Factors influencing adoption and sustained use of rehabilitation technologies in clinical practice:

A scoping review

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Abstract

Background:

In response to a growing recognition of the potential of rehabilitation technologies (RT) to improve efficiency in and outcomes from rehabilitation the purchase of RTs were prioritised in the author's practice setting. However, after the initial few months of use these devices were often abandoned and no longer routinely used in rehabilitation practice. These incidences in the author's clinical context mirror poor uptake of RT and abandonment of such devices. This scoping review sought to investigate the factors influencing adoption and sustained use of RT in clinical practice with a particular focus on patient and therapist perspectives.

Method:

This scoping review followed Arksey and O'Malley's five-stage methodology framework, advanced by Levac et al.. Eight electronic databases were searched from inception to April 2021. A total of 5486 unique papers were returned and screened by abstract and title. Data was analysed in two phases: Phase 1: Qualitative data exploring adoption found in the reviewed articles (including systematic reviews of quantitative research and qualitative research, scoping reviews and narrative reviews) was extracted and analysed through a six-step inductive thematic analysis process as described by Braun and Clarke. Subsequently, a thematic map was developed. Phase 2 involved the analysis of data pertaining to sustained use through an abductive approach where the codes generated were mapped onto existing themes developed in Stage 1. New themes emerged related to sustained use and there was an extension of themes that had been identified from the adoption literature. The results of the scoping review were then mapped to the current decision-making processes within the author's practice context to identify potential gaps in the process, serving as a roadmap to guide the revision of the evaluation and decision-making processes within the author's organisation.

Results:

Thirty-six studies were included in the scoping review, of which 28 review articles explored factors influencing adoption, six looked at factors influencing both adoption and sustained use while two primary research papers explored sustained use only. In Stage 1 four key themes were identified as influencing the adoption of RT in clinical practice; "knowledge", "device design", "patients' and therapists' circumstances and characteristics" and "person-centred approach". In Stage 2 an additional theme, "wider systemic conditions" was identified and subthemes in existing four themes were modified, expanded or added. This included: (i) modifying subthemes of "(therapist's) attitudes and beliefs", "perception of self and societal values" and "ease of set-up and operation" (ii)

expanding subthemes of “how to operate the device”, “how to tackle problems and access to support”, “demographic characteristics” and “supporting workload” and (iii) adding a subtheme on “individual preferences”. The themes prompted the generation of recommendations for the revision of the evaluation and decision-making processes within the author’s organisation, and to improve the adoption and sustained use of RT in the practice setting.

Conclusion:

There is limited research exploring the factors influencing sustained use of RT in clinical practice. The research to date provides sign posts for therapists, patients and carers, designers and developers of RT, management and decision makers of RT purchases and funders of the purchases, which may inform the development, evaluation and implementation of RT. Further research is required to facilitate continuous usage of RT within the clinical setting.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

1st February 2022

_____ _____

Signature Date

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Chapter 1: Introduction and literature review

Adoption and sustained use of rehabilitation technology

Rehabilitation technologies (RTs) are tools, equipment, and products which help people recover or improve function after injury or illness (National Institute of Health, 2018). RTs may be used during clinical assessments to inform treatment decisions or may be used as a treatment modality to achieve therapeutic goals. Examples of such technology include interactive neurorehabilitation systems (INR), virtual reality (VR), augmented reality (AR), body worn sensors, transcranial direct cranial stimulation (tDCS), mobile applications, robotics, and computer programmes or gaming systems designed specifically for rehabilitation or commercial use (National Institute of Health, 2018). While RT use is becoming more prevalent in rehabilitation settings (Keshner, 2004) in the author's practice context, the adoption and sustained use of RT remains poor (see Chapter 2: Practice context).

The 'adoption' of RT refers to the end-users (either the therapist and/or the patient) willingly taking up and using the device for its intended purpose (Chua & Kuah, 2017). While RT may be adopted based on evidence of efficacy from clinical trial or laboratory testing, it has been noted that use of RT frequently wanes over time after the initial hype. Poor adoption rates (Turchetti et al., 2014) and abandonment of devices (Riek, 2017) continue to be problematic for RT implementation in clinical practice. Adoption implies acceptance and is a precursor to sustained use. In this review, 'sustained use of RT' is defined as the continuous and sustained use of the device in the rehabilitation clinical practice (Hao et al., 2014). Besides considering the duration of time taken to achieve budget neutrality (IJzerman et al., 2003) which can differ from one device to another, factors such as the initial and subsequent associated costs, frequency of use, and clinical effectiveness should also be considered (Riek, 2017). Without sustained use of RT over a period that allows recovery of costs, the value of this technology may not be optimised. Sustained use of RT therefore plays an important part in achieving cost-effective quality care.

The adoption and sustained use of RT is closely tied to the acceptability and usability of the device (Kaleshtari et al., 2016). 'Acceptability', as defined by Sekhon et al. (2017), is a multi-faceted construct that reflects the anticipated or experienced emotional and cognitive responses to a healthcare intervention. Sekhon et al.'s (2017) Theoretical Framework of Acceptability (TFA) consists of seven component constructs: self-efficacy, opportunity costs, intervention coherence, ethicality, perceived effectiveness, burden and affective attitude. Conversely, 'usability' can be defined by five main constructs: learnability (ease of accomplishing the task), efficiency (the speed at which the task

can be performed), memorability (reestablishment of proficiency with the use of RT after a cessation period), errors (errors made by users during use) and satisfaction (pleasure derived from using the device) (Nielsen, 2012) The concepts of acceptability and usability have overlapping and distinct constructs which are interrelated. For example, the construct of 'learnability' in the usability framework could correspond with the effort required in the 'burden' construct of the acceptability framework, and 'satisfaction' with RT as an intervention could greatly affect the 'affective attitude' and 'perceived effectiveness' domains related to the acceptability of the device for sustained use. Like acceptability, usability is subjective in nature and largely affected by a user's needs, evaluations and experiences (Iwarsson & Ståhl, 2003; Sekhon et al., 2017; Tuena et al., 2020). Thus, to optimise RT adoption and sustained use, the acceptability and usability of RT must be understood from the users' perspective (Pallesen et al., 2018).

Frameworks for evaluating acceptability and usability

The acceptability and usability of RT has been investigated by several researchers with a number of models and frameworks proposed. Three models will be discussed here.

