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Factors Influencing Adoption and Sustained Use of Rehabilitation Technologies: A Scoping Review and Qualitative Analysis

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Abstract

Rehabilitation technology (RT) development has grown, however evidence suggests poor uptake by therapists and patients, with many devices abandoned. Successful implementation encompasses both 'adoption', where RT is first utilized, and 'sustained use', wherein RT remains in use over time. This scoping review and qualitative analysis aimed to explore the extent and nature of the relevant evidence base and investigate factors that influence adoption and sustained use of RT in clinical practice, from the perspectives of patients and therapists. A systematic search was conducted to identify qualitative and quantitative articles investigating adoption and/or sustained use of RT. Study characteristics were analyzed quantitatively. Factors influencing adoption and sustained use were analyzed using a two-stage thematic analysis. Stage 1 employed an inductive approach, analyzing data related to RT adoption from review papers. Stage 2 employed an abductive approach, where data related to sustained use from primary research and reviews was mapped to Stage 1 themes and new themes were identified. The review included 42 articles. The majority of articles explored RT adoption. Thematic analysis revealed five themes. Four influenced adoption of RT: 1) 'Knowledge' about RT; 2) 'Design' of RT; 3) 'Circumstances and Characteristics'; and, 4) the 'Person-centered' approach. These were confirmed and refined in the sustained use analysis, and a fifth theme, 'Healthcare Ecosystem', was identified. These findings highlight factors influencing adoption and sustained use of RT, providing insights for development and implementation of technology in rehabilitation clinical practice. Further research is needed to identify strategies that facilitate sustained use of RT.

Keywords: rehabilitation technology, assistive technology, adoption, sustained use, acceptability, usability, qualitative.

Introduction

Rehabilitation technologies (RTs) encompass tools, equipment, and products designed to facilitate recovery and improve function following injury or illness (1). Examples of RTs include virtual reality (VR), body worn sensors, neuromodulation devices, mobile applications, robotics, and gaming systems (1). RTs can be differentiated from assistive technologies (ATs), where RTs are those used to restore or improve body function (1) during the rehabilitation process, whereas ATs support or compensate for a loss of function, and include devices such as spectacles, prostheses, or hearing aids (2, 3). Within the field of RT, there is an abundance of research investigating the efficacy of various devices and technologies, however, there are notable barriers that hinder their implementation in rehabilitation practice (4-6). Successful clinical implementation of RT relies firstly on their 'adoption' by users, which involves therapists and patients willingly taking up and using the device for its intended purpose (7).

While RT may initially be adopted based on evidence of efficacy, it has been noted that use of RTs frequently wanes over time (8) and devices may be abandoned completely (9). Sustained use refers to the ongoing and continuous use of a RT in rehabilitation clinical practice (10), whether that be within the acute, outpatient clinic, home, or community setting. Sustained use is not strictly defined by a specific timeframe, but rather considers the value obtained relative to the cost of the RT (11) over a longer period of time. This value may vary for each RT dependent on factors such as frequency of use, population reach, and magnitude of clinical effectiveness (9). Optimal realization of the value of RTs necessitates their sustained use, yet little research has addressed what supports the sustained use of RT in clinical practice.

The adoption and sustained use of RT is thought to be underpinned by the concepts of acceptability and usability (6, 12). While conceptual understandings of acceptability and usability vary across the literature (12), acceptability broadly refers to the extent to which a system fulfils all the needs and requirements of the user and stakeholders, and includes both social and practical acceptability (13), whereas usability is the extent to which a system can be used by specified users to accomplish specified goals effectively, efficiently, and with satisfaction (14). Usability must take into consideration the initial learning phase of using a device, its ongoing use (regular or infrequent), the potential for errors or risk, maintenance requirements, as well as use by people with range of capabilities (14). To optimize RT for adoption and sustained use, acceptability and usability of RT must be understood from the perspectives of patients and therapists (15).

Previous literature reviews have explored the usability and acceptability of specific RTs such as mobile health technologies (16), virtual reality (17), or upper limb assistive technology (18), or have focused on specific patient populations, such as people with traumatic brain injury (19). There has yet to be a systematic exploration of the factors underpinning both adoption and sustained use of technologies in wider rehabilitation practice. Therefore, this scoping review and qualitative analysis aimed to explore the extent and nature of the relevant evidence base and to investigate the factors influencing adoption and sustained use of RT in rehabilitation practice from the perspectives of both patients and therapists.

Methods

Study design

Two broad research questions were identified. 1) What is the extent and nature of the evidence base investigating the adoption and sustained use of RT in clinical practice? 2) What are the factors that influence the adoption and/or sustained use of RT within the clinical practice setting from the perspectives of patients and therapists? Given the emergent nature of the field and the heterogeneity of evidence relevant to the review aim, two methods were selected to answer these research questions. The first question was answered with a scoping review to identify and map the evidence base in the field of rehabilitation (20-23). A scoping review methodology is suitable when aiming to summarize the breadth of literature and is iterative in response to the volume and nature of data that is identified (24). The second question was answered with a qualitative thematic analysis (24, 25). For the purpose of this review, RT was defined as technology that aims to improve physical or cognitive impairment, activity, or participation, as defined by the International Classification of Functioning, Disability and Health (ICF) (26). The clinical practice setting included any environment in which rehabilitation could be delivered, such inpatient and outpatient services, rehabilitation clinics, telerehabilitation, and the home or community environment.

Search strategy

Following extensive piloting, a systematic literature search was undertaken in April 2021, and updated in April 2023, utilizing the search terms in Table 1 in the following electronic databases: CINAHL/MEDLINE/SportDiscus via EBSCO, Scopus, Cochrane Library, and AMED. Additionally, reference lists of relevant articles were manually searched. Titles and abstracts were screened against the eligibility criteria outlined in Table 2. To enable consideration of the breadth of the evidence base, articles adopting both qualitative and quantitative research approaches were considered, as were both primary and secondary research (23, 27). Potentially eligible articles were categorized into three groups based on the type of RT use addressed: i) adoption, ii) adoption and sustained use, and iii) sustained use. In line with scoping review methodology, iterative changes were made to the initial search strategy in response to the data identified (23, 24). Due to the large volume of articles meeting the initial eligibility criteria in the adoption category, the eligibility criteria for adoption were refined (23, 24) to include only review articles and exclude primary research articles (see refined criteria in Table 2). Whereas there was substantially less literature in the 'sustained use' categories, necessitating the inclusion of both reviews and primary research (28-30) to ensure this relatively underexplored concept was sufficiently examined. Subsequently, titles and abstracts, and if necessary full-text articles, were screened against the refined eligibility criteria by a single author (XL, SO, GA, or VS). In cases where eligibility was unclear co-authors were consulted. All potentially included articles were cross-checked against the eligibility criteria by a second author.

Table 1. Search Terms

	Search terms
#1	rehab* N8 technolog*
#2	implement* OR uptake OR adopt* OR accept* OR ultili$ation OR utili$e OR use
#3	subacute OR post-acute OR rehabilitation OR clinic* OR occupational therapy OR physical therapy OR speech therapy
#4	#1 AND #2 AND #3

Table 2. Eligibility criteria

Inclusion Criteria	Exclusion Criteria
Research focus	
Studies that investigated adoption and/or sustained use of RT (as defined in this review) from the perspectives of patients and/or therapists, or studies that investigated underpinning concepts of usability and acceptability of RT.	Studies focused solely on the efficacy of a RT
Type of rehabilitation technology	
RT that aims to improve physical and cognitive impairment, activity or participation as defined by the ICF.	Electronic medical records and health information technology solely used for communication between different health workers. Assistive devices or technology worn and/or used extensively to enable/maintain function rather than improve function. Examples include prostheses, walking aids, or reminder systems used to compensate for loss of function.
Population	
Participants > 18 years of age who use the RT in the rehabilitation context.	
Publication	
Peer reviewed journals in English language from 2000 onwards.	Full-text unattainable.
Study design	
Qualitative and quantitative primary research or review articles. *Refined criteria: Review articles investigating adoption only. Primary research or review articles investigating sustained use.*	*Refined criteria: Primary research investigating adoption only.*

Data charting

The approach to data-charting was jointly developed by three researchers (XL, SO, NS) and iteratively piloted and refined (23). The following characteristics were extracted from each included article: study design, aim, study setting and population, study designs included (for review papers), method (for primary research), and the type of technology.

Data Analysis

To map the extent and nature of the relevant evidence base related to the adoption and sustained use of RT, a descriptive quantitative analysis of included articles was undertaken (31) and data were presented visually.

To identify the factors which may influence the adoption and sustained use of RT, a qualitative thematic analysis was undertaken (25, 32). This was undertaken within a pragmatic paradigm which values diverse perspectives and emphasizes practical knowledge and solutions to inform the advancement of rehabilitation (33, 34). Contributors to the analysis included an occupational therapist (XL) and two physiotherapy researchers (SO, NS), each of whom had significant clinical experience in rehabilitation. The thematic analysis was undertaken in two stages. Stage 1 analyzed textual data from review articles related to 'adoption only'. This initial stage used an inductive approach to develop an understanding of the well-studied area of adoption. Knowledge from Stage 1 was then used as a framework for Stage 2, which used an abductive approach (35) to explore the relatively underexplored field of sustained use. This second stage analyzed textual data from review and primary research articles related to 'adoption and sustained use' and 'sustained use only'. Further detail about each stage is provided below.

Full text articles were imported into NVivo (1.6.1). In Stage 1 of the thematic analysis, the familiarization process involved reading the articles and identifying the context for textual data relevant to the research aim. This data could be located in any part of the article that described or discussed study findings (36). Next, relevant textual data were coded using semantic codes generated from the data (XL, SO); these aimed to represent the raw data as closely as possible. The codes were then grouped using an inductive approach to produce initial subthemes and themes. Subthemes and themes were discussed, cross-checked against the raw data, and iteratively revised throughout the analysis process (XL, SO, NS). A thematic map was developed to provide a visual representation of the adoption themes and subthemes and their relationships (25). Stage 2 of the thematic analysis involved the same familiarization process, however an abductive approach (35) was utilized. This involved deductively coding data to Stage 1 codes, subthemes, and themes, and then inductively coding data to identify new codes relevant to sustained use of RT. Subsequently, the themes and subthemes were refined and broadened to ensure fitting of codes from both sustained use and adoption literature (XL, SO, NS). As Stage 2 involved combining both primary research and reviews, the articles were screened to determine if any of the primary research articles were also included in the reviews. The Stage 2 thematic analysis was checked to ensure any primary research that was also included in review articles was not overemphasized.

