usability. Three of these four studies involved more

Table 1. Studies included in the review (n=46)

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
Adams et al.[11]	Multiple wearable sensors in Parkinson and Huntington disease individuals: A pilot study in clinic and at home. *Digit Biomark.* 2017;1(1):52–63.	N/A	Mixed	56	N/A	Parkinson disease, Huntington disease, and prodromal Huntington disease	Accelerometer-based sensors on chest and limbs
Agarwal et al.[7]	Physical activity monitors can be successfully implemented to assess perioperative activity in urologic surgery. *Mhealth.* 2018;4:43.	N/A	Home	42	2016	Retropubic prostatectomy	Fitbit watch and app
Ali et al.[12]	Engagement with consumer smartwatches for tracking symptoms of individuals living with multiple long-term conditions (multimorbidity): A longitudinal observational study. *J Multimorb Comorb.* 2021;11:26335565211062791.	England	Home	49	2020	Multiple long-term conditions	Watch with mobile app
Amore et al.[8]	Efficacy and patients' satisfaction with the ORCAM MyEye Device among visually impaired people: A multicenter study. *J Med Syst.* 2023;47(1):11.	Italy, Canada, Mexico, Brazil	Multiple non-home care settings	100	N/A	Visual impairments from various ocular diseases	OrCam miniature camera device with Bluetooth connectivity to audio devices that is magnetically mounted on spectacle frame
Argent et al.[13]	Wearable sensor-based exercise biofeedback for orthopaedic rehabilitation: A mixed methods user evaluation of a prototype system. *Sensors (Basel).* 2019;19(2):432.	Ireland	Home	15	N/A	Orthopedic rehabilitation of patients who recently underwent knee replacement surgery	Inertial measurement unit worn through neoprene sleeve pulled over the shin that streams data to tablet app via Bluetooth
Bae et al.[14]	Building and implementing a contactless clinical trial protocol for	South Korea	COVID-19	86	N/A	COVID-19	Fitbit Charge 4 watch and Garmin Venu SQ watch to

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
	patients with COVID-19: A Korean perspective. *Front Med (Lausanne)*. 2022;9:975243.		treatment center				monitor heart rate, heart rate variability, respiratory rate, etc. and mobiCARE +Temp MT100D electronic patch thermometer
Bhatlawande et al.[15]	Electronic bracelet and vision-enabled waist-belt for mobility of visually impaired people. *Assist Technol*. 2014;26(4):186–195.	India	Controlled and real-world outdoor environments	15	N/A	Total blindness	Waist belt and electronic bracelet that serve as virtual cane with vibration unit and earphone that beeps with obstacle alerts
Biondi et al.[16]	Feasibility and acceptability of an ultra-long-term at-home EEG monitoring system (EEG@HOME) for people with epilepsy. *Epilepsy Behav*. 2023;151:109609.	UK	Remote	11	N/A	Epilepsy	EEG system and Fitbit watch paired with smartphone app for seizure and behavior monitoring
Bonometti et al.[17]	Usability of a continuous oxygen saturation device for home telemonitoring. *Digit Health*. 2023;9:20552076231194547.	Italy	Home	17	N/A	Oxygen therapy post-COVID-19	Elastic ring continuous oxygen saturation monitoring device worn on thumb or index finger that transmits data to app
Boroojerdi et al.[18]	Clinical feasibility of a wearable, conformable sensor patch to monitor motor symptoms in Parkinson's disease. *Parkinsonism Relat Disord*. 2019;61:70–76.	N/A	Clinic and home	21	2015–2016	Parkinson's disease	Accelerometer and electromyograph embedded into NIMBLE patch that attaches to skin via an adhesive sticker and transmits information to a smartphone/tablet and server
Brown et al.[19]	A novel, wearable, electronic visual aid to assist those with reduced peripheral vision. *PLoS One*. 2019;14(10):e0223755.	N/A	N/A	26	N/A	Retinosa pigmentosa	LEO Belt device, which uses a 3D camera and conveys information by delivering vibrations to the torso

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
Bruno et al.[20]	Day and night comfort and stability on the body of four wearable devices for seizure detection: A direct user-experience. *Epilepsy Behav.* 2020;112.	England and Germany	Hospital	115	N/A	Epilepsy	Seizure detection devices: (1) IMEC upper armband with electrocardiogram ECG and surface electromyography wires and patch electrodes, (2) Epilog scalp patch electrode EEG device, (3) E4 wristband for continuous data acquisition for daily life, (4) Everion upper arm band for continuous data acquisition for daily life
Chang et al.[21]	A novel smart somatosensory wearable assistive device for older adults' home rehabilitation during the COVID-19 pandemic. *Front Public Health.* 2023;11:1026662.	Taiwan	N/A	25	N/A	Rehabilitation for older adults	Somatosensory assistive device worn on knee/shin
Cooper et al.[22]	Exploring the impact and acceptance of wearable sensor technology for pre- and postoperative rehabilitation in knee replacement patients: A UK-based pilot study. *JB JS Open Access.* 2022;7(2): e21.00154.	UK	Home	17	N/A	Rehabilitation pre and post total knee arthroplasty and unicondylar knee arthroplasty	BPMpathway device, which includes sensor worn on lower leg to monitor range of motion that transmits data to patient and clinician
D'Ancona et al.[23]	Implantation of an innovative intracardiac microcomputer system for web-based real-time monitoring of heart failure:	N/A	Remote	21	N/A	Chronic heart failure	VLAP-system, including miniaturized pressure sensor implanted percutaneously that communicates wirelessly