Venkatesh et al. (2003) developed the Unified Theory of Acceptance and Usability of Technology (UTAUT) model. This model assumes that most behaviours can be accurately predicted when the intention to perform them can be adequately measured and helps to identify factors that explain why a technology is used in the first place (Peek et al., 2019). In this model, performance expectancy, effort expectancy and social influence are identified as factors which determine the behavioural intention (Tuena et al., 2020). This behavioural intention, along with facilitating conditions such as gender, age and experience (Ziefle & Wilkowska, 2010) influence use behaviour (Peek et al., 2019). The UTAUT model has been successfully adapted and applied in several studies that explored the acceptability and actual use of health technologies, such as those delivered through mobile phone technology (mHealth (Hoque & Sorwar, 2017) and electronic medical records (Maillet et al., 2015). However, when applied to RT, Liu et al. (2015) found that several theoretical assertions of the model were not supported in the adoption of RT. For example, the model asserts that if esteemed colleagues perceive the RT to be useful then the participating therapist will be more likely to use it. However, this was not observed in the study data. As such, the model may have some limitations when applied to RT.

Sekhon et al.'s (2017) TFA acceptability framework, introduced above, though primarily conceptualised broadly for various healthcare interventions, offers another useful framework for considering the acceptability and usability of RT. The seven constructs of acceptability can potentially be applied during the design and development, implementation and evaluation of RT

(Sekhon et al., 2017). However, of the 43 systematic reviews that have used this framework to evaluate healthcare interventions, only two of these reviews featured RT for physical or cognitive rehabilitation (Davis et al., 2014; Galdas et al., 2014). As such, the framework's applicability to RT still needs further validation.

Lastly, with specific consideration of RT acceptability and usability, Kaleshtari et al (2016) proposed a model called Rehabilitation Technology Acceptance and Usability (RTAU). This model aims to assess all aspects of RT usability by breaking down the complex process of acceptance and use of RT into sequential phases. Each phase is then subjected to influences by the environment, personal factors, objective factors like accessibility, and subjective factors such as trust in the provider. While the model was developed specifically for RT, its validity in the clinical context has yet to be evaluated.

While a number of frameworks for acceptability and usability exist, it is clear that there is not one unified set of constructs in existing frameworks and models that incorporates all the factors that influence the acceptability and usability of RT, and that identifies the factors which influence the adoption and sustained use of RT in the clinical context.

Factors influencing adoption and sustained use of RT

A range of studies have investigated the barriers and facilitators to the adoption and sustained use of RT. A scoping review of 24 articles by Glegg and Levac (2018) provided an overview of the relevant characteristics related to the adoption of Virtual Reality/ Active Video Games (VR/AVG) by therapists. They utilised the Theoretical Domains Framework (TDF) to provide a structure for the known barriers and facilitators to clinical uptake of VR/AVG. They found that adoption is facilitated when the technology is motivating, addresses patients' goals or needs, has gradable features and is transferable to real-life (Glegg & Levac, 2018). Other factors, such as the competency of the end-users and the support they receive to implement the VR/AVG in their clinical practice, also serve as potential barriers and facilitators. However, the review failed to identify the broader institutional factors such as the devices' financial feasibility, marketability and safety (Jones et al., 2010), which also influence adoption and sustained use. Similarly, patient and therapist perspectives were not investigated, yet these are critical to ensuring engagement, active participation and addressing poor adoption (Rusu et al., 2015). For example, patients value timely feedback for correcting their performance, along with enjoyable and engaging features (Timmermans et al., 2009). These elements encourage individuals to take control of their rehabilitation, facilitate their engagement and adherence, and enhance the likelihood of RT adoption and sustained use (Timmermans et al., 2009). Thus, the scoping review by Glegg and Levac

(2018) failed to address a number of factors that are known to be important to adoption and sustained use. In addition, this review was limited to one type of RT.

Other studies have used qualitative and quantitative methods to examine factors which influence adoption of RT (Liu et al., 2015; Signal et al., 2019; Wu et al., 2014) and sustained use of a single type of RT (Kononova et al., 2019; Sullivan & Lachman, 2017). However, none of these studies or reviews have conceptualized and/or broadly considered the factors that influence sustained use of RT.

Summary of literature

A number of gaps have been identified in the literature related to the adoption and sustained use of RT. Firstly, there is no accepted framework for evaluating the acceptability and usability of RT, which is essential to understanding how to facilitate the adoption and sustained use of RT. Secondly, the previous scoping review of the adoption literature only addressed one type of RT and did not include end-user perspectives. Finally, no studies have reviewed the factors that influence sustained use of RT more broadly.

Chapter 2: Practice context

Healthcare institutions in Singapore are encouraged to innovate, to include the use of technology, and scale up current value-driven strategies to achieve the goal of maximizing quality outcomes that matter to patients (Tan, 2016). A strategy is considered to be value-driven when it assists in achieving better quality outcomes, such as patient satisfaction and faster rates of recovery, for every dollar spent (Conway, 2009). The use of technology is often viewed as an essential value-driven strategy when considering the increasing therapy demand for an ageing population. For example, in the case of stroke rehabilitation, technology may provide the high-intensity therapy required to produce better quality outcomes (Westlake & Byl, 2013) with minimal time burden on the therapist (Masiero et al., 2011; Norouzi-Gheidari et al., 2012).

The clinical context for this project is a 400-bedded inpatient rehabilitation facility (Jurong Community Hospital) where the author practices. Over the span of two years (from 2018 to 2020), four different RT were purchased by the occupational therapy department, while all four were adopted through the efforts from four members of the implementation workgroup; Usage of the RT within the clinical setting were less than ideal and primarily limited to the workgroup members despite extensive training being conducted with all eleven therapists in the department. Over time, use among the four members also reduced with just two members using the devices after six months. These two members had been responsible for setting up the specific intervention programme with the devices. After one year neither of the remaining devices was in use as both members had left the facility. At this time, only one of the four devices is used, albeit only once every two to three months. The other three devices are only switched on for service maintenance. This abandonment and lack of sustained use prompted the author to reflect on the context and processes associated with the evaluation, adoption, and sustained use of RT in her practice context.