Results

Study Selection

The screening and selection of articles can be seen in Figure 1. A total of 42 articles were included. There were 25 review articles related to 'adoption only', 15 articles related to 'adoption and sustained use', and 2 articles related to 'sustained use only'. The characteristics of included studies are shown in Tables 3 and 4.

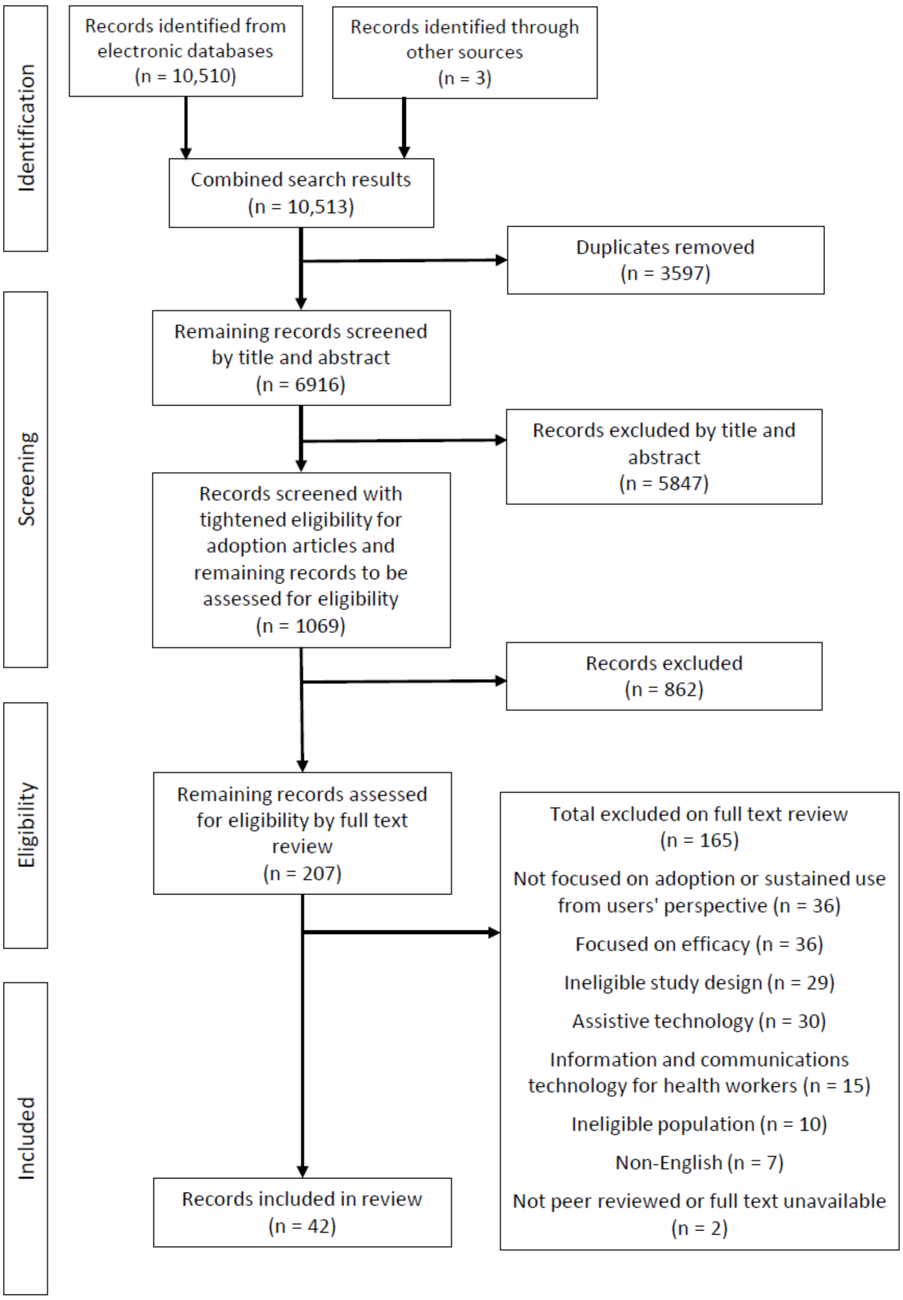

Figure 1. PRISMA flowchart

Characteristics of the evidence base

The 25 review articles investigating adoption alone (Table 3) included 13 systematic reviews, 2 scoping reviews, and 10 narrative reviews. Reviews included articles from a range of study designs (refer to Figure 2), including quantitative (n=3), qualitative (n=2), or a combination of study designs (mixed methods, quantitative and/or qualitative, n=12). However, eight reviews failed to adequately report the source studies which informed their review. The review articles featured a wide variety of

RT including robotics, augmented reality (AR), virtual reality (VR), mobile applications (apps), video games, wearables, mobility-related devices, and telerehabilitation platforms. This range of RT is presented in Figure 3 alongside the timepoint of each study which demonstrates an increase in review papers since 2018.

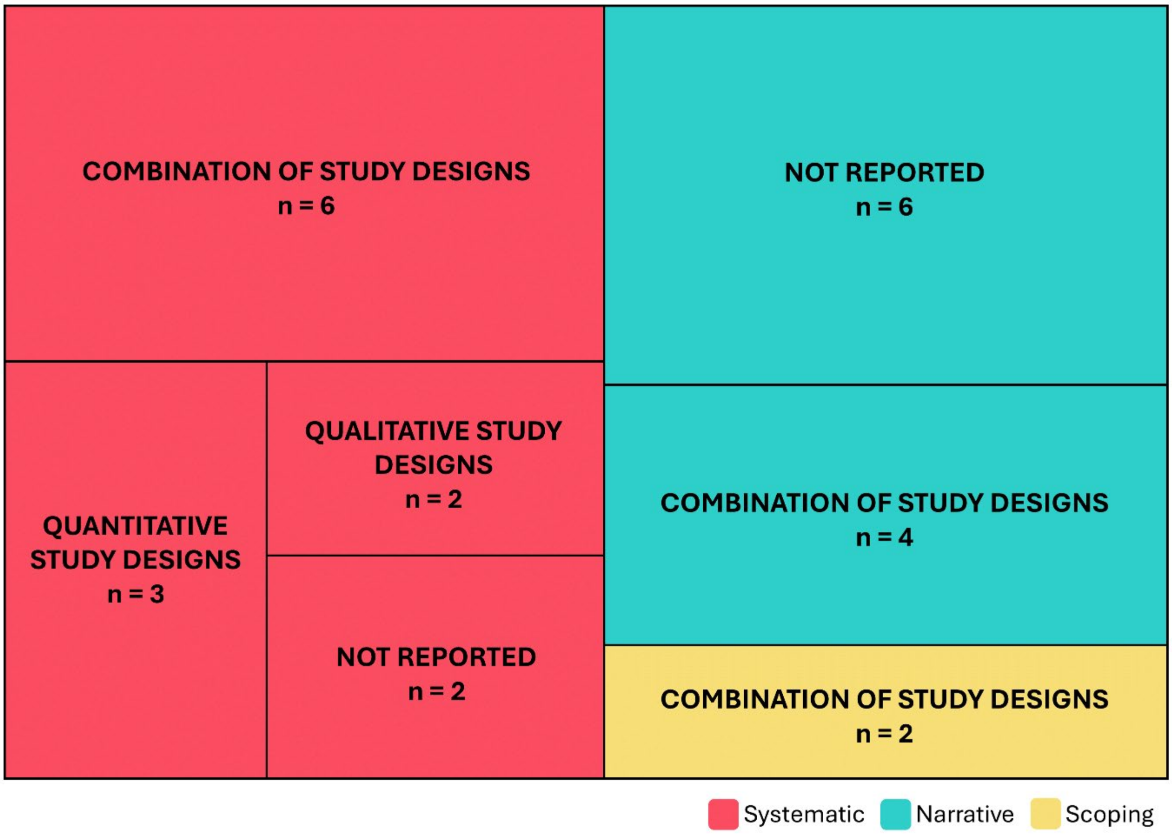

Figure 2. Study designs of articles within the review papers investigating adoption of rehabilitation technologies. Study designs were either quantitative only, qualitative only, a combination of study designs (mixed methods, quantitative and/or qualitative) or not reported.

The 15 articles investigating adoption and sustained use (Table 4) included 5 review papers (3 narrative, 1 systematic, and 1 scoping) and 10 primary research studies (3 qualitative, 4 quantitative observational, 1 descriptive, 2 retrospective). The 2 articles in the sustained use category were randomized controlled trials (RCTs). Participants in the included articles included therapists, service providers, patients, and/or caregivers. The articles featured a variety of RT including robotics, augmented reality (AR), virtual reality (VR), mobile applications, video games, wearables, and telerehabilitation platforms (see Figure 3).