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
	Usability and patients' attitudes. *JMIR Cardio*. 2021;5(1):e21055.						with a wearable chest belt device that sends information to healthcare professionals
Demers et al.[24]	Wearable technology to capture arm use of people with stroke in home and community settings: Feasibility and early insights on motor performance. *Phys Ther*. 2024;104(2):pzad172.	N/A	Mixed	30	N/A	Arm/hand use and mobility in stroke survivors	MiGo inertial measurement unit wrist-worn watches that transmit data to server via Bluetooth
Elnagger et al.[25]	Applying mobile technology to sustain physical activity after completion of cardiac rehabilitation: Acceptability study. *JMIR Hum Factors*. 2021;8(3): e25356.	USA	Remote	26	N/A	Cardiac rehabilitation patients following release	Fitbit Charge 2
Fredriksson et al.[26]	Intermittent vs continuous electrocardiogram event recording for detection of atrial fibrillation-Compliance and ease of use in an ambulatory elderly population. *Clin Cardiol*. 2020;43(4):355–362.	Sweden	Remote	N/A	N/A	Atrial fibrillation	R-test 4 Evolution ECG heart monitor worn around the neck with one lead attached to chest
Giorgino et al.[27]	Assessment of sensorized garments as a flexible support to self-administered post-stroke physical rehabilitation. *Eur J Phys Rehabil Med*. 2009;45(1):75–84.	N/A	N/A	13	N/A	Post-stroke rehabilitation	Garment embedded with kinesthetic sensors that assesses patient exercises that connects wirelessly to a computer to provides patient feedback
Goudelocke et al.[28]	A multicenter study evaluating the FREquency of use and efficacy of a	USA	Remote	87	2021–2023	Overactive bladder	Aviation device, which includes a garment

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
	novel closed-loop wearable tibial neuromodulation system for overactive bladder and urgency urinary incontinence (FREEOAB). *Urology*. 2024;183:63–69.						containing electrodes that detects muscle contractions and connects to an app that allows patient to control and monitor bladder control therapy sessions
Grym et al.[29]	Feasibility of smart wristbands for continuous monitoring during pregnancy and one month after birth. *BMC Pregnancy Childbirth*. 2019;19(1):34.	Finland	Remote	20	2016–2017	Pregnancy	Garmin Vívosmart HR watch that estimates steps, heart rate, etc. and sends data to Garmin Connect website or Garmin Connect app via Bluetooth
Hendriks et al.[30]	Feasibility of a sensor-based technological platform in assessing gait and sleep of in-hospital stroke and incomplete spinal cord injury (iSCI) patients. *Sensors (Basel)*. 2020;20(10):2748.	Netherlands	Home	24	N/A	Stroke and spinal cord injury	Inertial measurement unit sensors around ankles
Ingvaldsen et al.[31]	A biofeedback app for migraine: Development and usability Study. *JMIR Form Res*. 2021;5(7).	Norway	Home	18	2019–2020	Migraine	Cerebri biofeedback set up, including surface electromyography sensor for measuring muscle tension, a device with 2 finger-worn sensors to measure peripheral skin temperature and heart rate, and an app connected to devices via Bluetooth

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
Kane et al.[32]	First experience with a wireless system incorporating physiologic assessments and direct confirmation of digital tablet ingestions in ambulatory patients with schizophrenia or bipolar disorder. *J Clin Psychiatry.* 2013;74(6):e533–540.	USA	Remote	27	2010–2011	Schizophrenia and bipolar disorder	Ingestible sensor that communicates with adhesive sensor worn on torso that measures patient characteristics when medicine is ingested and transmits data to patient smartphone/tablet and web-based provider panel
Kim et al.[33]	Qualitative assessment of tongue drive system by people with high-level spinal cord injury. *J Rehabil Res Dev.* 2014;51(3):451–465.	USA	N/A	11	N/A	Tetraplegia from spinal cord injury	Tongue driven system, including headgear with magnetic sensors and tongue piercing that translates tongue gestures into application commands
Kinsella et al.[34]	Evaluating the usability of a wearable social skills training technology for children with Autism Spectrum Disorder. *Frontiers in Robotics and AI.* 2017;4:31.	Canada	N/A	15	N/A	Autism Spectrum Disorder	Google Glass with Holli social skills coaching app, which provides prompts for conversation directly on the glass
Kleiman et al.[35]	Using wearable physiological monitors with suicidal adolescent inpatients: Feasibility and acceptability study. *JMIR Mhealth Uhealth.* 2019;7(9).	N/A	Hospital	50 patients	N/A	Severe psychiatric problems in adolescents	Empatica E4 wrist-worn behavioral and psychophysiological monitor
Lakshminarayanan et al.[36]	Feasibility and usability of a wearable orthotic for stroke survivors with hand impairment. *Disabil Rehabil Assist Technol.* 2017;12(2):175–183.	N/A	N/A	10	N/A	Stroke survivors	Therabracelet vibrating wristband to improve dexterous hand function

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
Liverani et al.[37]	User experiences and perceptions of health wearables: an exploratory study in Cambodia. *Glob Health Res Policy*. 2021;6(1):33.	Cambodia	Remote	156	2019–2020	Hypertension	Watch-type device with a linked smartphone app
Macea et al.[38]	In-hospital and home-based long-term monitoring of focal epilepsy with a wearable electroencephalographic device: Diagnostic yield and user experience. *Epilepsia*. 2023;64(4):937–950.	Belgium	Hospital and home	16	N/A	Epilepsy	Sensor Dot EEG device which uses dry electrode patches with algorithm to detect possible seizures
Malhotra et al.[39]	Physical activity in hemodialysis patients on nondialysis and dialysis days: Prospective observational study. *Hemodial Int*. 2021;25(2):240–248.	N/A	Remote	45	N/A	Hemodialysis patients	Fitbit Charge 2
Marschollek et al.[40]	Multimodal activity monitoring for home rehabilitation of geriatric fracture patients--feasibility and acceptance of sensor systems in the GAL-NATARS study. *Inform Health Soc Care*. 2014;39(3–4):262–271.	N/A	Home	14	N/A	Mobility-impairing fractures in geriatric patients	Multimodal activity monitoring system, which included a Shimmer2r wearable accelerometer
Noble et al.[9]	Medication adherence and activity patterns underlying uncontrolled hypertension: Assessment and recommendations by practicing pharmacists using digital health care. *J Am Pharm Assoc*. 2016;56(3):310–315.	Scotland	Home	15	N/A	Blood pressure levels	Ingestible and patch sensors that connect to phone app