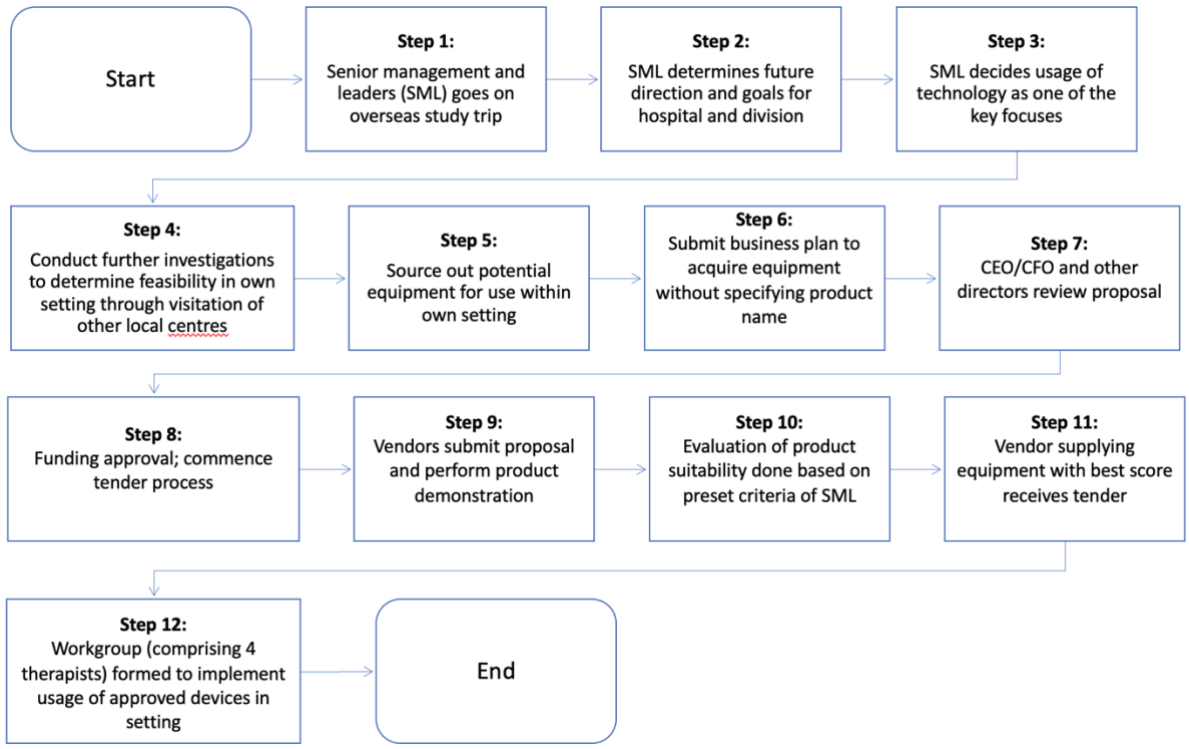
This facility's current evaluation process for the acquisition of rehabilitation technologies (RT) appears to focus on the device's usability, such as ease of operation
after an initial demonstration, and its durability. Little to no evaluation of the clinical need is undertaken. There is no scoping of the size of the patient population who could utilize the RT or the extent to which the device will address the patients' clinical needs. There is little consideration of the potential end users' perspectives within the evaluation process. The likelihood that staff and patients will actively embrace new technology, and whether it will support rehabilitation practices and work flow are not considered. As such, the decision-making process involved in the acquisition of the RT by the senior management and administrators may often place greater emphasis on the technology and its potential to deliver what it promises as opposed to the end-users' experience and

goals. Clinicians on the ground are then expected to redesign existing workflow to incorporate the use of the devices. This appears to lead to poor adoption and early abandonment of RT, with RT devices being left to sit on shelves after their initial introduction into the setting.

Figure 1 outlines the current process which take place in the author's practice context, from the conceptualisation of utilising the RT to its implementation within the clinical setting. Supplementary File 1 includes the current list of criteria for product evaluation by the senior management in the practice setting.

Figure 1

Process map on RT acquisition at Jurong Community Hospital



Research Aim and Objectives

The aim of this research was to enhance understanding of the factors which support RT adoption and sustained use in the author's practice context. This objective is achieved through the conduct of a scoping review to investigate the factors influencing adoption and sustained use of RT in clinical practice. The review will consider the two main end-users' perspectives: patients and clinicians, which are currently not considered in the work process of RT acquisition. Using the results of the scoping review, a mapping exercise will be undertaken to compare the current decision-making processes within the author's practice context against the factors identified in the literature. This has potential to serve as a roadmap to guide the revision of the evaluation and decision-making

processes within the author's organisation, and to improve the adoption and sustained use of RT in the practice setting.

Chapter 3: Methods

A scoping review methodology was selected as it can provide a broad exploration of the topic of interest (Munn et al., 2018). This type of review can also assist in providing clarity on the concept of sustained use: a concept which has not been fully explored and conceptualised as identified in the preliminary literature review conducted. In this scoping review, Arksey and O'Malley's (2005) five-stage methodology framework, advanced by Levac et al. (2010) was followed. This method allows for the identification of the research questions and relevant studies, selection of studies, charting of the data, and collation and summarisation of the findings.

Stage 1: Identifying the research questions

The objective of the scoping review was to investigate the factors influencing adoption and sustained use of RTs in clinical practice. As such the primary research questions were: "What are the factors that influence the adoption of RT within the clinical setting?" and "What are the factors that influence the sustained use of RT within the clinical setting?"

Stage 2: Identifying relevant studies

The search strategy in Table 1 was piloted extensively to check the appropriateness of keywords and databases, and to ensure relevant papers were identified**.** A proximity search was used for the term 'rehabilitation technology' with the aim to capture as many relevant articles as possible.

Table 1

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

The finalised search strategy was carried out in April 2021 in the following eight databases: CIHAHL (EBSCO), MEDLINE, Scopus, Cochrane Library, Web of Science, EMBASE, AMED and Sport Discus. Further hand searching of reference lists from relevant articles was undertaken for the full text articles obtained. Results from all databases were exported to Mendeley Desktop Version 1.19.8, where duplicates were subsequently removed.

Stage 3: Study selection

The titles and abstracts of the articles retrieved in the literature search were manually screened against the inclusion and exclusion criteria as outlined in Table 2.

Table 2

Table of inclusion and exclusion criteria

	Inclusion Criteria	Exclusion Criteria
Research focus	Studies that investigate acceptability, usability, adoption, or sustained use of RT (as defined in this review)	Studies focused solely on the efficacy of RT device
Type of rehabilitation technology	RT that aims to improve physical and cognitive impairment, activity or participation as defined by the ICF (Steel et al., 2011)	Electronic medical records (EMR) and health information technology solely used for communication between different health workers or clinicians with patients Assistive devices which are wore and used extensively to increase, maintain or improve function such as prosthesis and adaptive equipment like walking aid.
Population	Participants greater than 18 years old who uses the RT in the context of rehabilitation	
Language	English	
Time period	From 2000 onwards	
Publication type	Peer-reviewed qualitative and quantitative primary research or review articles. Refined criteria: Review articles investigating adoption only (and not sustained use). Primary research or review articles investigating sustained use.	Full-text unattainable Refined criteria: Primary research investigating adoption only

The articles were then grouped into three categories based on the time period they addressed: i) adoption, ii) adoption and sustained use, and iii) sustained use. Due to the large volume of articles

meeting the initial inclusion criteria in the adoption category, a consensus was reached among the author and primary supervisor to refine the criteria to only 'review articles'. The full text were then obtained for articles in each category and reviewed a second time against the eligibility criteria.

Stage 4: Charting data

In consultation with the project supervisors, the author purposively developed a data extraction table. The extraction table was first trialled on a few randomly selected articles and then modified to include any unforeseen data that was relevant to the research question. The following study characteristics were charted: type of article, aim, study setting and population, study designs included (for review papers), method (for primary research), and the type of technology. Any textual data related to the research questions were extracted in full paragraph or section and recorded in Nvivo, version 1.6.1 for coding.