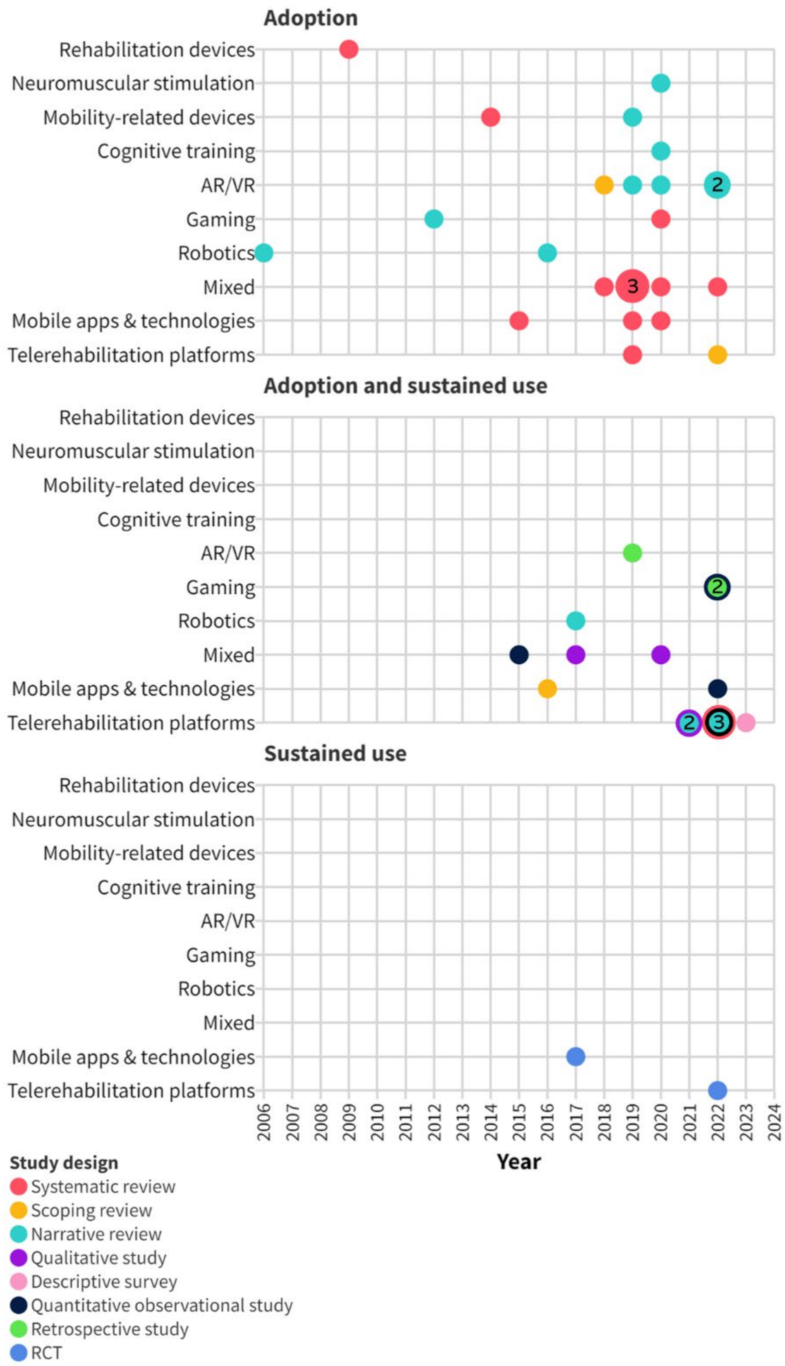

Figure 3. Timeline of articles (dots) investigating adoption, adoption and sustained use, and sustained use only, according to the type of technology investigated. Dots are colored according to study design. Dots representing more than 1 article are labelled.

Table 3. Study characteristics for review articles investigating 'adoption' of rehabilitation technology

Author	Review type	Review aim	Studies and participants (n)	Study designs included	Type of technology
Agnew et al (2022) (37)	Scoping	To investigate the literature focusing on the use of mHealth in musculoskeletal physiotherapy and summarize the evidence.	28 studies. Participants with musculoskeletal conditions including post-operatively. 15 geographical locations.	10 RCTs, 9 other quantitative, 4 qualitative, 1 mixed methods, others not described.	TR including video conferencing, telephone calls, text messages, video-based exercises, web or mobile phone applications.
Alqahtani (2019) (38)	Narrative	To identify potential future areas of development and research in mobility-assistive technology.	15 out of 28 studies were relevant to research question (n = 2573: ~2403 users; 178 professionals; 5 caregivers).	1 questionnaire, 2 surveys, 5 focus groups, 1 systematic review, 2 literature reviews, 2 interview-based, 1 survey, 1 scoping.	Mobility assistive technology including exoskeletons and therapeutic brain machine interfaces.
Aqel (2019) (39)	Narrative	To present a narrative review of state-of-the-art assistive technologies, their types, applications, selection criteria, challenges, and how can they be used in rehabilitation.	Not reported	All study designs	Deep learning and neural networks, AR, VR, Internet of Things (IoT).
Babaiasl et al. (2016) (40)	Narrative	To investigate the requirements for rehabilitation robots and the most outstanding works in robot-aided upper-limb rehabilitation, and provide clinical outcomes of built robots that demonstrate their usability and acceptance in real-life.	Number of studies not provided. Participants with stroke.	Not reported	Rehabilitation robots: MIT-Manus, Mirror Image motion enabler (MIME), GENTLE/s, Bi-Manu-Track, REHAROB, Dampace, T-WREX, MGA-exoskeleton, L-EXOS, ARMin.
Chen et al. (2019) (41)	Systematic	To synthesise the current knowledge of technologies and human factors in home-based technologies for stroke rehabilitation.	31 studies with 25 systems. Participants not provided.	12 quantitative, 2 qualitative, 11 mixed quantitative and qualitative approach.	Games, telerehabilitation, robotic devices, virtual reality devices, sensors, and tablets.

Fabricatore et al. (2020) (42)	Narrative	To use a neuropsychological rehabilitation perspective to analyze studies reporting on technological solutions for people with dementia, and to analyze purposes/uses, supported impairments and disabilities, and how engagement was considered.	138 studies. Number of participants not provided. Participants with dementia or caregivers of people with dementia.	Not reported	Technological solutions for cognitive retraining and assistive technology (environment modification, activity recognition, monitoring).
Glegg & Levac (2018) (17)	Scoping	To apply the Theoretical Domain Framework (TDF) to examine the extent, range, and nature of studies assessing virtual reality (VR)/active video game (AVG) barriers and facilitators and/or recommending or evaluating knowledge translation interventions to promote VR/AVG adoption.	24 studies. Participants not provided. Focus on stroke, CP or brain injury (18 studies), geriatrics, burns, or lung cancer (3 studies), or not specified (3 studies).	4 mixed methods, 7 qualitative, 3 cross-sectional, 1 usability, 3 perspective, 2 descriptive, 1 narrative, 1 case study, 1 feasibility.	Off-the-shelf AVGs (6 studies), custom VR/AVGs (10 studies), VR using head-mounted displays (1 study), VR/AVG system not specified (7 studies).
Gorman & Gustafsson (2022) (43)	Narrative	To explore research relating to the use of augmented reality technology for rehabilitation after stroke in order to better understand the current and potential future application of this technology.	18 studies (n = 326). 7 studies relevant (n=129, including stroke, health professionals and developers).	1 mixed methods, 1 feasibility, 4 pre-post, 1 case series.	Augmented reality
Hamilton et al. (2019) (44)	Systematic (qualitative)	To synthesize therapist experiences of using feedback-based technology for physical rehabilitation through a systematic review of qualitative studies.	10 studies. Therapists (n=56; PTs (n=36), OTs (n=19), recreation therapists (n=3) that use feedback-based technologies in neurological and aged care rehabilitation.	1 feasibility, 4 mixed methods, 1 case study, 2 usability, 1 exploratory, 1 phenomenological.	Feedback-based RT: gaming (1 study), VR (4 studies), computer-based (2 studies), commercially available (1 study), robotics (2 studies), other (1 study).
Howard et al. (2020) (45)	Systematic (qualitative)	To identify the common barriers to acquiring and using assistive technology for users with chronic conditions through a systematic meta-synthesis and applying a transdiagnostic approach to identify if barriers are common across chronic conditions.	40 studies (n=1609). Caregivers (n=142), clinicians/providers (n=106), people with chronic conditions (n=1327) including dementia (7 studies), mobility impairments (7 studies), hearing & visual impairments (4 studies), stroke (3 studies), acquired/TBI (3 studies), SCI (2 studies), CP (1 study), cognitive or intellectual disability (2 studies), COPD (1 study), ALS (1 study), aphasia (1 study), mixed (8 studies).	Qualitative studies (design not reported).	Mixed (20 studies), computer access (2 studies), electronic planning (1 study), mobility aids (5 studies), memory aids (1 study), telehealth (1 study), UL (2 studies), ICT (1 study), prosthetics & orthoses (2 studies), environmental controls and augmented communication (3 studies), visual/hearing aids (2 studies).

Islam (2006) (46)	Narrative	To describes some of the technologies being developed to assist the process and delivery of stroke rehabilitation, their potential benefits in practice and stakeholder perceptions of these new technologies.	Not reported	Not reported	UL robotic devices/ systems: MIT MaNUS, MIME (20 studies), ARM (1 study).
Kim et al. (2020) (47)	Narrative	To explore: the technologies used in VR rehabilitation, the clinical application and evidence for VR in motor rehabilitation in stroke, and considerations for VR application in stroke rehabilitation.	Not reported	Not reported	Virtual reality
Lukacs et al. (2022) (48)	Narrative	To perform a narrative review of the use of VR in physical rehabilitation to explore how VR was adopted, and consider the recommendations to facilitate the use of VR in physiotherapy practice as well its barriers.	Not reported	Not reported	Virtual reality
Marston (2012) (49)	Narrative	To present an overview of how videogame technologies can be used to address health issues contributing to reduced independence in older adults.	37 studies (n=599 older adults)	3 evaluation, 1 case report, 7 pilot, 6 experimental, 10 RCTs, 1 crossover, 1 prospective, 4 case studies, 1 unknown.	Interactive videogames: commercially available (e.g. Dance Revolution mat; Nintendo Wii) and purpose-built (e.g. VR, Wii Balance Board).
Medina et al. (2019) (50)	Systematic	To conduct a systematic review of the literature on usability and accessibility in tele-rehabilitation platforms carried out through the PRISMA method.	Two reviews on usability (26 studies) and accessibility (11 studies). Number of participants not reported	Not reported	Telerehabilitation platforms including games and wearable devices
O'Connor et al. (2020) (51)	Narrative	To explore design considerations for effective neuromuscular electrical stimulation exercise prescription in cancer rehabilitation, with simultaneous consideration for fundamental principles of exercise training and the current state of the art in neuromuscular electrical stimulation technologies and application methodologies.	7 relevant articles cited. Total number of articles not reported.	Not reported.	Neuromuscular electrical stimulation