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
Oswald et al.[41]	Longitudinal collection of patient-reported outcomes and activity data during CAR-T Therapy: Feasibility, acceptability, and data visualization. *Cancers (Basel).* 2022;14(11):2742.	US	Home	12	2021	Cancer	Fitbit tracker worn on wrist with data uploaded to iPad
Pais et al.[42]	Evaluation of 1-year in-home monitoring technology by home-dwelling older adults, family caregivers, and nurses. *Front Public Health*. 2020;8:518957.	Switzerland	Home	13	2017–2018	Older adults	Home monitoring program for older adults that includes wearable activity tracker
Peyrot et al.[43]	Patient perceptions and preferences for a mealtime insulin delivery patch. *Diabetes Ther.* 2018;9(1):297–307.	USA	Home	101	2007–2010	Type 1 and type 2 diabetes	Small patch mealtime insulin-delivery system
Savoldelli et al.[44]	Improving the user experience of televisits and telemonitoring for heart failure patients in less than 6 months: A methodological approach. *Int J Med Inform.* 2022;161:104717.	Italy	Home	15	N/A	Heart failure	Hodwy Senior of Comftech garment fitted with ECG electrodes on the chest and below the left shoulder blade and a pocket that holds a wireless thermometer, as well as a GIMA Oxy-10 finger pulse-oximeter
Schuurmans et al.[45]	Multimodal remote home monitoring of lung transplant recipients during COVID-19 vaccinations: Usability pilot study of the COVIDA Desk incorporating wearable devices. *Medicina (Kaunas)*. 2023;59(3):617.	Switzerland	Remote	10	N/A	Lung transplant recipients following COVID-19 vaccinations	Ring pulse oximeter, Fitbit, and core temperature device

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
Schwenk et al.[46]	Interactive balance training integrating sensor-based visual feedback of movement performance: a pilot study in older adults. *J Neuroeng Rehabil.* 2014;11(1):164.	USA	Quiet room of senior living community	30	2013–2014	Senior citizens with fall risk	Wearable inertial sensors for estimation of joint angles and position for balance training program
Stellpflug et al.[47]	Continuous physiological monitoring improves patient outcomes. *Am J Nurs.* 2021;121(4):40–46.	USA	Hospital	137	2018	Patients admitted to hospital's general medical unit	Wrist-worn device for continuous vital sign monitoring using a three-lead system
Taylor-Piliae et al.[48]	Objective fall risk detection in stroke survivors using wearable sensor technology: a feasibility study. *Top Stroke Rehabil.* 2016;23(6):393–399.	USA	Remote	10	N/A	Fall risk for stroke survivors	PAMSys kinematic motion sensor to monitor fall risk and gait
Valiaho et al.[10]	Continuous 24-h photoplethysmogram monitoring enables detection of atrial fibrillation. *Front Physiol.* 2021;12:778775.	Finland	Hospital	135	N/A	Atrial fibrillation and sinus rhythm	Faros 360 Holter ECG device, which adheres to chest, and Empatica E4 wrist-band for continuous atrial fibrillation detection
Van Velthoven et al.[49]	ChroniSense national early warning score study: Comparison study of a wearable wrist device to measure vital signs in patients who are hospitalized. *J Med Internet Res.* 2023;25:e40226.	UK	Hospital	132	2019–2020	Heart conditions	ChroniSense Polso wearable wrist device for vital sign monitoring
Vaughn et al.[50]	Mobile health technology for pediatric symptom monitoring: A feasibility study. *Nurs Res.* 2020;69(2):142–148.	USA	Hospital and remote	6	N/A	Pediatric blood and marrow transplant patients	Microsoft Band II and Series 1 Apple Watch activity trackers

(continued)

Table 1. Continued.

Author	Reference	Geographic Setting	Research Setting	Sample Size	Time Period	Condition(s) Examined	Wearable Device
Virbel-Fleischman et al.[51]	Body-worn sensors for Parkinson's disease: A qualitative approach with patients and healthcare professionals. *PLoS One.* 2022;17(5):e0265438.	N/A	Hospital and remote	22	2019	Parkinson's disease without dementia	3 body worn sensors: (1) PKG Watch which reports severity of Parkinson's disease symptoms, (2) Kinesia 360 set of two wrist- and ankle-worn sensor bands which reports appearance and severity of Parkinson's disease symptoms and connects to smartphone app, and (3) STAT-ON waist-worn sensor-belt worn, which provides summary of motor symptoms
Volcansek et al.[52]	Acceptability of continuous glucose monitoring in elderly diabetes patients using multiple daily insulin injections. *Diabetes Technol Ther.* 2019;21(10):566–574.	Slovenia	Remote	22	N/A	Type 1 and 2 diabetes	Dexcom G4 Continuous Glucose Monitoring System, which includes wearable sensor connected to transmitter

Abbreviations: ECG, electrocardiogram; EEG, electroencephalogram.

Table 2. Main relevant satisfaction findings for select studies included in the review (n=26).