Stage 5: Collation, summary and reporting of results

Study characteristics were summarised descriptively. This included a summative description of the amount and range of the related literature, including the number and types of studies stratified by the inclusion categories and further organised by other relevant categories (e.g., methodologies, publication years etc.).

Qualitative data was analysed through a six-step inductive thematic analysis process as described by Braun and Clarke (2006). This was undertaken in two phases, analysing the adoption literature first, and then the sustained use literature.

Phase 1 involved familiarising with the data by charting the findings of the adoption articles that were relevant to the research question. Next, codes were generated from the data; these aimed to represent the raw data as closely as possible. This phase was undertaken with feedback from the project supervisors. The codes were then grouped to produce subthemes and themes. These were discussed with the project supervisors to identify and revise themes related to the adoption of RT. This process allowed different perspectives and theoretical influences to be considered to provide more depth and breathe to the analysis (Braun & Clarke, 2013). A thematic map was developed to give a visual representation of the themes and subthemes and their relationships (Braun & Clarke, 2006).

Phase 2 involved analysing the sustained use literature. Following familiarisation, the qualitative data was then coded from the relevant articles. As the number of articles exploring sustained use was small, an abductive approach (Dubois & Gadde, 2002) was used. The data was deductively coded and grouped using the codes, subthemes and themes generated in Stage 1. Then

the data was inductively coded to identify new codes specific to the sustained use data. Subsequently, the themes and subthemes were refined and broaden to ensure fitting of codes from both sustained use and adoption categories. Themes or subthemes that were new or missing from the sustained use literature were identified through sustained use codes which did not fit into the refined descriptors of existing adoption themes or subthemes.

Stage 6: Knowledge translation and consultation exercise (Levac et al., 2010)

Using the results of the scoping review, a mapping exercise was undertaken against the evaluation and decision-making process currently in used by the author's organisation for the acquisition of RT to identify missing factors.

Chapter 4: Results

This chapter conveys the findings of the scoping review in two stages. Stage 1 presents a thematic analysis of the literature related to the adoption of rehabilitation technology (RT). Stage 2 maps the themes identified in Stage 1 to the articles investigating sustained use, to look for similarities and differences.

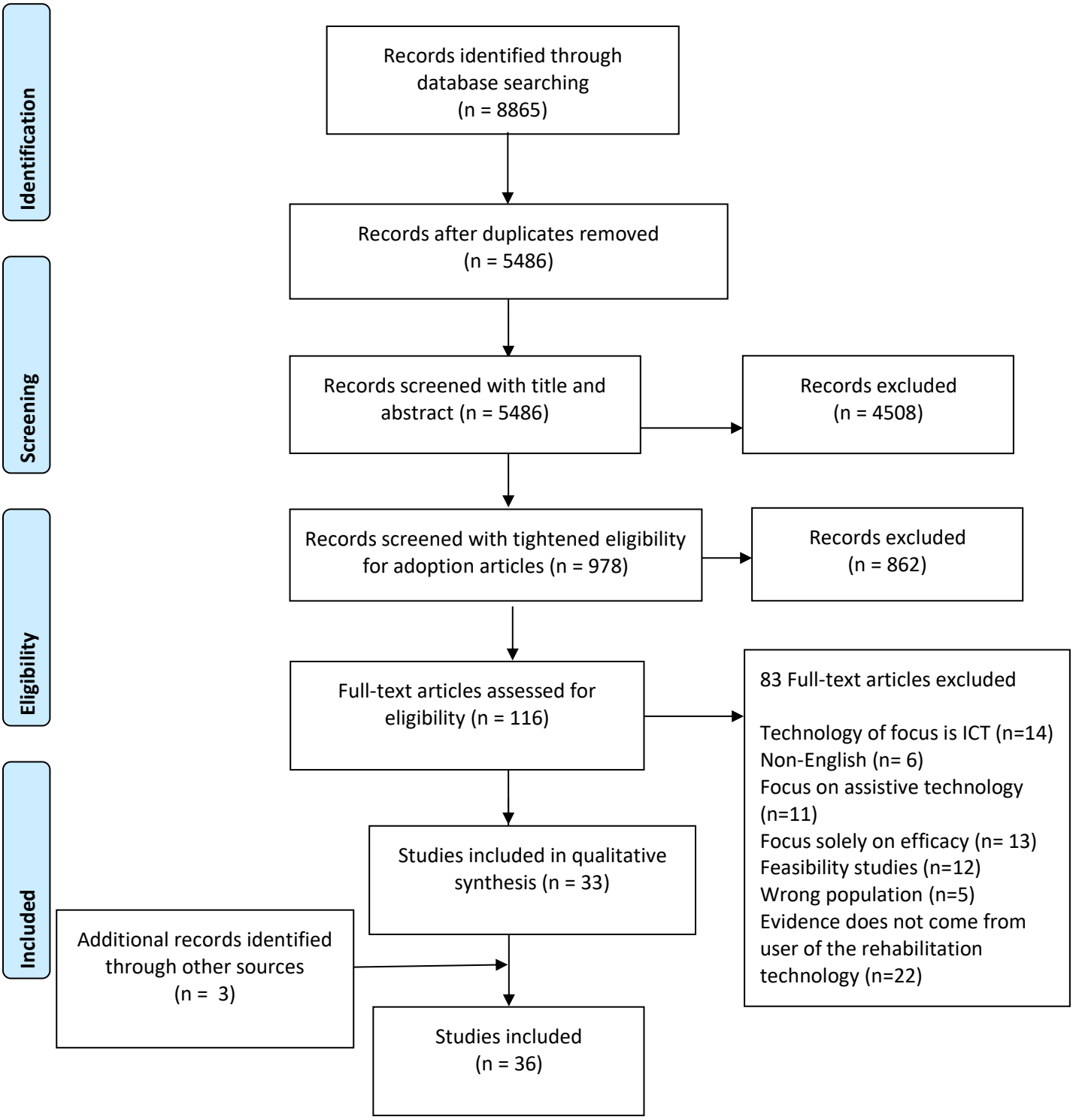
Study Selection

The literature search identified 5486 unique results. Following title and abstract screening, 978 potentially relevant articles were retained and divided into three categories: (i) adoption (n=967); ii) sustained use and adoption (n=8); (iii) sustained use (n=3) of RT. After refinement of the eligibility criteria to include only review articles related to adoption, there were 29 review articles and seven primary research papers included; this resulted in a total of 36 articles being included in the scoping review. Of the 36 articles included, 28 (78%) explored factors influencing adoption of RT, six (17%) examined factors influencing sustained use and adoption of RT, and two (5%) evaluated factors affecting sustained use.