Palomares-Pecho et al. (2020) (52)	Systematic	To identify how the use of adaptable applications has contributed, in the context of rehabilitation, not only to the treatment of patients but also to therapists in their work, in addition to identifying how they have addressed the process of adaptation and extension of the applications.	13 studies of 28 studies relevant to research question (Total n=162; therapists n=50, teachers n=3, adults n=83, students n=5; children n=21). Conditions: aphasia, neurodevelopmental disorders, amnesia, mental health, stroke, hand disabilities, multiple sclerosis.	Not reported	Serious games, playful games, gamification, informative or communication interfaces
Ramprasad et al. (2015) (53)	Systematic	To examine the potential for older people to accept and use tablet technology in clinical settings by assessing satisfaction and effectiveness.	12 studies (n=589). Participant characteristics not reported.	4 RCTs, 4 cross-sectional, 4 pre-post.	Tablet technology for medication self-management (2 studies), post-surgery education (1 study), memory (1 study), cognitive rehabilitation (2 studies), exercise (2 studies), TR (2 studies), speech (1 study), caregiver support (1 study).
Steel & Gray (2009) (54)	Systematic	To review published studies to describe issues and quality of evidence surrounding assistive technology use by the baby boomer generation.	11 studies (n = 976). CP (1 study, n=100), SCI (2 studies, n=56), various (1 study, n=39), MS and SCI (1 study, n=227), orthopedic (3 studies, n=236), stroke and SCI (1 study, n= 47), stroke (1 study, n=144), general medical and orthopedic (1 study, n=127).	7 cross-sectional, 3 mixed interview and surveys, 1 interview-based.	Assistive and rehabilitation devices mostly prescribed for post discharge use.
Steins (2014) (55)	Systematic	To explore wearable accelerometry-based technology (ABT) capable of assessing mobility-related functional activities intended for rehabilitation purposes in community settings for neurological populations. Focus of the review was on the accuracy of ABT-based methods, types of outcome measures, and the implementation of ABT in non-clinical settings for rehabilitation purposes.	12 studies (n= 269). Healthy (n= 83) and health conditions: PD (7 studies, n=81) and stroke (5 studies, n=105). All studies inclusive of participants born between 1946-1965.	8 experimental, 2 pilot, 1 clinical trial, 1 cross sectional.	Wearable accelerometry-based technology

Tadas & Coyle (2020) (56)	Systematic (qualitative)	To engage more directly with people's experiences of technology that supports CR and self-management. The primary objective of this paper is to provide answers to the following research question: What are the primary barriers to and facilitators and trends of digital interventions to support CR and self-management?	16 studies (n=884). Patients (n=850), teammates (n=6), caregivers (n=7), cardiologists (n=11), businesspeople (n=6); human-computer interaction experts (n=4)	5 interview-based, 1 questionnaire, 2 focus groups, 5 mixed methods, 1 survey, 1 field, 1 unknown.	Mobile applications, web-based programs, telehealth technologies.
van Ommeren et al. (2018) (18)	Systematic (qualitative)	To get more insight into the factors that can bring the design of assistive technology to higher levels of satisfaction and acceptance, studies about user perspectives on assistive technology for the upper limb after stroke are systematically reviewed.	9 studies (n=139 people with stroke, n=384 caregivers).	3 focus groups, 4 interview-based, 2 questionnaires	Gaming, robotics, and other upper limb rehabilitation systems.
Vaezipour et al. (2019) (19)	Systematic	To systematically review the literature to identify methods and measures used to evaluate user acceptance relating to rehabilitation technologies for adults with moderate to severe TBI, their caregivers, and healthcare professionals.	13 studies (n= 225). Moderate to severe TBI (n=204), adult family members or caregivers of persons with TBI (n=19); health professionals (n=2)	2 qualitative (interviews and focus groups), 6 quantitative, 5 mixed-methods.	Internet-based (3 studies), smartphone applications (4 studies), videoconferencing (2 studies), video games (1 study), and computer-based (3 studies).
Xu et al. (2019) (57)	Systematic	To assess the effect of mobile applications as an intervention for improving adherence to cardiac rehabilitation (CR)	8 studies. Individuals undergoing CR (n=506).	4 RCTs, 3 quasi-experimental, 1 non-randomized controlled study.	Mobile applications
Zanatta et al. (2022) (58)	Systematic	To review the literature concerning the evaluation of the usability of technological devices, namely robotics and VR, implemented in combination or independently in the neuromotor rehabilitation context, considering both patients' and healthcare professionals' perspectives	68 studies on robotics (n=14), VR (n=40), and combination (n=14). Patients (n=1464) with stroke, other neurological conditions, musculoskeletal disorders, geriatric and cardiopulmonary conditions. Healthcare professionals (n=72). 26 geographical locations.	47 quantitative, 3 qualitative, 18 mixed methods.	Robotics, VR, or both.

Abbreviations: ALS, amyotrophic lateral sclerosis; COPD, chronic obstructive pulmonary disease; CP, cerebral palsy; MS, multiple sclerosis; SCI, spinal cord injury; TBI, traumatic brain injury; TR, telerehabilitation; VR, virtual reality.

Table 4. Study characteristics for articles investigating 'adoption and sustained use' and 'sustained use' of rehabilitation technology

Author	Article type	Study aim	Setting and study population	Method	Type of technology
Adoption and sustained use					
Ahonle et al. (2021) (59)	Qualitative study	To investigate factors that enabled and constrained routine use of video tele-technologies in delivering individualized community-based vocational rehabilitation services and to identify impacts and promising practices in implementation.	Vocational rehabilitation specialists (n=3) from two Veteran Health Administration Medical sites that used TR to supplement face-to-face community-based vocational services.	Semi-structured interviews about experiences with tele-vocational rehabilitation. Thematic analysis.	Video TR
Blanc et al. (2022) (8)	Quantitative observational study (longitudinal)	To evaluate the uses of a digital self-rehabilitation device in patients with Parkinson's Disease and their independent physiotherapists in a health territory (in France)	Brittany, France. Physiotherapists (n=10) and patients with Parkinson's Disease (n=31).	Digital tool provided for 1 year. Questionnaire on Unified Theory of Acceptance and Use of Technology at baseline, 2m, and 12m.	Interactive digital tool (tablet with serious game app and arm-worn inertial sensors) supporting self-guided rehabilitation.
Boot et al. (2020) (60)	Qualitative study	To understand the barriers and facilitators to effectively access and continuously use essential assistive products for people with intellectual disabilities.	Ireland. Community group home and centralized care setting. Mild to profound intellectual disability (n=15) and providers of assistive products (n=15).	Face-to-face interviews. Data analyzed via constant comparative analysis.	Assistive products defined as products which improve a person's daily functioning, independence, and inclusion, and prevent impairments and secondary health conditions. The majority targeted mobility, communication and self-care.
Cano Porras et al. (2019) (61)	Retrospective study	To provide clinicians and researchers with a critical examination of the challenges and outcomes involved with the implementation of virtual reality in clinical practice.	Israel Rehabilitation Centre. Total (n= 167). PD (n=36), stroke (n=31), MS (n=9), TBI (n=10), other (n=42), non-neurological conditions (n=39).	Retrospective audit of clinical records from Nov 2014 to March 2018. Evaluated with physical outcomes and Suitability Evaluation Questionnaire.	Virtual reality, 12 sessions.

Chua & Kuah (2017) (7)	Narrative review	To discuss the application of current evidence-based practice and knowledge in relation to treatment in the rehabilitation clinic, perspectives from rehabilitation professionals using robotic-aided therapy with regard to challenges and strategies for problem solving, and to present innovation philosophies with regard to sustainability of clinical RTs.	Articles reviewed not reported. Described 95-bedded inpatient rehabilitation facility in Singapore.	Not reported	UL devices: Armeo Spring Inmotion II, ReJoyce MediTutor, HandTutor. LL devices: Lokomat, Neurocom SMART, Balance Master, Bioness L300. General devices: Jintronix, NeuroMove, MediTutor: 3D tutor, Dynavision 2000, NintendoWii, Microsoft Xbox Kinect.
Ciortea et al. (2021) (62)	Narrative review	To identify the main challenges that may be faced when trying to initiate post-stroke TR with the help of technology, and to contribute to the decision-making process in this emerging field.	46 articles. Post-stroke.	Included articles discussing challenges of TR implementation. Study designs not fully described but included reviews and primary research.	TR
Davis-Cheshire et al. (2022) (63)	Quantitative observational study (cross-sectional)	To explore the use of apps by occupational therapy practitioners in the United States to gain a more complete overview of utilization and perceived effectiveness, and assess trends by population served, practice setting, occupation addressed, and client deficit.	OTs (n=34), OT assistants (n=34).	26-item questionnaire	Apps used in assessment or intervention process
Giesbrecht et al. (2023) (64)	Descriptive survey	To obtain a descriptive overview of current TR practice among rehabilitation professionals in Canada and the Netherlands and identify perceived barriers to and facilitators of practice.	Rehabilitation therapists (n=723). Majority from Canada (n=666). Most common profession was OTs (n=434).	Web-based survey assessing experience and confidence in providing TR and perceived effectiveness and satisfaction with TR delivery.	TR
Hellstén et al. (2022) (65)	Quantitative observational study (cross-sectional)	To investigate physiotherapists' opinions of the current state of remote physiotherapy in Finland.	Finland. PTs in private sector (n=423) and public sector (n=152).	32-item web-based questionnaire	TR largely using computers, tablets, smartphones, and telephones.