Author(s)	Main relevant findings	Converted score	Level of satisfaction
Adams et al.[11]	86% participants were "willing" or "very willing" to wear the sensors again	N/A[a]	N/A[a]
	69% had a positive or very positive experience with the sensors on the whole		N/A[a]
Agarwal et al.[7]	95% were satisfied with the technology	95	Higher
Amore et al.[8]	Average QUEST 2.0[b] score: 3.6 (1–5)	72	Moderate
	Average QUEST 2.0[b] assistive device subscale score: 3.7 (1–5)	74	Moderate
	Average QUEST 2.0[b] services score: 4.2 (1–5)	84	Higher
Bae et al.[14]	Overall satisfaction with wearable device: 3.56 (1–5)	71.2	Moderate
	Willingness to use a wearable device for managing infectious diseases in the future: 3.39 (1–5)	67.8	Moderate
Bhatlawande et al.[15]	93.33% of participants expressed satisfaction with information content of the system	93.33	Higher
Bonometti et al.[17]	Overall PSSUQ[c] satisfaction during use score: 1.29 (1–7)[d]	81.57	Higher
	Overall satisfaction questionnaire score: 4.41 (1–5)	88.2	Higher
Boroojerdi et al.[18]	61.9% said they were willing to wear patch for 1–2 days a week during the day	61.9	Moderate
	47.6% said they were willing to wear patch for 1–2 days a week during the night	47.6	Lower
Cooper et al.[22]	81.25% agreed or strongly agreed with "I liked using the range-of-motion sensor"	N/A[a]	N/A[a]
Elnagger et al.[25]	Overall satisfaction with Fitbit: 4.86 (1–5)	97.2	Higher
Giorgino et al.[27]	46% would prefer to continue treatment with a therapist and the system as opposed to therapist only	46	Lower
Goudelocke et al.[28]	90.8% reported satisfaction scores with the garment and app equal to or greater than 2 (0–4)	N/A[a]	N/A[a]
Kim et al.[33]	Satisfaction score for tongue driven system: 4.56 (1–5)	91.2	Higher
Kleiman et al.[35]	Mean score for "I liked wearing the device": 3.60 (0–10)	36	Lower
Liverani et al.[37]	89.1% would continue using the watch	89.1	Higher
Malhotra et al.[39]	53% agree/strongly agree with "Overall, I was satisfied with the activity tracker"	N/A[a]	N/A[a]
Noble et al.[9]	100% patients found experience positive	100	Higher
Oswald et al.[41]	Mean satisfaction with wearing Fitbit: 2.9 (0–4)	72.5	Moderate

(continued)

Table 2. Continued.

Author(s)	Main relevant findings	Converted score	Level of satisfaction
Pais et al.[42]	Overall average satisfaction with wearable tool: 3.5 (1–5)	70	Moderate
	Overall average satisfaction with wearable service: 3.6 (1–5)	72	Moderate
Peyrot et al.[43]	Mean overall satisfaction score: 69.4 (1–100)	69.4	Moderate
Savoldelli et al.[44]	71.43% of patients were satisfied with overall experience of using monitoring kit	71.43	Moderate
Schuurmans et al.[45]	10% willing to continue use of the ring-oximeter	10	Lower
	70% willing to continue use of the wrist-accelerometer	70	Moderate
	40% willing to continue use of the core temperature device	40	Lower
	100% willing to continue use of the COVIDA application	100	Higher
Schwenk et al.[46]	Mean score for form and design of the technology are optimal: 3.07 (0–4)	76.8	Moderate
Valiaho et al.[10]	82.2% of the patients would be willing to use the wristband at home for rhythm monitoring	82.2	Higher
Van Velthoven et al.[49]	75% were satisfied with the device	75	Moderate
	80% would recommend device to others	80	Moderate
Vaughn et al.[50]	Average satisfaction/acceptability score: 2.52 (0–4)	63	Moderate
Volcansek et al.[52]	100% perceived continuous glucose monitoring device use as overall positive and helpful	100	Higher

Note: To determine the level of satisfaction among respondents, we converted all numeric scores to score out of 100. We classified scores of less than 60 as "lower satisfaction," scores between 60 and 80 as "moderate satisfaction," and scores greater than 80 as "higher satisfaction." We reverse coded scales for which a lower score indicated a more positive outcome.
[a]Please refer to main finding for more information. Scores were not able to be converted.
[b]QUEST 2.0: Quebec User Evaluation of Satisfaction with Assistive Technology
[c]PSSUQ: Post-Study System Usability Questionnaire
[d]A lower score is better.

significant medical conditions such as chronic heart failure, stroke, and epilepsy. None of the wearable technology across the four studies was similar.

Discussion

To our knowledge, this represents the first review of published empirical articles examining patients' experience with wearable technology. Several general observations can be made from the findings. First, at present there is not a large number of studies examining how patients experience wearable technology. This is surprising given the hype associated with wearables in health care.[53,54] Much of this hype focuses on the benefits for health care quality and patients generally with using wearable technology to help promote wellness and prevention, while managing various medical conditions. However, from a patient experience standpoint, there is still much to know and validate in this regard, especially as the technology continues to advance. Second, the extant literature, limited as it is, does seem to support a positive patient experience with wearables in terms of satisfaction and usability, although the evidence is mixed when it comes to comfort. Third, the moderate to higher satisfaction, usability, and comfort findings across studies in the review do not suggest any sort of pattern with respect to the type of wearable, medical situation, or location. Rather, there is a fair degree of inherent variety in the literature suggesting that patients can have positive experiences with wearable technology regardless of the clinical context, treatment location, or wearable itself.

Table 3. Main relevant usability findings for select studies included in the review (n=24)

Author(s)	Main relevant findings	Converted score	Level of usability
Ali et al.[12]	86% agreed it was easy to navigate smartwatch app	86	Higher
	80% found it easy to enter symptoms using the smartwatch	80	Moderate
Amore et al.[8]	Mean SUS[a] score: 62.5 (0–100)	62.5	Moderate
Argent et al.[13]	Mean SUS[a] 90.8 (0–100)	90.8	Higher
	Mean usability rating: 4.2 (1–5)	84	Higher
Bae et al.[14]	Ease of use score: 2.85 (1–5)	57	Lower
Bhatlawande et al.[15]	System capability and usability score: 26.20 (0–40)	65.5	Moderate
Biondi et al.[16]	Average SUS[a] total score for the EEG system: 63.9 (0–100)	63.9	Moderate
	Average SUS[a] for Fitbit: 81.6 (0–100)	81.6	Higher
	Average PSSUQ[b] for EEG: 2.4[c] (1–7)	65.71	Moderate
	Average PSSUQ[b] for Fitbit: 1.9[c](1–7)	72.86	Moderate
Bonometti et al.[17]	Average PSSUQ[b] overall score: 1.54[c] (1–7)	78	Moderate
	Average PSSUQ[b] ease of use score: 1.29[c] (1–7)	81.57	Higher
	Average PSSUQ[b] ease of retrieving information score: 1.29[c] (1–7)	81.57	Higher
Boroojerdi et al.[18]	Median use difficulty: 7.0 (1–7)[d]	100	Higher
Bruno et al.[20]	Mean TAM-FF[e] scores for four devices ranged from 1.9 for E4 device to 3.0 (1–7)[c] for Epilog device (other two devices in between those means)	72.86–57.14	Moderate - Lower
	40% strongly agreed that the E4 device was usable	N/A[f]	N/A[f]
	52% strongly agreed that the IMEC device was usable	N/A[f]	N/A[f]
	52% strongly agreed that the Everion device was usable	N/A[f]	N/A[f]
	45% strongly agreed that the Epilog device was usable	N/A[f]	N/A[f]
Chang et al.[21]	Mean SUS[a] score: 77.70 (0–100)	77.70	Moderate
Cooper et al.[22]	88.24% agreed or strongly agreed with “I was able to use the range-of-motion sensor by myself”	N/A[f]	N/A[f]
Demers et al.[24]	Mean SUS[a] score: 85.4 (0–100)	85.4	Higher
D’Ancona et al.[23]	Mean score overall comfort and ease of use with the system: 3.9 (1–5)	78	Moderate
Goudelocke et al.[28]	97.7% found the system easy to use	97.7	Higher
Grym et al.[29]	Mean ease of functionality score at first follow-up: 4.5 (1–5)	90	Higher
	Mean ease of functionality score during second trimester: 4.6 (1–5)	92	Higher