Descriptive Statistics

There were 28 review articles investigating adoption alone; these included 12 (48%) systematic reviews of quantitative research, six (21%) systematic reviews of qualitative research, two (7%) scoping reviews and eight (29%) narrative reviews (see Table 3). All but four of the 28 adoption review papers listed or indicated the number of studies that were included in their review. The number of reviewed studies within each article ranged from six to 138. Participants within the adoption reviews included therapists, service providers, patients and/or carers, and participant numbers ranged from 56 to 2573. There was a wide variety of RT being reviewed including robotics, augmented reality (AR) and virtual reality (VR), mobile applications, video games, and wearables. The eight articles investigating adoption and sustained use, or sustained use alone, included one scoping review of 42 studies investigating mobile health technology, while the other seven studies focused on a range of RT including upper and lower limb robotics, VR, mobile applications and unspecified assistive technology and products (see Table 3).

Figure 2
PRISMA flow diagram



Note. Flow diagram adapted from (Moher et al., 2009)

Table 3

Study characteristics for review articles investigating 'adoption' of rehabilitation technology

Adoption articles					
Article (year) Title	**Type of review**	**Review aim**	**Studies and participants (n)**	**Study designs included**	**Type of technology**
Aqel (2019) Review of Recent Research Trends in Assistive Technologies for Rehabilitation	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).
Alqahtani (2019) Stakeholder perspectives on research and development priorities for mobility assistive-technology: A literature review.	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 group discussions, 1 systematic review, 2 literature reviews, 2 interview-based, 1 web-based survey, 1 scoping review.	Mobility AT including exoskeletons
Babaiasl (2016) A review of technological and clinical aspects of robot-aided rehabilitation of upper-extremity after stroke.	Narrative	To provide an overview of the terms used in robot-aided upper-limb rehabilitation; To investigate the requirements for rehabilitation robots and the most outstanding works in robot-aided upper-limb rehabilitation and their control schemes; And to provide clinical outcomes of the built robots that demonstrates their usability of in real-life applications and their acceptance.	Number of studies not provided. Participants with stroke.	Not reported	Rehabilitation robots: MIT-Manus, Mirror Image motion enabler (MIME), GENTLE/s, Bi-Manu-Track, Assisted rehabilitation and measurement guide, REHAROB, Dampace, T-WREX, MGA-exoskeleton, L-EXOS, ARMin,
Brandt (2020) The effects of assistive technology service delivery processes and factors associated with	Systematic	To investigate effects of different assistive technology service delivery processes (AT-SDPs) for people with functional limitations, including investigation of factors associated with positive outcomes.	12 articles representing 10 studies; n = 1310 (RCTs n=389; cohort n=153; cross sectional n=768). Participants with spinal cord injury, multiple	5 RCTs, 2 cohorts, 5 cross-sectional.	AT in general

positive outcomes – a systematic review.			sclerosis, stroke, Parkinson's Disease and arthritis, intellectual disability, hearing impairment and mobility impairment.		
Chen (2019) Home-based technologies for stroke rehabilitation: A systematic review	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.
Dahler (2016) Meanings and experiences of assistive technologies in everyday lives of older citizens: a meta-interpretive review	Systematic (qualitative)	To synthesize the available qualitative studies on the meaning of assistive technologies (AT) in elderly people's everyday lives in order to identify central concepts, themes, and findings from existing research	16 studies (n = 225; older adults > 65 years n=182, family/caregivers n=21, staff n=22).	7 interviews, 4 focus groups, 1 mixed methods, 1 literature survey and focus group, 3 observation and interviews.	AT in general (smart home technology, wheelchair, scooters, access technology, gerontechnology, fall detectors, occupancy sensors).
Fabricatore (2020) When technology cares for people with dementia: A critical review using neuropsychological rehabilitation as a conceptual framework.	Narrative	To critically examine the available literature on dementia and technology using an NR framework to guide the coding, analysis and interpretation of data; through classification of the main technology used, examine the purpose of technological solutions, types of impairments and disabilities addressed by technologies and conceptualisation of engagement of PwD with technology	138 studies. Number of participants not provided. Participants with dementia or caregivers of people with dementia.	Not reported	Technological solutions for compensation of cognitive impairment, environment modification, cognitive retraining, monitoring caregiver support, activity recognition and others.
Glegg (2018) Barriers, Facilitators and Interventions to Support	Scoping	To apply the Theoretical Domain Framework (TDF) to examine the extent, range, and nature of	24 studies. Participants not provided. Majority of articles (18/24, 75%)	1 qualitative case study, 4 mixed methods, 7 qualitative, 3 perspective,	VR/AVG, motion capture, custom software, worn sensors, sensor glove,

Virtual Reality Implementation in Rehabilitation: A Scoping Review		studies assessing VR/AVG barriers and facilitators and/or recommending or evaluating KT interventions to promote VR/AVG adoption in rehabilitation since 2005. Secondary objectives: - To present an overview of factors known to limit or support VR/AVG adoption for rehabilitation; -To describe the KT strategies that have been recommended or evaluated to address these factors and to report on their effectiveness, where possible; and - To provide recommendations for technology development, research, and clinical implementation based on these findings.	focused on neurological rehabilitation (stroke, cerebral palsy, or acquired brain injury), with 3 (12.5%) focusing on geriatrics, burns, or lung cancer, and 3 (12.5%) not specifying a population.	3 cross-sectional, 2 descriptive, 1 narrative, 1 usability, 1 feasibility.	handheld sensor, head mounted display. Off-the-shelf AVGs (6 studies), VR/AVGs with custom-developed software (10 studies), VR using head-mounted displays (1 study), did not specify VR/AVG system (7 studies).
Gorman (2020) The use of augmented reality for rehabilitation after stroke: a narrative review.	Narrative	To explore research relating to the use of Augmented Reality (AR) technology for rehabilitation after stroke in order to better understand the current, and potential future application of this technology to enhance stroke rehabilitation.	18 studies (n = 326). Stroke (n=215), healthy (n=55), health professionals/ developers (n=56). 9 studies relevant (n=160; stroke (n=106), participants (n=46), health professionals/ developers (n=8).	3 mixed methods, 1 pre-post test with questionnaire, 1 questionnaire, 4 pre-post test (outcome measure).	AR
Hamilton (2019) Experiences of therapists using feedback-based technology to improve physical function in rehabilitation settings: a qualitative systematic review.	Systematic (qualitative)	To synthesise 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, 3 mixed methods, 1 case study, 2 usability, 1 exploratory, 1 experimental study, 1 phenomenological.	Feedback-based technologies: gaming device (1 study), VR systems (4 studies), computer-based system (2 studies), commercially available (1 study), robotics (2 studies), platform (1