Liu et al. (2015) (66)	Quantitative observational study (cross-sectional)	To examine what factors affect the acceptance behavior and use of new technologies for rehabilitation by therapists at a large rehabilitation hospital in Canada.	Canada. Large rehabilitation hospital. OTs and PTs providing therapeutic interventions (n=85).	45-item questionnaire	Examples include driving simulator, ReJoyce, Bioness H200, Touch table, Dynavision D2, Nintendo Wii, and Xbox Kinect.
Matthew-Maich et al. (2016) (16)	Scoping review	To conduct a scoping review of current practices and recommendations for designing, implementing, and evaluating mHealth technologies to support the management of chronic conditions in community-dwelling older adults.	42 articles. Conditions: diabetes (4 studies), stroke (5 studies), heart (4 studies), COPD (1 study), dementia/cognitive impairment (3 studies), chronic conditions (6 studies), older adults or those receiving homecare (18 studies; 5 older adults, 6 homecare, 1 caregiver burden).	Extracted data related to user-centered design, collaborative approaches, usability, acceptability, and feasibility of mHealth. Studies included: 7 descriptive, 3 case studies, 7 theoretical and position papers, 7 qualitative studies, 6 controlled trials, 3 mixed-methods, 3 cross-sectional, 3 systematic or scoping reviews, 2 methods papers.	mHealth solutions designed for use by both patients and clinicians (19 studies), clinicians only (7 studies), patients only (5 studies), caregivers, patients, and clinicians (4 studies), patients and caregivers (3 studies), family caregivers (1 study) or non-specific populations (3 studies).
Michell et al. (2022) (67)	Narrative review	To report the experiences of healthcare workers and researchers on the implementation of TR in Australia and South America, creating a comparative narrative.	Australia, Chile, Brazil, Columbia. Number of studies not reported	Summarized relevant articles prior to December 2020	TR
Ramos Muñoz et al. (2022) (68)	Retrospective study	To study the relationship between challenge level and perseverance using long-term, self-determined exercise patterns of individuals engaging in home rehabilitation with a sensor-based exercise system without formal supervision.	Anonymous data from people with stroke (n=2,581) who had used FitMi for >8 weeks.	Retrospective analysis of ‘use data’ over 3.5-year period.	FitMi: 2 pucklike sensors and software that visually guides the user through 40 therapeutic exercises for the hands, arms, legs, and torso in a game-like setting.
Stephenson et al. (2022) (69)	Systematic review	To explore factors influencing the delivery of stroke TR interventions, including platforms, technical requirements, training, support, access, cost, usability and acceptability.	31 studies. People with stroke (n=3368), samples sizes from 10 to 573 participants. 14 geographical locations, with 8 studies in USA.	Narrative synthesis exploring facilitators and challenges to implementation, and usability and acceptability.	Synchronous TR, asynchronous TR, and tele-support.

Tuikka & Sachdeva (2017) (70)	Qualitative study	To understand and document the level and quality of assistive technology driven rehabilitative support offered to people with impairments within Finland.	Finland. Hospitals and national social security institutes. People with severe visual impairments, parents of children with autism, service providers (n=10).	Semi-structured interviews focused on experiences of accessing, applying and using technology.	Assistive and rehabilitation technology
Sustained Use					
Pandey et al. (2017) (71)	RCT	To evaluate the impact of text message reminders over 12m on adherence to cardiac medications and exercise among patients receiving cardiac rehabilitation after hospitalization for myocardial infarction (MI).	Canada. Outpatient cardiac rehabilitation program. Patients post MI. Medication adherence trial (n=34) and exercise adherence trial (n=50).	Medication trial: Randomized to 'usual care alone' or 'usual care & daily text messages'. Exercise trial: Randomized to 'usual care alone' or 'usual care & daily text messages'. Surveyed at 12m about experience with text messages.	Automated text-messaging system
Spindler et al. (2022) (72)	RCT	To evaluate changes over time in eHealth literacy for heart failure patients in a TR program compared to a traditional rehabilitation program.	Denmark. People with heart failure-related hospitalization (n=136).	Randomized to 'TR' or 'traditional rehabilitation'. eHealth Literacy Questionnaire at 6m & 12m which includes items related to user's experience with the technology.	TR program (Future Patient Program) involving an interactive portal, education, self-tracking devices and goal setting.

Abbreviations: COPD, chronic obstructive pulmonary disease; LL, lower limb; m, month; mHealth, mobile health; MS, multiple sclerosis; PD, Parkinson's disease; TBI, traumatic brain injury; TR, telerehabilitation; UL, upper limb.

Figure 4 Thematic map of adoption and sustained use literature

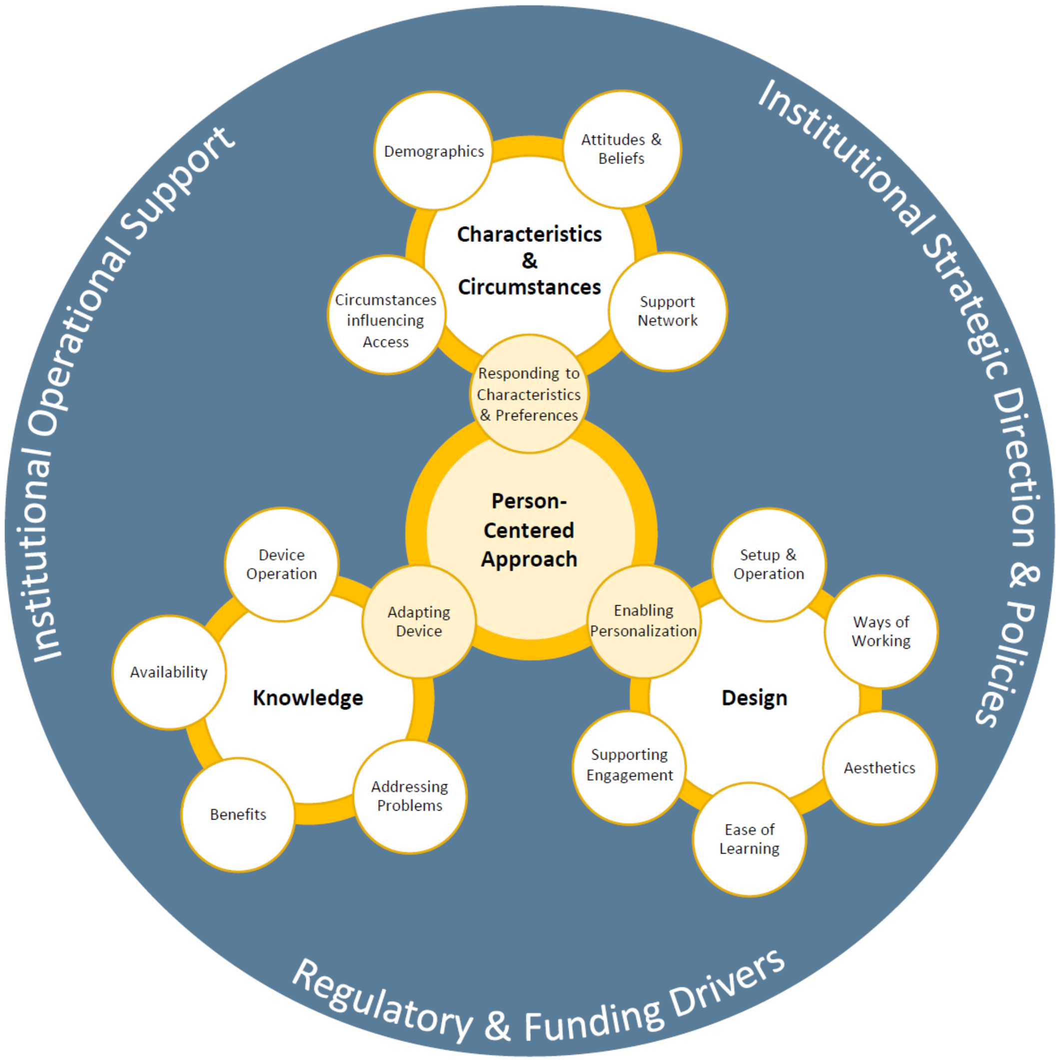

Figure 4 legend: Figure illustrates the four central themes and subthemes identified in the adoption and sustained use literature. The fifth theme 'Health Ecosystem' identified in the sustained use literature is depicted by the outer circle.

Thematic analysis of factors influencing the adoption and sustained use of rehabilitation technologies

1. Adoption of rehabilitation technology

The first stage of the thematic analysis examined the 25 adoption review papers (17-19, 37-58) and revealed four major themes which influenced the adoption of rehabilitation technologies: i) Knowledge, ii) Design, iii) Characteristics and Circumstances, and iv) Person-centered Approach. Figure 4 illustrates these four themes and subthemes in the center of the figure.

Theme 1: Knowledge

This theme describes the importance of developing knowledge to support the adoption of RT and is underpinned by four subthemes: i) Knowledge of what is available; ii) Knowledge of benefits; iii) How to operate the device; and iv) How to address problems and access support.

i) Knowledge of what is available

Therapist and patient knowledge about RT availability is a precursor to successful adoption. Patients rely on therapists keeping them informed (18). Thus, a lack of therapist knowledge of what technologies were available and how they could be accessed potentially hindered adoption (45).

ii) Knowledge of benefits

Therapists' knowledge of the advantages and disadvantages of RTs, including who the device would benefit (17, 45, 49, 54) played a vital role in adoption (55, 58). Therapists also considered research evidence supporting efficacy (45) and whether benefits had been observed in clinical practice (44). While some therapists required evidence demonstrating superiority over conventional therapy (40), others also considered benefits related to motivation, engagement, and socialization (44). Crucially, patients' perceptions of potential benefits (58) and their actual experiences of benefit were also influential factors in adoption.

iii) How to operate the device

Several reviews emphasized the importance of technical knowledge in operation and adaptation of the RT (45, 49, 52).