(continued)

Table 3. Continued.

Author(s)	Main relevant findings	Converted score	Level of usability
	Mean ease of functionality score during third trimester: 4.6 (1–5)	92	Higher
	Mean ease of functionality score postpartum: 4.2 (1–5)	84	Higher
Hendriks et al.[30]	Median ease of use score for inertial measurement unit sensors: 9 (0–10)	90	Higher
Ingvaldsen et al.[31]	Median engagement score at two weeks: 3.5 (1–5)	70	Moderate
	Median functionality score at two weeks: 4.3 (1–5)	86	Higher
	Median engagement score at four weeks: 3.5 (1–5)	70	Moderate
	Median functionality score at four weeks: 4.4 (1–5)	88	Higher
Kane et al.[32]	70% found system concept easy to understand	70	Moderate
Kim et al.[33]	63.6% said system calibration was very easy	63.6	Moderate
	50% preferred the tongue driven system over current assistive technologies regarding ease of use	50	Lower
Lakshminarayanan et al.[36]	Mean score for ease of putting on and taking off: 3.2 (1–5)	64	Moderate
	Mean score for ease of control: 4.0 (1–5)	80	Moderate
	Mean score for safety of use: 4.6 (1–5)	92	Higher
	Mean score for ease of maintenance: 3.8 (1–5)	76	Moderate
Macea et al.[38]	Median usability score for using wearable device for up to 4 weeks: 7 (1–10)	70	Moderate
Malhotra et al.[39]	44% agree/strongly agree with "I found the activity tracker to be clear and understandable to use"	N/A[f]	N/A[f]
Vaughn et al.[50]	Average ease of use score: 3.76 (0–4)	94	Higher
	Average technical capability: 3.18 (0–4)	79.5	Moderate
Virbel-Fleischman et al.[51]	Median overall SUS[a] score: 87.5 (0–100)	87.5	Higher
	Median SUS[a] scores for PKG watch: 90 (0–100)	90	Higher
	Median SUS[a] scores for Kinesia 360: 87.5 (0–100)	87.5	Higher
	Median SUS[a] scores for STAT-ON: 95 (0–100)	95	Higher

Note: To determine the level of satisfaction among respondents, we converted all numeric scores to score out of 100. We classified scores of less than 60 as "lower satisfaction," scores between 60 and 80 as "moderate satisfaction," and scores greater than 80 as "higher satisfaction." We reverse coded scales for which a lower score indicated a more positive outcome.
Abbreviations: EEG, electroencephalogram.
[a]SUS: System Usability Scale
[b]PSSUQ, Post-Study System Usability Questionnaire
[c]A lower score is better
[d]Higher score indicates favorable result in this case.
[e]TAM-FF: Technology Acceptance Model Fast Form
[f]Please refer to main finding for more information. Scores were not able to be converted.

Table 4. Main relevant findings related to comfort of wearable for select studies included in the review (n=14).

Author(s)	Main relevant findings	Converted score	Level of comfort
Adams et al.[11]	25% responded "very positive" and 50% responded "positive" to "how comfortable were the wearable sensors?"	N/A[a]	N/A[a]
Bhatlawande et al.[15]	80% appreciated comfort of the system	80	Moderate
Brown et al.[19]	100% at least adequately satisfied with comfort	100	Higher
Bruno et al.[20]	42% responded that the E4 device was comfortable during sleep	42	Lower
	40% responded that the IMEC device was comfortable during sleep	40	Lower
	63% responded that the Everion device was comfortable during sleep	63	Moderate
	40% responded that the Epilog device was comfortable during sleep	40	Lower
	28% responded that the E4 device was comfortable to be worn for a long time	28	Lower
	35% responded that the IMEC device was comfortable to be worn for a long time	35	Lower
	52% responded that the Everion device was comfortable to be worn for a long time	52	Lower
	50% responded that the Epilog device was comfortable to be worn for a long time	50	Lower
D'Ancona et al.[23]	Mean score level of comfort during measurement: 4.0 (1–5)	80	Moderate
	Mean score overall comfort and ease of use with the system: 3.9 (1–5)	78	Moderate
Grym et al.[29]	Mean wearability score at first follow-up: 4.0 (1–5)	80	Moderate
	Mean wearability score at second trimester: 4.1 (1–5)	82	Higher
	Mean wearability score at third trimester: 4.2 (1–5)	84	Higher
	Mean wearability score postpartum: 3.9 (1–5)	78	Moderate
Kinsella et al.[34]	Mean response to how much participant agrees with "The special glasses fit comfortably on my face": 4.2 (1–5)	84	Higher
Kleiman et al.[35]	The device was uncomfortable to wear: 5.23 (0–10)[b]	52.3	Lower
Lakshminarayanan et al.[36]	Average score for "comfortable to wear": 4.3 (1–5)	86	Higher
Macea et al.[38]	Median score for comfort using sensor device/patches: 7 (1–10)	70	Moderate
Malhotra et al.[39]	62% agree/strongly agree with "The activity tracker was comfortable to wear"	N/A[a]	N/A[a]
Stellpflug et al.[47]	About 70% agreed that the device was comfortable to wear	70	Moderate
Taylor-Pillae et al.[48]	100% reported that the PAMSys was comfortable to wear for the full 48 h	100	Higher
Van Velthoven et al.[49]	49% felt the device was comfortable to wear	49	Lower