					study).
Howard (2020) Exploring the barriers to using assistive technology for individuals with chronic conditions: a meta-synthesis review	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). Carers (n=142), health professionals/ service provider (n=106), patients/ persons with chronic conditions (n=1327). Conditions: dementia (7 studies), mobility impairments (7 studies), hearing and visual impairments (4 studies), stroke (3 studies), acquired/ traumatic brain injuries (3 studies), spinal cord injury (2 studies), cerebral palsy (1 study), cognitive disabilities (1 study), intellectual disability (1 study), COPD (1 study), amyotrophic lateral sclerosis (1 study), aphasia (1 study) and studies recruiting a mix of health conditions (8 studies).	Qualitative studies (design not reported).	Mixed (20 studies), computer access (2 studies), electronics planning devices (1 studies), mobility aids (5 studies, memory aids (1 study), telehealth/ telecare (1 study), UL rehab (2 studies), ICT (1 study), prosthetic & orthosis (2 studies), ACC & environmental controls (3 studies), visual/ hearing aids (2 studies).
Islam (2006) Does technology have a role to play in assisting stroke therapy? A review of practical issues for practitioners.	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 (2020) Clinical Application of Virtual Reality for Upper Limb Motor Rehabilitation in Stroke: Review of Technologies and Clinical Evidence	Narrative	To provide insight in (1) the technologies used in VR rehabilitation, including sensors; (2) the clinical application of and evidence for VR in stroke rehabilitation; and (3) considerations for VR application in stroke rehabilitation. Meta-analyses	Not reported	Not reported	VR
Larsen (2019) Older adults' perspectives on the process of becoming users of assistive technology: a qualitative systematic review and meta-synthesis	Systematic (qualitative)	To identify, synthesize, and evaluate existing literature concerning the process of becoming a user of assistive technology (AT).	17 articles (14 studies). Community-dwelling older adults > 65 years old (n=296). Conditions: non-specific (9 studies); CVA (2 studies); hearing deficit (1 study); memory deficit (1 study); vision impairment (1 study).	All qualitative. 6 longitudinal, 8 retrospective. Methods included 8 interview-based, 3 focus groups, 2 combined interviews and focus groups, 1 open-end questionnaire and focus group.	Mobility devices (7 studies), different types (4 studies), to support cognitive impairment (1 study), vision loss (1 study), and hearing loss (1 study).
Marasinghe (2016) Assistive technologies in reducing caregiver burden among informal caregivers of older adults: A systematic review	Systematic	To investigate, evaluate, and synthesise existing findings to examine whether and how assistive technologies reduce caregiver burden.	10 studies (n=376). Caregivers (n=116); AT users (n=228); health professionals (n=32). AT users were older adults who live in their homes in the community	7 qualitative, 2 RCTs, 1 mixed methods.	AT in general (mobility devices, home-monitoring and communication, ISISEMD-intelligent system for independent living and self-care of seniors with cognitive impairment, ICT, assistive robotics).
Marston (2012) Interactive Videogame Technologies to Support Independence in the Elderly: A Narrative Review.	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, 6 experimental, 7 pilot, 10 RCTs, 1 crossover, 1 unknown, 4 case studies, 1 prospective.	Interactive videogames: commercially available (e.g. Dance Dance Revolution mat; Nintendo Wii) and purpose-built (e.g.VR; Wii Balance Board).

Medina (2019) A Systematic Review of Usability and Accessibility in Tele-Rehabilitation Systems	Systematic	To conduct a systematic review of the literature on usability and accessibility in tele-rehabilitation platforms carried out through the PRISMA method.	26 usability studies and 11 accessibility studies. Number of participants not reported	Not reported	Wearable devices and vision-based systems based on depth cameras and intelligent algorithms
Ommeren (2017) Preliminary Extraction of Themes from a Review About User Perspectives on Assistive Technology for the Upper Limb After Stroke	Systematic (qualitative)	To gain insight into the factors that play a role in the successful use of upper extremity assistive technology in rehabilitation and daily life activities of stroke survivors through a systematic analysis of the literature.	6 studies (n=176 stroke and caregivers)	1 questionnaire, 3 focus groups, 2 interview-based.	Robotic devices for stroke
Palomares-Pecho (2020) End-user adaptable technologies for rehabilitation: a systematic literature review	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	Adaptable technologies: informative interfaces (adults), serious games, playful games.
Ramprasad (2015) The use of tablet technology by elderly in health care settings-is it effective and satisfying? A systematic review and meta-analysis	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). Characteristics of participants not reported.	4 RCTs, 4 cross-sectional, 4 pre-post.	Tablet technology for medication self-management (2 studies) , post-surgery education (1 study), memory retention (1 study), cognitive rehabilitation (2 studies), and exercise promotion (2 studies), telerehabilitation (2 studies), speech

					technique (1 study), leisure reprieve for caretakers (1 study).
Saeed (2020) An exploration of usability issues in telecare monitoring systems and possible solutions: a systematic literature review	Systematic	To explore the relevant usability issues and identify possible solutions to improve the usability of telecare monitoring systems.	15 studies (n=144). Patients (n=42), carers (n=4), technical users (n=30), medical experts (n=39). Conditions: heart failure (3 studies), chronic disease (2 studies), comorbidity (1 study), cystic fibrosis (1 study), COPD (3 studies), frail elderly (2 studies), rehabilitation (2 studies), dementia (1 study).	3 Not specified 1 pilot, 4 surveys, 1 case study, 1 heuristic evaluation, 2 interview-based, 1 think aloud interview-based, 1 iterative user-centred, 1 descriptive, 1 feasibility.	Telecare monitoring systems (e.g. smartphone, wireless sensor networks, eCAALYX system, web based monitoring system, home telecare contacts, local call centre with integrated community response service, iPads and FitBitR, AMICA mobile app, sensing device, heart patient monitoring system).
Steel (2009) Baby boomers' use and perception of recommended assistive technology: a systematic review.	Systematic	To review published studies to describe issues and quality of evidence surrounding assistive technology (AT) use by the baby boomer generation.	11 studies (n = 976). Cerebral palsy (1 study, n=100), SCI (2 studies, n=56), various (1 study, n=39), multiple sclerosis and SCI (1 study, n=227), orthopaedic (3 studies, n=236), CVA and SCI (1 study, n= 47), CVA (1 study, n=144), general medical and orthopaedic (1 study, n=127).	7 cross-sectional, 3 mixed interview and surveys, 1 interview-based.	AT in general for post discharge use
Steins (2014) Wearable accelerometry-based technology capable of assessing functional activities in neurological populations in	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	12 studies (n= 269). Healthy (n= 83) and health conditions: PD (7 studies, n=81) and CVA (5 studies, n=105).	8 experimental, 2 pilot, 1 clinical trial, 1 cross sectional.	Wearable accelerometry-based technology

community settings: a systematic review.		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.			
Strubbia (2020) Use of technology in supporting goal setting in rehabilitation for adults: a scoping review.	Scoping	To map the extant literature evaluating the use of technology for goal setting in adult rehabilitation and the impact of technology for patient outcomes. Design	27 studies (16 programmes/ software described). Adults with heart conditions (3 studies), neurological disorders (2 studies), diabetes (2 studies), COPD (2 studies), schizophrenia (2 studies) and cancer-related fatigue (1 study).	8 RCTs, 7 observational, 5 qualitative, 4 mixed-methods studies, 2 descriptive, 1 pilot.	Mobile apps (7 studies), websites (3 studies), mobile apps/website hybrids (2 studies), two apps and two websites connected to a pedometer.
Tadas (2020) Barriers to and Facilitators of Technology in Cardiac Rehabilitation and Self-Management: Systematic Qualitative Grounded Theory Review.	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), business people (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.	Application, web-based programme, telehealth.
Vaezipour (2019) Acceptance of Rehabilitation Technology in Adults With Moderate to Severe Traumatic Brain Injury, Their Caregivers, and Healthcare Professionals: A Systematic Review.	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 carers 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).