"A lack of training and instructions provided to the end user… was a barrier..." (Howard et al., 2022, p.398) (45)

This knowledge could be acquired through competency training (17, 37) and familiarization time (44). These opportunities for skill development could occur within the workplace, and within university undergraduate and postgraduate courses (48).

iv) How to address problems and access support

Having the knowledge or available technical support to resolve technical issues was important to reduce frustration and facilitate adoption for therapists and patients (18, 19, 37, 44, 58).

"However, it was recommended that to improve usability, the inclusion of a learning phase, and teach(ing) compensation strategies to deal with unexpected technical failures and errors, was important." (Vaezipour et al., 2019, p.E78) (19)

Theme 2: Design

This theme describes the impact of RT design on adoption, encompassing both facilitating and hindering factors. This theme is supported by five subthemes: i) Ease of learning; ii) Ease of set-up and operation; iii) Features supporting patient engagement; iv) Aesthetics; and v) Supporting ways of working.

i) Ease of learning

RTs that were easily understood with minimal learning requirements facilitated adoption (42, 52).

"Usability requirements of the technology to optimise use by therapists included… easy to understand terminology and clear user instructions" (Hamilton et al., 2019, p.1747) (44)

Conversely, devices requiring a longer learning period that relied on intrinsic motivation from therapists to support them through the learning process hampered adoption (44).

ii) Ease of set-up and operation

Therapists and patients preferred RT designs with intuitive interfaces and an easy setup (17, 18, 38, 40, 44, 45, 49, 51) to support more time in actual use of the RT for rehabilitation.

"Users wanted devices that were simple to use and operate" (Howard et al., 2022, p.8) (45)

RTs that required additional set up time were less acceptable to therapists (37, 40, 52). RTs that were difficult to use required more technical support (58) and this could lead to frustration and disengagement (19, 37, 58). For patients, ease of using the RT without the therapist also influenced adoption (18, 51, 58).

iii) Features supporting patient engagement

RT design which supports patient engagement can facilitate adoption. This can be achieved by designing devices that facilitate motivation, engagement, and a positive emotional experience, through features such as monitoring, reminders, rewards, chat functions and personalized feedback (42, 48, 49, 56-58). Patients valued interactive features (37) and an element of fun provided by gamification aimed at supporting engagement (19, 47, 48, 53, 58).

"Most of the participants also reported positive experiences towards the (personalised) feedback which could lead to promotion of social support as well as increase the motivation" (Xu et al., 2019, p.8) (57)

Patient engagement was also facilitated by design features that considered data security (57), safety of the user, and the fit with real-life home and community environments (18, 44, 58).

iv) Aesthetics

The aesthetics of RT impacted adoption (44, 54). Notably, Howard et al. (2022) (45) reported that users expressed concerns about RT being too different from mainstream technology, which led to feelings of social stigmatization and embarrassment.

"The aesthetics of a device were also discussed by some users as a barrier to using their assistive technology." (Howard et al., 2022, p.397) (45)

v) Supporting ways of working

RTs that support the work of therapists were highly valued.

"All interviewees expressed an appreciation for the ways in which tele-vocational rehabilitation enabled them to enhance both their workflow and the traditional face-to-face vocation rehabilitation services provided" (Ahonle et al., 2021, p.229) (59)

This support could occur through assistance with treatment planning (39), improved quality and intensity of therapy (46), analysis of performance data (48, 52), improved clinical record keeping and report writing (43-45, 49), and by saving time (59). RT that can be integrated into the routines of conventional practice facilitates adoption (37, 48).

Theme 3: Characteristics and circumstances

The third major theme describes the individual characteristics and the social and environmental factors that influence adoption. It is underpinned by five subthemes: i) Circumstances influencing access to the device; ii) Demographic characteristics; iii) Attitudes and beliefs of individuals and society; iv) Patients' support network.

i) Circumstances influencing accessibility to RT

The circumstances of the patient and therapist influenced whether they had access to RT and therefore facilitated or hindered adoption. Cost was a key factor influencing adoption (48). There needs to be access to funding for the RT (18) including initial and maintenance costs (40, 45). Time-consuming administrative processes associated with accessing the device were a hinderance to the acquisition of RT (45). Adoption was also limited by a lack of therapist time for both use and personalization of RT (52).

"In terms of accessibility, concerns not only exist regarding purchasing the equipment and whether the time needed from staff can be billed (to) the insurance (provider)…" (van Ommeren et al., 2018, p.14) (18)

Gaining access to the RT also involves physical access, such as travelling to the rehabilitation center for therapy (40) or placing the device in the home without it taking up space, which can be an inconvenience to the patient and family members (41).

ii) Demographic characteristics

Age, ethnicity, culture, and severity of impairment were among the personal characteristics which appeared to influence adoption. Some authors suggested that patients in older age groups were more resistant to the use of RT (56), however other authors presented contrary findings (54). Users of different ethnicities and cultures experience health services differently, and likewise, their acceptance of RT may differ (52, 54). The patient's ability to learn how to use the technology was also a factor (58); for example, people with stroke may take longer to learn how to use the technology (18). The severity of patients' health conditions may also affect how they interact with RT (42, 54) and whether they can resolve technical problems (19), impacting on adoption.

iii) Attitudes and beliefs of individuals and society

Patients' willingness to try (56) and therapists' motivation to use and adapt RT to the patient (52) influenced adoption. The attitude and beliefs of an individual were noted to be shaped by their past experience of technology, with poor experiences negatively affecting adoption (45). For the patient, persistent encouragement and engagement from the therapist supported their willingness to adopt RT (44). Whereas, perceived societal values were barriers to adoption by making patients feel stigmatized, vulnerable and self-conscious (45). For therapists, their perception of their professional role in relation to technology use influenced adoption. While some therapists chose to take an active role in engaging patients with RT (44), others were concerned that RT threatens conventional hands-on practice (48).

"As telerehabilitation could provide care to those who cannot access face-to-face care, physiotherapists will have to come to terms with the idea that physical therapy does not always require hands-on therapy." (Lukacs et al., 2022, p.287) (48)

iv) Patients' support network

The patient's support network was noted to have a substantial impact on the adoption of RT. This included both the collaborative therapeutic relationship between therapist and patient (44) and support from family members and caregivers (54).

"Equally important to the physical environment, are aspects of the client's social environment such as the presence of caregivers and family members for personal assistance and emotional support" (Steel & Gray, 2009, p.133) (54)

Theme 4: Person-centered

The final theme on adoption emphasized the importance of a person-centered approach to RT implementation. This theme was influenced by three subthemes, and each was interconnected with the three other major adoption themes above. The subthemes were: i) How to adapt the device; ii) Design features enabling personalization; and iii) Responding to personal characteristics and preferences of users of RT.

i) How to adapt the device

Therapist's knowledge of how to adapt and personalize the RT to the patient facilitated adoption and was considered more important than the ease of setting up or operating the RT (44).

"Healthcare professionals need to maintain up to date knowledge and training if they are to appropriately respond to user's needs" (Howard et al., 2020, p.14) (45)

ii) Design features enabling personalization

RT that is adaptable and modifiable to an individual's needs was key to adoption (18, 44, 45). It was noted that both hardware and software should be customizable to the patients' physical and cognitive needs, and their progression over time (18). These customizable features can encourage adoption by both patients and therapists (53, 56, 58). In addition, adoption was supported by design features which take into account personal preferences, such as the preferred genre of therapeutic video games (49), and which allow for personalized activities, feedback and motivational cues (18, 57).

"The level of personalization of the technology was a particularly relevant design feature implemented to facilitate engagement… in terms of how much a technology fits the (persons) habitual practices and preferences, and uses personal information to tailor contents and prompts/instructions." (Fabricatore et al., 2020, p.1572) (42)

iii) Responding to personal characteristics and preferences of users

To facilitate adoption, the therapist must choose to use a person-centered approach when incorporating RT into rehabilitation. That is, they must respond to the personal characteristics of the patient and personalize the RT as necessary; for example, by ensuring the right challenge level, optimal safety, relevant feedback, and correct performance (44). The willingness of the therapist to also cater to individual patient preferences was also found to be important (52).

"Both users and prescribers described how a universal design or one size fits all approach to assistive technology design was not appropriate to cover the individual needs and circumstances of each user." (Howard et al., 2022, p398) (45)

Therapists should also consider patients' comfort and tolerance for the technology (47, 51, 58) as well as cognitive workload and fatigue levels (58), which may hinder adoption.

2. Sustained use of rehabilitation technology

The second stage of the thematic analysis coded data from the 'adoption and sustained use' (7, 8, 16, 59-70) and 'sustained use only' (71, 72) articles. Article screening in this stage found only one primary research paper (66) was also included in a single review (7). The literature was deductively coded to Stage 1 codes, subthemes, and themes, and then coded inductively to identify new codes relevant to sustained use of RT. This process retained the four themes identified in Stage 1 and extended the scope of some subthemes. An additional theme, *'Health Ecosystem*' was also identified. Figure 4 illustrates the combination of themes and subthemes from Stage 1 and Stage 2 with the additional theme from the sustained use literature depicted in the outer circle. Here we describe how the themes changed in response to the Stage 2 analysis.

Theme 1: Knowledge

The role of knowledge in supporting the sustained use of RT echoed the findings from the adoption literature. However, the first subtheme, *'What is available'* did not play a significant role in the sustained use literature, presumably because sustained use relates to RT that is already in practice. In the *'Benefits*' subtheme, in addition to the knowledge of efficacy evidence and which RT suits the patient, the role of actual real-world use to show practical evidence of effectiveness and usefulness for engagement was emphasized (59, 61-63, 67).

"Awareness of why AP (assistive products) was needed and understanding how to use the AP, were both facilitators for continuous use." (Boot et al., 2020, p.179) (60)

The other subthemes, '*How to operate the device*' and *'How to address problems and access support',* were confirmed and extended to highlight the importance of the patient and caregiver knowing how to operate the device (60) and having access to technical support (69, 70).

Theme 2: Design

RT design remained a strong factor in the sustained use literature. The sub-themes *'Ease of learning'* and *'Ease of set-up and operation'* persisted, with additional considerations such as device size and portability, and fragility and maintenance requirements (16, 62, 63), which were particularly important in promoting sustained use in home and community environments.