Note: To determine the level of satisfaction among respondents, we converted all numeric scores to score out of 100. We classified scores of less than 60 as "lower satisfaction," scores between 60 and 80 as "moderate satisfaction," and scores greater than 80 as "higher satisfaction." We reverse coded scales for which a lower score indicated a more positive outcome.
[a]Please refer to main finding for more information. Scores were not able to be converted.
[b]A lower score is better.

Table 5. Comparison of comfort, usability, and satisfaction levels for select studies in the review (n=14).

Author(s)	Level of comfort	Level of usability	Level of satisfaction
Amore et al.[8]	No finding	Moderate	Moderate Moderate Higher
Bae et al.[14]	No finding	Lower	Moderate Moderate
Bhatlawande et al.[15]	Moderate	Moderate	Higher
Bonometti et al.[17]	No finding	Moderate Higher Higher	Higher Higher
Boroojerdi et al.[18]	No finding	Higher	Moderate Lower
Bruno et al.[20]	Lower Lower Lower Lower Moderate Lower Lower Lower	Moderate – Lower N/A N/A N/A N/A	No finding
D'Ancona et al.[23]	Moderate Moderate	Moderate	No finding
Grym et al.[29]	Moderate Higher Higher Moderate	Higher Higher Higher Higher	No finding
Kim et al.[33]	No finding	Moderate Lower	Higher
Kleiman et al.[35]	Lower	No finding	Lower
Lakshminarayanan et al.[36]	Higher	Moderate Moderate Higher Moderate	No finding
Macea et al.[38]	Moderate	Moderate	No finding
Van Velthoven et al.[49]	Lower	No finding	Moderate Moderate
Vaughn et al.[50]	No finding	Higher Moderate	Moderate

From a practical standpoint, the review findings suggest that health care organizations should view wearable technology as a viable complement to other traditional aspects of patient care, that can be used to help physicians in their clinical monitoring, for empowering patients to engage in their health care, and to provide important data for decision making. Extant literature already shows wearable technology to be cost-effective and able to increase quality-adjusted life years for individuals.[6] But to gain widespread acceptance, physicians will want to be reimbursed appropriately for investing in such technology and for the additional work associated with using wearable technology in their practices.

Future research opportunities related to the wearable experience

Additional research opportunities exist that will help enhance the empirical literature on patients' experiences with wearable technology. An obvious one is the need for additional studies that examine the experience within a multivariate context, to help determine which factors are most associated with either a positive or negative wearable experience.[55] Such studies would require: (a) larger sample sizes in order to include more contextual variables in models that can isolate the independent effects of various factors on experiential variables like satisfaction and usability; (b) different types of wearables and medical situations examined in the same study to compare patients' experience; and (c) greater inclusion of quality and effectiveness measures in the same studies as the patient experience measures. The ability to compare reported levels of quality and effectiveness in the same study as levels of satisfaction and usability can offer a robust picture of wearable value in patient care. For example, if a specific wearable can deliver both patient satisfaction and improved quality of care, it merits greater investment than one that does less.

Longitudinal studies that assess the wearable experience over time in patient care situations are also needed. There is evidence that individuals generally may become less engaged or satisfied with a wearable as they use it longer. However, this research has focused on the voluntary use of wearable devices for general health and wellness monitoring, such as in the use of smart watches. There is less understanding of whether patients whose conditions require them to engage with different types of wearables also experience a more negative or ambivalent experience as time goes on. Generally, patient perceptions of usability or comfort may indeed change over time.[56] If a wearable is used for a longer period, it makes sense to gauge how patients interact with that wearable for the full time they have it. In addition, qualitative investigations of patients' experiences can create a more precise understanding of the most important parts of a patient's wearable experience. For instance, is comfort as important as usability? Can patients be satisfied with a wearable even if it is perceived as less comfortable? What specifically does "usability" mean across different types of medical situations and wearable technologies? Does satisfaction depend on other dimensions such as usability and comfort? Questions such as these require data collection from patients that go into greater depth around their everyday experiences with wearable technology.

Two related limitations of the review are worth noting. First, it is possible that some relevant empirical studies of the wearable experience were missed. For example, there could be peer-reviewed research that examines patient satisfaction or usability as a minor aim such that specific findings are not identified in an article title or abstract. Second, there may be data on the patient experience not published in peer-reviewed journals that was missed as only research published in peer-reviewed journals was included in the review. For example, survey data collected by private companies around patient perceptions related to wearables might exist, although it might be assumed that in these instances, validating whether or not a given survey respondent actually has used a specific wearable is difficult. We decided to hold to the gold standard of including only research that had undergone peer-review and which used patient samples where it was validated a specific type of wearable had been used by those being asked about their experiences.

Conclusion

This review shows that the early literature on patients' experience with wearable technology paints a promising yet incomplete picture. In most situations, there are adequate levels of satisfaction, usability, and comfort expressed by patients towards wearable technology. What has to be better understood is the array of factors which drive these positive feelings, and how different dimensions of the experience interact with each other over time to produce higher levels of satisfaction with wearable technology.

Contributorship: All listed authors met the following criteria for this paper:

- Made a significant contribution to the concept, design, acquisition, analysis or interpretation of data
- Drafted the article or revised it critically for important intellectual content
- Approved the final version of the article for publication
- Agreed to be accountable for all aspects of the work and resolved any issues related to its accuracy or integrity

Acknowledgements: N/A

Consent to participate: Not applicable.

Data availability: Information on review data is available by contacting the corresponding author.

Declaration of conflicting interests: The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical considerations: Not applicable.