Werner (2018) A systematic review of study results reported for the evaluation of robotic rollators from the perspective of users	Systematic review with narrative synthesis	To evaluate the effectiveness and perception of robotic rollators (RRs) from the perspective of users.	17 studies (n=132). Residents of residential facilities/recipients of support services (n=56), healthy individuals (n=21), patients (n=55).	Experimental	Robotic rollators
Xu (2019) The effect of mobile applications for improving adherence in cardiac rehabilitation (CR): a systematic review and meta-analysis.	Systematic	To assess the effect of mobile applications as an intervention for improving adherence to CR.	8 studies. Individuals undergoing CR (n=506).	4 RCTs, 3 quasi-experimental, 1 controlled non-randomised pre-post test.	Mobile applications
Abbreviations: AR, augmented reality; AT, assistive technology; VR, virtual reality; AVG, active video game					

Table 4

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

Article (year) **Title**	**Article type**	**Study aim**	**Setting and study population**	**Method to determine acceptability, usability, adoption, or sustained use of RT**	**Type of technology**
Adoption and Sustained Use					
Boot (2020) Are there differences in factors influencing access and continued use of assistive products (AP) for people with intellectual disabilities living in group homes?	Qualitative	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 centralised care setting. Mild to profound intellectual disability (n=15) and providers of assistive products (n=15).	Face-to-face interviews. Data analysed via constant comparative analysis.	AP: defined as products which improve a person's daily functioning, independence and inclusion, and prevent impairments and secondary health conditions.
Chua (2017) Innovating With Rehabilitation Technology in the Real World Promises, Potentials, and Perspectives	Descriptive	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. To present innovation philosophies with regard to sustainability of clinical rehabilitation technologies.	Singapore. 95-bedded inpatient rehab facility.	Not reported	Upper Limb Devices including Armeo Spring Inmotion II, ReJoyce MediTutor, HandTutor. Lower Limb/Gait/ Balance Devices including Lokomat, Neurocom SMART, Balance Master, Bioness L300, General devices including Jintronix, NeuroMove, MediTutor: 3D tutor, Dynavision 2000, NintendoWii*, Microsoft Xbox Kinect*.
Liu (2015) What factors determine therapists' acceptance of new technologies for	Cross-sectional exploratory	To examine what factors affect the acceptance behaviour and use of new technologies for rehabilitation by therapists at a	Canada. Large rehabilitation hospital.	45-item questionnaire	CAREN system, Lokomat, Driving simulator, ReJoyce, The Cube, Touch table, Dynavision D2; Bioness

rehabilitation – a study using the Unified Theory of Acceptance and Use of Technology (UTAUT)		large rehabilitation hospital in Canada.	OTs and PTs providing therapeutic interventions (n=85).		H200; RT 300; Game cycle; SMART Podium; Nintendo Wii, Xbox Kinect, GS console, Robots, Others.
Matthew-Maich (2016) Designing, Implementing, and Evaluating Mobile Health Technologies for Managing Chronic Conditions in Older Adults: A Scoping Review	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 conditions (4 studies), COPD (1 study), dementia/cognitive impairment (3 studies), general chronic conditions (6 studies), older adults or those receiving homecare services (18 studies; 5 for older adults, 6 home care patients, 1 caregiver burden).	Extracted data related to user-centred design, collaborative approaches, usability, acceptability and feasibility of mHealth solutions Type of studies included: descriptive report (4 studies), case studies describing implementation process (3 studies), predictive modelling techniques for screening patients in use of technology (2 studies), theoretical and position papers) (7 studies), qualitative descriptive studies (3 studies), controlled trials (6 studies), mixed-methods (3 studies), qualitative (4 studies), cross-sectional (3 studies), systematic or scoping reviews (3 studies), methods only (2 studies); focus on simulation (1 study).	mHealth solutions designed for use by both patients and HCPs (19 studies), HCPs only (7 studies), patients only (5 studies), caregivers, patients and HCPs (4 studies), and patients and caregivers (3 studies), family caregivers (1 study) or non-specific population (3 studies).

Porras (2019) Advanced virtual reality-based rehabilitation of balance and gait in clinical practice	Retrospective study	To evaluate the effect of VR-based rehabilitation treatments on balance and gait, cognitive dual-task load, patient's balance confidence (ABC-scale) and perception of suitability	Israel. Rehabilitation Centre. Total (n= 167), Patients with neurological conditions: PD (n=36), poststroke (n=31), MS (n=9), TBI (n=10), others (n=42) and Patients without neurological conditions (n=39)	Retrospective study of patients clinical records from Nov 2014 to March 2018. SEQ used to evaluate perception towards VR as a rehabilitation tool and effect of VR in the rehabilitation process.	VR
Tuikka (2017) Experiences from Assistive Technology Services and Their Delivery in Finland	Qualitative study	To understand and document the level and quality of assistive technology (AT) driven rehabilitative support offered to people with impairments within Finland.	Finland. City hospitals and national social security institutes. People with severe visual impairments, parents of children with autism impairments, and service providers (n=10).	Interviews	AT
Sustained Use					
Beaudoin (2019) Long-term use of the JACO robotic arm: a case series	Case series	To document the long-term impacts of this assistive device on users and their family caregivers following prolonged use	Canada, community setting. 7 users of the device (CP n=2, tetraplegia n=2, DMD n=1, AMC, n=1, SMA n=1) and 5 caregivers (spouse n=1; mothers n=4).	Validated questionnaires: QUEST and PIADS-10 to determine satisfaction with JACO and psychosocial impacts of its use; CATOM to determine impacts of JACO use on family/caregivers. Descriptive statistics..	JACO robotic arm
Pandey (2017) The Impact of Text Messaging on Medication Adherence	RCT	To evaluate the impact of text message reminders over 12 months on adherence to cardiac medications and exercise among	Canada. Outpatient cardiac rehabilitation programme. Patients post MI	Patient from both trials were surveyed to find out about their experience with daily text messages	Automated text-messaging system