"The teletherapy system should fulfil some basic requirements such as assuring user safety, being user-friendly, not needing frequent technical maintenance, and requiring minimal home reorganisation and investment." (Ciortea et al., 2021, p.7) (62)

While patients and therapists continued to prefer RT that is easy to set up and use (61, 63, 67), therapists showed a willingness to overcome learning challenges as long as the expected outcomes were achieved (66). *'Features supporting patient engagement'* remained an important subtheme, particularly where the strategies used were simple and easy to integrate in practice (71). In contrast, the *'Aesthetics'* was not deemed significant in the sustained use literature. Regarding the subtheme, *'Supporting ways of working'*, different factors were emphasized in the adoption and sustained use literature. Adoption studies emphasized supporting the therapist's work, while the sustained use literature focused on the workflow of caregivers, patients, and therapists. For example, Boot et al. (2020) (60) found that RT which reduced the time and effort required of the caregiver increased the likelihood of sustained use. Similarly, therapists appreciated time saving benefits, such as reduced driving time through telerehabilitation which enabled more patients to be seen (59).

Theme 3: Characteristics and Circumstances

The patients' and therapists' circumstances and characteristics strongly influenced sustained use. The subtheme *'Circumstances influencing access to RT'* remained important, with therapists emphasizing the significance of access to RT (59, 63, 64). In addition to RT access, the availability of adjunct equipment, such as exercise equipment in the home for telerehabilitation was a contributing factor (65).

"Further, barriers for remote physiotherapy that have been presented are demands in communication through a screen, lack of physical contact with rehabilitee, short of appropriate rehabilitation equipment in rehabilitees environment, digital literacy…" (Hellstén et al., 2022, p.7) (65)

The subtheme of *'Demographic characteristics'* was confirmed in the sustained use literature, emphasizing the need to address technological literacy and bridge the digital divide for individuals whose circumstances limit access to the internet and devices (69). The subtheme of *'Patients' support network'* was also evident but the emphasis was on the support from caregivers and family, rather than therapists (16, 62).

The subtheme of *'Attitudes and beliefs of individuals and society'* featured strongly in the sustained use literature. This subtheme extended to incorporate changes in attitudes and beliefs over time. It was noted that introducing patients to technology earlier in their rehabilitation may support familiarization and a positive attitude towards RT in the longer term (72). However, the potential for the degradation of the initial "wow effect" along with a diminishing belief in the usefulness and benefits of RT were also noted (8). As with the adoption literature, therapists were concerned about their ability to deliver quality care (8, 65), for example when establishing a therapeutic relationship over telerehabilitation or assessing a patient without physical touch (62, 64, 65, 67). The perceived attitudes of others and society continued to influence sustained use (60), but appeared less influential in the longer term as the RT becomes part of the patients' daily lives (8). For therapists, the attitudes and beliefs of colleagues only proved influential when RT use was mandated (66).

Theme 4: Person-centered

The importance of a person-centered approach was echoed in the sustained use literature. The subthemes *'Knowledge of how to adapt the device' and 'Device design which enables personalization'* were reinforced. RT features which supported sustained use included design features that enabled the rehabilitation challenge level to be adapted (68) and which supported the fit with the patients daily routine (16).

"Therefore, when it comes to telerehabilitation, it seems that the focus should not only be on high-performance technology, but also on therapists who should be ready to adapt and modify the therapy and handle a disengaged, demotivated, frustrated or bored patient" (Ciortea et al., 2021, p.7) (62)

The subtheme *'Responding to personal characteristics and preferences of users of RT'* also highlighted the importance of challenge, where it was essential that therapists chose the optimal challenge point for the patient (62) to promote satisfaction and enjoyment (68). The importance of ensuring that patients experienced success in the early stages of RT use, was noted to enhance sustained use in the longer term (68). This subtheme also emphasized the role of the therapist in supporting the integration of RT into the patient's routine (59, 62) and accounting for their interests (16) and preferences (62) when adapting RT. This included the potential to draw on a range of RTs and considering how they worked together, such as using computer games during telerehabilitation (62, 69).

Theme 5: Healthcare Ecosystem

This new theme contextualizes the influence of factors at different levels of the health ecosystem on the sustained use of RT. This theme is formed by three subthemes: i) Institutional operational support; ii) Institutional strategic direction and policies; and iii) Healthcare ecosystem regulatory and funding drivers.

i) Institutional operational support

The healthcare institution played an important role in providing a supportive environment for the sustained use of RT. Examples of institutional support included the provision of additional time to set up or store the device outside of the stipulated time spent using the RT (7), the presence of passionate leaders and clinician champions that promote the use of RTs (16, 59), dedicated technical support (59), a supportive IT department (62), and the provision of professional education to support competency training (64).

"The better the organizational and technical infrastructure to support use of the new technologies, the greater the… use of new technologies by therapists…" (Liu et al., 2015, p.453) (66)

Sustained use was also supported by a redesign of the workflow to incorporate the use of the RT, and by addressing safety concerns through the establishment of emergency protocols and drills to prevent adverse events (7, 59, 61).

ii) Institutional strategic direction and policies

The healthcare institutions’ strategic direction and supporting policies influenced the sustained use of RT. An institution’s structure influenced its ability to respond to new strategic priorities; where smaller private companies were noted to be better placed to make changes that promote RT use (65).

“…private sector companies are usually smaller and more dynamic, and this may partly explain the rapid implementation of remote physiotherapy in the private sector” (Hellstén et al., 2022, p.6) (65)

The development of a strategic business plan that facilitated implementation and sustained use of RT was possible but required secure and sustainable funding (16). Institutional policies which actively support RT sustained use (62) were valued (7).

ii) Healthcare ecosystem regulatory and funding drivers

This subtheme highlighted the role of government and private sector healthcare policies and funding in supporting or hindering the sustained use of RT. To adopt and sustain use of RTs, healthcare institutions were required to align their budget and planning with broader funding drivers (60).

“Sustainable implementation will be facilitated by permanent funding of telehealth by Governments, private health insurers, and other third-party payers for the delivery of physiotherapy care via telerehabilitation in the same model that face-to-face care is funded.” (Michell et al., 2022, p.537) (67)

Yet, healthcare funding cycles may not adequately support the ongoing operational costs of RT (16). In the context of the COVID-19 pandemic, travel restrictions and social distancing requirements prompted the rapid adoption of telerehabilitation technologies (62, 65, 67) with many governments and private sector healthcare funders moving to temporarily fund telerehabilitation. Although for some therapists, not receiving appropriate financial compensation has presented a barrier to sustained use (65, 67). The regulatory environment strongly influenced the adoption and sustained use of RT. Within the COVID-19 context, many regulatory bodies supported the use of RT with the development of new practice guidelines (67). However, in some countries the adoption and sustained use of RT was significantly limited by regulatory restrictions on telerehabilitation practice (67).

Discussion

This scoping review firstly explored the extent and nature of the evidence base related to the adoption and sustained use of RT. The initial scoping of the evidence base revealed a large body of primary research investigating the adoption of different types of RT. Thus, the scope of the adoption literature was narrowed to focus on the 25 review articles exploring the adoption of RT. Most of these review papers on adoption were published after 2016, reflecting the increase in RT development and implementation in the past decade. There was a smaller body of review evidence investigating sustained use, with only five review articles that investigated 'adoption and sustained use'. When looking at the primary research, there were only 10 studies investigating 'adoption and sustained use' (seven quantitative studies and three qualitative studies) and only two RCTs investigating 'sustained use only'; this highlights the paucity of evidence, particularly qualitative evidence, investigating the sustained use of RT. Across the body of evidence, telerehabilitation and mobile applications and technologies were popular. This likely reflects the increase in remote rehabilitation, particularly in relation to the Covid19 pandemic (67).

This review also explored the factors influencing adoption and sustained use of RT in clinical practice through a qualitative analysis. Whilst previous reviews has focused on the adoption of specific types of RT or patient populations (16-19) this is the first review to broaden the lens to encompass user perspectives and practices that may enhance the sustained use of RTs. Five central themes which influence the adoption and sustained use of RT were identified. We found that leveraging i) Knowledge, ii) RT Design, and considering personal iii) Characteristics and Circumstances, as part of iv) a Person-centered rehabilitation approach, promotes the adoption and sustained use of RT, where the v) Healthcare Ecosystem is aligned in support.

The theme, *'Characteristics and Circumstances'*, emphasized how the personal characteristics and circumstances of patients and therapists affect the adoption and sustained use of RT. Within this theme, attitudes, beliefs, and perceptions were found to significantly shape the acceptance of and behaviors towards RT. Rehabilitation literature highlights that a therapist's approach to patient clinical management is influenced by their own attitudes and beliefs (73, 74). This perspective extends to RT. The acceptance and effectiveness of RT are closely tied to an attitude which is receptive to RT and responsive to challenges (7).

Therefore, cultivating positive attitudes to RT in both patients and therapists, early introduction of RT in the rehabilitation journey, and enhancing RT competency, should be integral to RT implementation.

The findings of the *'Characteristics and Circumstances'* theme are also analogous with literature addressing healthcare accessibility and equity (75, 76). Factors such as cost, location, culture, gender, and health literacy are identified as barriers to access (76-78). Notably, while RT may ameliorate these barriers by supporting access to rehabilitation through remote monitoring and treatment (78, 79), issues with technology literacy, self-efficacy, and technical malfunctions may compromise this advantage. Recognition of these factors in the design and implementation of RT in clinical practice is paramount to ensure that all patients receive equitable benefits from RT.

At the core of the themes of *'Knowledge'*, *'Design'*, and *'Characteristics and Circumstances'* was the theme of a *'Person-centered'* approach. The hallmarks of this person-centered approach are identifying and responding to the patient's values, preferences and needs, and this echoes the wider literature on person-centered care (80, 81). Literature has shown that technology can be used to enhance person-centered care and deliver more favorable outcomes (82). Furthermore, the findings emphasize that the concept of person-centered care extends beyond the patient to encompass families and caregivers, where knowledge and support of the patient, family, and caregivers contributes to sustained use of RT.