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

ORCID iD: Timothy Hoff https://orcid.org/0000-0001-8281-5200

References

1. Nova Advisor. U.S. Wearable Medical Devices Market. 2023. https://www.novaoneadvisor.com/report/us-wearable-medical-devices-market (accessed 22 July 2024).
2. Goswami J. Technology Brings Care to Home for Chronically Ill Patients. 2020. https://www.healthcareitnews.com/blog/technology-brings-care-home-chronically-ill-patients (accessed 22 July 2024).
3. Vaidya A. How Connected Health Tech Bolsters Chronic Care, Behavioral Health. 2023. https://mhealthintelligence.com/features/how-connected-health-tech-bolsters-chronic-care-behavioral-health (accessed 22 July 2024).
4. Jo A, Coronel BD, Coakes CE, et al. Is there a benefit to patients using wearable devices such as fitbit or health apps on mobiles? A systematic review. *Am J Med* 2019; 132: 1394–1400. e1391.
5. Mattison G, Canfell O, Forrester D, et al. The influence of wearables on health care outcomes in chronic disease: systematic review. *J Med Internet Res* 2022; 24: e36690.
6. De Sario Velasquez GD, Borna S, Maniaci MJ, et al. Economic perspective of the use of wearables in health care: a systematic review. *Mayo Clin Proce: Digital Health* 2024; 2: 299–317.
7. Agarwal DK, Viers BR, Rivera ME, et al. Physical activity monitors can be successfully implemented to assess perioperative activity in urologic surgery. *Mhealth* 2018; 4: 43.
8. Amore F, Silvestri V, Guidobaldi M, et al. Efficacy and patients' satisfaction with the ORCAM MyEye device among visually impaired people: a multicenter study. *J Med Syst* 2023; 47: 11.
9. Noble K, Brown K, Medina M, et al. Medication adherence and activity patterns underlying uncontrolled hypertension: assessment and recommendations by practicing pharmacists using digital health care. *J Am Pharm Assoc* 2016; 56: 310–315.
10. Valiaho ES, Lipponen JA, Kuoppa P, et al. Continuous 24-h photoplethysmogram monitoring enables detection of atrial fibrillation. *Front Physiol* 2021; 12: 778775.
11. Adams JL, Dinesh K, Xiong M, et al. Multiple wearable sensors in Parkinson and Huntington disease individuals: a pilot study in clinic and at home. *Digit Biomark* 2017; 1: 52–63.
12. Ali SM, Selby DA, Khalid K, et al. Engagement with consumer smartwatches for tracking symptoms of individuals living with multiple long-term conditions (multimorbidity): a longitudinal observational study. *J Multimorb Comorb* 2021; 11, 26335565211062791.
13. Argent R, Slevin P, Bevilacqua A, et al. Wearable sensor-based exercise biofeedback for orthopaedic rehabilitation: a mixed methods user evaluation of a prototype system. *Sensors (Basel)* 2019; 19: 432.
14. Bae YS, Sung S, Lee J, et al. Building and implementing a contactless clinical trial protocol for patients with COVID-19: a Korean perspective. *Front Med (Lausanne)* 2022; 9: 975243.
15. Bhatlawande S, Sunkari A, Mahadevappa M, et al. Electronic bracelet and vision-enabled waist-belt for mobility of visually impaired people. *Assist Technol* 2014; 26: 186–195.
16. Biondi A, Simblett SK, Viana PF, et al. Feasibility and acceptability of an ultra-long-term at-home EEG monitoring system (EEG@HOME) for people with epilepsy. *Epilepsy Behav* 2023; 151: 109609.
17. Bonometti F, Bernocchi P, Vitali A, et al. Usability of a continuous oxygen saturation device for home telemonitoring. *Digit Health* 2023; 9, 20552076231194547.
18. Boroojerdi B, Ghaffari R, Mahadevan N, et al. Clinical feasibility of a wearable, conformable sensor patch to monitor motor symptoms in Parkinson's disease. *Parkinsonism Relat Disord* 2019; 61: 70–76.
19. Brown FE, Sutton J, Yuen HM, et al. A novel, wearable, electronic visual aid to assist those with reduced peripheral vision. *PLoS One* 2019; 14: e0223755.
20. Bruno E, Biondi A, Böttcher S, et al. Day and night comfort and stability on the body of four wearable devices for seizure detection: a direct user-experience. *Epilepsy Behav* 2020; 112: 107478.
21. Chang CH, Lien WC, Chiu TP, et al. A novel smart somatosensory wearable assistive device for older adults' home rehabilitation during the COVID-19 pandemic. *Front Public Health* 2023; 11: 1026662.
22. Cooper DM, Bhuskute N and Walsh G. Exploring the impact and acceptance of wearable sensor technology for pre- and post-operative rehabilitation in knee replacement patients: a U. K.-based pilot study. *JB JS Open Access* 2022; 7: e21.00154.
23. D'Ancona G, Murero M, Feickert S, et al. Implantation of an innovative intracardiac microcomputer system for web-based real-time monitoring of heart failure: usability and patients' attitudes. *JMIR Cardio* 2021; 5: e21055.
24. Demers M, Bishop L, Cain A, et al. Wearable technology to capture arm use of people with stroke in home and community settings: feasibility and early insights on motor performance. *Phys Ther* 2024; 104: pzad172.
25. Elnaggar A, von Oppenfeld J, Whooley MA, et al. Applying mobile technology to sustain physical activity after completion of cardiac rehabilitation: acceptability study. *JMIR Hum Factors* 2021; 8: e25356.
26. Fredriksson T, Kemp Gudmundsdottir K, Frykman V, et al. Intermittent vs continuous electrocardiogram event recording for detection of atrial fibrillation-compliance and ease of use in an ambulatory elderly population. *Clin Cardiol* 2020; 43: 355–362.
27. Giorgino T, Tormene P, Maggioni G, et al. Assessment of sensorized garments as a flexible support to self-administered post-stroke physical rehabilitation. *Eur J Phys Rehabil Med* 2009; 45: 75–84.
28. Goudelocke C, Sobol J, Poulos D, et al. A multicenter study evaluating the FREquency of use and efficacy of a novel closed-loop wearable tibial neuromodulation system for overactive bladder and urgency urinary incontinence (FREEOAB). *Urology* 2024; 183: 63–69.
29. Grym K, Niela-Vilen H, Ekholm E, et al. Feasibility of smart wristbands for continuous monitoring during pregnancy and one month after birth. *BMC Pregnancy Childbirth* 2019; 19: 34.