The theme, *'Device Design'*, stresses the critical role that usability and acceptability play in the adoption and sustained use of RT, which are also strongly reflected in the broader health technology design literature (83). Notably, device design that responds to the specific needs of the patient and caregiver, including consideration of usability and integration into daily routines within home contexts, was a determinant of sustained use. The findings of this review also underscore the importance of designing adaptable RT that can accommodate personalization of both the device and the rehabilitation process. In the sustained use literature, the importance of device features which enable adaptation of the challenge level of rehabilitation were emphasized, including the capacity to respond to changes in the patient's capabilities as they recovered. The need to design RTs which support personalization of rehabilitation across the rehabilitation journey and in multiple use contexts calls for a high level of technological and design sophistication.

The review findings surface a key insight related to the role of device design in promoting engagement in rehabilitation. Engagement in rehabilitation is conceptualized as a co-constructed process, where the patient and therapist actively partner, encouraging committed and invested participation in the intervention process (84). In the context of RT, the patient, therapist and RT may be viewed as a triad, where RT features such as gamified elements (19) or reminders (56), could be harnessed to support patient engagement. Crucially, Bright et al. (2015) emphasizes the importance of the therapist's role in facilitating engagement (84). This necessitates therapists possessing the skills to undertake a person-centered approach to assessment and rehabilitation planning, in conjunction with knowledge of the features of RT which can best be leveraged to support this process for an individual patient. Consequently, while device design features should support patient engagement and enable personalization, it is imperative that rehabilitation therapists are equipped with the knowledge and skills to ensure that these design features are effectively utilized within the rehabilitation process.

In promoting the adoption and sustained use of RTs in clinical practice, the review emphasized the significant role of knowledge development among therapists, patients, and caregivers. It underscores that therapist's knowledge should extend beyond the technical operation of the RT, to include the breadth of RT available, and how to customize and modify RT to meet patient needs within a person-centered rehabilitation approach. The findings also emphasize the importance of ensuring patients and caregivers are equipped with the knowledge to both operate the device and troubleshoot technical issues, in support of sustained use. The discrepancy between the evidence of clinical efficacy demonstrated by many RTs (85-87) and the low adoption rates in clinical practice (88, 89) may be better understood in light of the central role that practical knowledge and skills played in supporting sustained use in this review. Historically, the majority of RT research has focused on establishing evidence of efficacy within highly controlled RCTs. The insights gathered from this review highlight the need for a research approach, such as implementation science (90), which scrutinizes what, why, how, and for whom RT may work in real-world contexts.

The final theme, *'Healthcare Ecosystem'*, which emerged from the sustained use data emphasizes the crucial need to consider a broad range of stakeholder perspectives. This theme highlights the complex interplay across various layers of influence, ranging from the immediacy of institutional support, extending to institutional strategic priorities, to broader mandates from governmental and regulatory bodies. Significantly, it illustrates the impact of the healthcare ecosystem, on the likelihood of successful RT adoption and sustained use. This systemic perspective aligns with implementation science principles, which acknowledge the key roles that political, cultural, social, and economic contexts play in transforming healthcare practice (90-92). This finding calls for the involvement of all stakeholders in the development, evaluation, and implementation of RT. By aligning strategic efforts across the healthcare ecosystem, we may support the adoption and sustained use of RTs in clinical practice and maximize their potential to augment access to, and outcomes from rehabilitation.

The findings demonstrate strong alignment with existing frameworks for evaluating the use of technology in healthcare (93-95) while also extending understanding in several key areas. Areas of agreement include the importance of *'Device Design'* features, which aligns with core concepts of perceived usefulness and ease of use within the Technology Acceptance Model (TAM) (94), and the significance of personal *'Characteristics and Circumstances'*, which is consistent with the Human Activity Assistive Technology (HAAT) (95, 96) and Matching Person and Technology (MPT) Models (93). However, our findings extend beyond these established frameworks in four important ways. First, while existing frameworks typically present a static view of technology acceptance, our findings reveal distinct factors influencing initial adoption versus sustained use, highlighting the dynamic nature of technology implementation in rehabilitation practice. Second, the identification of *'Knowledge'* as a discrete theme within the thematic analysis emphasizes that, while this aspect is implicit in existing frameworks, it requires more explicit attention for successful implementation. Third, while previous assistive technology frameworks such as the HAAT and MPT highlight the importance of the use context (95) or environment (93), this paper's specific focus on rehabilitation technology has highlighted the central role of the *'Person-centered'* rehabilitation approach, which is driven by the knowledge and skills of the therapist, but relies on technology that can be personalized to patients. Fourth, the *'Healthcare Ecosystem'* theme reveals the crucial influence of broader healthcare system factors. The influence of institutional, funding, and regulatory policies has been recognized in previous assistive technology frameworks such as the Assistive Technology Device Selection Framework (97) and the MPT (93). However, the findings of this review have highlighted specific operational supports that may enhance the sustained use of rehabilitation technologies such as providing therapists with additional set up time, easy storage, technical support, training, and clinical workflow that incorporates RT. These extensions to current understanding offer valuable guidance for supporting both the adoption and sustained use of RT in clinical practice.

Implications

This scoping review and qualitative analysis provide important guidance for RT developers, the broader healthcare ecosystem, and rehabilitation therapists. The findings indicate that to support sustained use of RT, developers should prioritize the development of devices that enable person-centered rehabilitation. Adaptable RT that can accommodate personalization, offer adjustable challenge levels, and adapt to changes in the patient's capabilities over time are a priority. Furthermore, prioritizing device features that promote patient engagement in the rehabilitation process and seamlessly integrate into ways of working and daily routines increase the likelihood of sustained use. Involving users throughout the RT design process is crucial to achieving these objectives (98). Government, healthcare and health research funders, and professional and regulatory bodies should foster an ecosystem that recognizes the potential of RTs and supports equitable access to evidenced-based RT within rehabilitation services. This includes policies and funding which supports their sustained use, updating professional codes of conduct to reflect the role of RT in practice, and further development of practice guidelines that facilitate RT implementation in practice. Recognizing the crucial role of knowledge, both training institutions and professional bodies have a role to play in developing training programs which enhance clinician competency in working with RTs. Therapists also play a crucial role in facilitating the adoption and sustained use of RT. Cultivating a positive attitude towards RT and understanding its potential benefits is an essential first step. Therapists should aim to introduce RT early in the rehabilitation journey to foster acceptance and encourage sustained use. Patients, family, and caregivers should be encouraged to actively engage with RT use, especially where a RT is intended for use without a therapist present. Therapists must also develop the skills necessary to undertake a person-centered approach to assessment and rehabilitation planning with RT, and this includes utilizing the RT to facilitate patient engagement and personalized care.

Limitations

This review is subject to limitations. Given the emergent nature of the research field, a large body of literature was considered in the search process. As a result, articles were screened by one author, in consultation with the research team. The review included a range of qualitative and quantitative articles, including both reviews and primary research, to ensure the breadth and diversity of literature was captured. This richness in data contributed to information power (99) and ensured credibility and depth to the findings. However, qualitative synthesis does not enable the quantification of primary data. In line with the scoping review process (24), our eligibility criteria evolved over time in response to the scope of the literature. We responded to the large body of primary research related to RT adoption by refining our criteria to include only review articles related to adoption. This may have introduced potential limitation, as the original research in each review was not directly evaluated (24). While we have presented the setting and type of RT for each article to enable readers to establish the context independently, there is a risk that the context of individual articles may have been obscured during the analysis process. Moreover, given that most of the sustained use literature also included adoption content, some codes related to adoption may have been erroneously interpreted as sustained use, and vice versa. Given the small number of articles focusing primarily on sustained use, there may be additional factors related to sustained use that have not been presented here. These limitations were mitigated by revisiting the raw data multiple times over an extended period, taking reflexive notes, and holding multiple team meetings to discuss the codes and themes. Furthermore, the scoping review approach enabled us to identify a range of overlapping factors that influence adoption and sustained use across a wide range of technologies but did not support the investigation of factors specific to individual technologies or populations. As the body of sustained use literature grows, future research should explore specific strategies that facilitate sustained use across the range of RT and use contexts and consider multiple stakeholder perspectives.

Conclusion

This comprehensive scoping review has presented the characteristics of the evidence base investigating the adoption and sustained use of RT. Furthermore, the findings from 42 studies have been evaluated using qualitative thematic analysis to elucidate the factors that influence the adoption and sustained use of RT. The first four themes highlighted the ways in which 1) 'Knowledge' and 2) 'RT design' could be leveraged to support adoption and sustained use, and the importance of considering personal 3) 'Characteristics and Circumstances' as part of a 4) 'Person-centered' approach. The fifth theme, 'Healthcare Ecosystem', emphasized the different levels of the healthcare system that influence the sustained use of RT. These five key themes provide crucial insights for those involved in the development and implementation of technology in rehabilitation clinical practice. Thus, the findings offer implications for a broad range of stakeholders including RT developers, rehabilitation therapists, patients, family members, caregivers, healthcare institutions, and government and regulatory bodies. Further research is needed to facilitate the sustained use of RT. Particular emphasis should be placed on identifying strategies that promote sustained use of RT while considering the range of stakeholder perspectives within the healthcare ecosystem.

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None

Data Availability

The data sets (qualitative coding) generated during the study are available from the corresponding author on reasonable request.

Disclosure Statement

The authors report there are no competing interests to declare.

Ethics Approval and Consent

Ethical approval was not required for this research. All included studies obtained ethical approval and informed consent from participants.

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Author Contributions

N.S., X.L., and S.O. conceptualized the study and designed the methodology. All authors contributed to article screening and selection. X.L., S.O., and N.S. performed the thematic analysis. X.L., N.S., S.O., and G.A. designed the visualization. N.S. and S.O. supervised the project. The original manuscript draft was written by S.O., N.S, and X.L. All authors reviewed and critically revised the manuscript.

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