30. Hendriks MMS, Vos-van der Hulst M and Keijsers NLW. Feasibility of a sensor-based technological platform in assessing gait and sleep of in-hospital stroke and incomplete spinal cord injury (iSCI) patients. *Sensors (Basel)* 2020; 20: 2748.
31. Ingvaldsen SH, Tronvik E, Brenner E, et al. A biofeedback app for migraine: development and usability study. *JMIR Format Res* 2021; 5: e23229.
32. Kane JM, Perlis RH, DiCarlo LA, et al. First experience with a wireless system incorporating physiologic assessments and direct confirmation of digital tablet ingestions in ambulatory patients with schizophrenia or bipolar disorder. *J Clin Psychiatry* 2013; 74: e533–e540.
33. Kim J, Park H, Bruce J, et al. Qualitative assessment of tongue drive system by people with high-level spinal cord injury. *J Rehabil Res Dev* 2014; 51: 451–465.
34. Kinsella BG, Chow S and Kushki A. Evaluating the usability of a wearable social skills training technology for children with autism spectrum disorder. *Front Robot AI* 2017; 4.
35. Kleiman E, Millner AJ, Joyce VW, et al. Using wearable physiological monitors with suicidal adolescent inpatients: feasibility and acceptability study. *JMIR Mhealth Uhealth* 2019; 7.
36. Lakshminarayanan K, Wang F, Webster JG, et al. Feasibility and usability of a wearable orthotic for stroke survivors with hand impairment. *Disabil Rehabil Assist Technol* 2017; 12: 175–183.
37. Liverani M, Ir P, Wiseman V, et al. User experiences and perceptions of health wearables: an exploratory study in Cambodia. *Glob Health Res Policy* 2021; 6.
38. Macea J, Bhagubai M, Broux V, et al. In-hospital and home-based long-term monitoring of focal epilepsy with a wearable electroencephalographic device: diagnostic yield and user experience. *Epilepsia* 2023; 64: 937–950.
39. Malhotra R, Kumar U, Virgen P, et al. Physical activity in hemodialysis patients on nondialysis and dialysis days: prospective observational study. *Hemodial Int* 2021; 25: 240–248.
40. Marschollek M, Becker M, Bauer JM, et al. Multimodal activity monitoring for home rehabilitation of geriatric fracture patients--feasibility and acceptance of sensor systems in the GAL-NATARS study. *Inf Health Soc Care* 2014; 39: 262–271.
41. Oswald LB, Li X, Carvajal R, et al. Longitudinal collection of patient-reported outcomes and activity data during CAR-T therapy: feasibility, acceptability, and data visualization. *Cancers (Basel)* 2022; 14: 2742.
42. Pais B, Buluschek P, DuPasquier G, et al. Evaluation of 1-year in-home monitoring technology by home-dwelling older adults, family caregivers, and nurses. *Front Public Health* 2020; 8: 518957.
43. Peyrot M, Dreon D, Zraick V, et al. Patient perceptions and preferences for a mealtime insulin delivery patch. *Diabetes Ther* 2018; 9: 297–307.
44. Savoldelli A, Vitali A, Remuzzi A, et al. Improving the user experience of televisits and telemonitoring for heart failure patients in less than 6 months: a methodological approach. *Int J Med Inform* 2022; 161: 104717.
45. Schuurmans MM, Muszynski M, Li X, et al. Multimodal remote home monitoring of lung transplant recipients during COVID-19 vaccinations: usability pilot study of the COVIDA desk incorporating wearable devices. *Medicina (Kaunas)* 2023; 59: 617.
46. Schwenk M, Grewal GS, Honarvar B, et al. Interactive balance training integrating sensor-based visual feedback of movement performance: a pilot study in older adults. *J Neuroeng Rehabil* 2014; 11: 164.
47. Stellpflug C, Pierson L, Roloff D, et al. Continuous physiological monitoring improves patient outcomes. *Am J Nurs* 2021; 121: 40–46.
48. Taylor-Piliae RE, Mohler MJ, Najafi B, et al. Objective fall risk detection in stroke survivors using wearable sensor technology: a feasibility study. *Top Stroke Rehabil* 2016; 23: 393–399.
49. Van Velthoven MH, Oke J and Kardos A. Chronisense national early warning score study: comparison study of a wearable wrist device to measure vital signs in patients who are hospitalized. *J Med Internet Res* 2023; 25: e40226.
50. Vaughn J, Gollarahalli S, Shaw RJ, et al. Mobile health technology for pediatric symptom monitoring: a feasibility study. *Nurs Res* 2020; 69: 142–148.
51. Virbel-Fleischman C, Retory Y, Hardy S, et al. Body-worn sensors for Parkinson's disease: a qualitative approach with patients and healthcare professionals. *PLoS One* 2022; 17: e0265438.
52. Volcansek S, Lunder M and Janez A. Acceptability of continuous glucose monitoring in elderly diabetes patients using multiple daily insulin injections. *Diabetes Technol Ther* 2019; 21: 566–574.
53. Apple. Apple Watch. 2024. https://www.apple.com/watch/ (accessed 22 July 2024).
54. Kang HS and Exworthy M. Wearing the future-wearables to empower users to take greater responsibility for their health and care: scoping review. *JMIR Mhealth Uhealth* 2022; 10: e35684.
55. Smuck M, Odonkor CA, Wilt JK, et al. The emerging clinical role of wearables: factors for successful implementation in healthcare. *NPJ Digit Med* 2021; 4.
56. Oben P. Understanding the patient experience: a conceptual framework. *J Patient Exp* 2020; 7: 906–910.