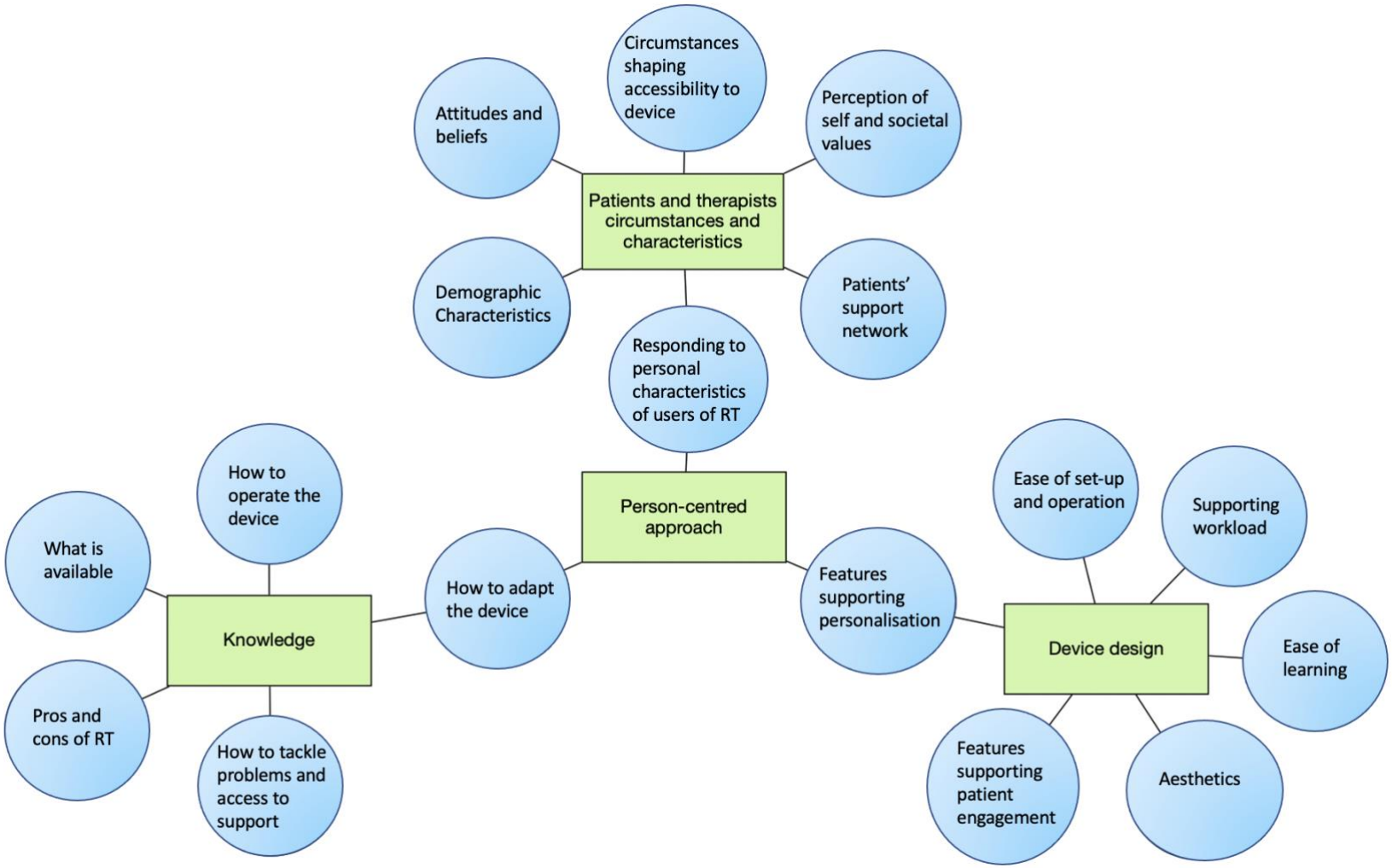
and Exercise Among Postmyocardial Infarction Patients: Randomized Controlled Pilot Trial		patients receiving cardiac rehabilitation after hospitalization for MI.	Medication adherence trial (n=34) and Exercise adherence trial (n=50).	reminders. Medication adherence trial: patients randomly received either usual care alone or usual care plus daily text message reminders delivered at the time of day medications were to be taken. Exercise adherence trial: patients randomly received either usual care alone or usual care plus 4 daily text messages reminding them to exercise as directed.	
Abbreviations: AP, assistive products; HCPs,healthcare professionals ;mHealth, mobile health; PD, Parkinson's disease; MS, multiple sclerosis; TBI, traumatic brain injury; CP, cerebral palsy; DMD, Duchenne muscular dystrophy; AMC, arthrogryposis multiplex congenital; SMA, spinal muscular atrophy; MI,myocardial infarction; SEQ, Suitability Evaluation Questionnaire; AT, assistive technology; QUEST, Quebec User Evaluation of Satisfaction with Assistive Technology; CATOM, Caregiver Assistive Technology Outcome Measure; PIADS, Psychosocial Impact of Assistive Devices Scale; VR, Virtual reality					

Stage 1: Thematic analysis of review articles of adoption

Thematic analysis of the 28 adoption reviews revealed four major themes which influenced the adoption of rehabilitation technologies: (i) Knowledge; (ii) Device design; (iii) Personal characteristics of patients and therapists; and (iv) Person-centred approach. Figure 3 illustrates the conceptual relationships between the various themes and subthemes. A supplementary table (Supplementary File 2) showing indicative quotes for each factor is provided in the appendix.

Figure 3

Themes related to the adoption of rehabilitation technology



Note. Figure 3 illustrates themes (green) and subthemes (blue) identified from the thematic analysis of review articles on adoption of RT (n=28).

Theme 1: Knowledge

> *"A lack of training and instructions provided to the end user… was a barrier to people using their assistive technology." (Howard et al., 2020, p.9)*

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) Pros and cons of different RTs; iii) How to operate the device, and; iv) How to tackle problems and access to support.

i) Knowledge of what is available

> *"Lack of knowledge about available technologies is mentioned as a significant barrier for assistive technology use, among elderly people as well as among professionals." (Dahler et al., 2016, p.624)*

Therapist and patient knowledge about RT availability is a precursor to successful adoption of the technology. For therapists, up to date knowledge of what technologies were available and how they could be accessed supported adoption (Dahler et al., 2016; Howard et al., 2020). For patients, the expectation was that therapists would keep them informed of what was available (van Ommeren et al., 2017).

ii) Pros and cons of rehabilitation technology

> *"Users … lacked information about the benefits of using assistive technology that is important in the context of behaviour change for motivating adoption."*
> (Howard et al., 2020, p14)

Therapists knowledge of the specific advantages and disadvantages of RT including who the device would benefit (Glegg & Levac, 2018; Howard et al., 2020; Marston & Smith, 2012; Steel & Gray, 2009) and what the device is used for in clinical practice was important for adoption (Steins et al., 2014; Vaezipour et al., 2019). Evidence of efficacy of the device from both research and in actual practice was valued (Vaezipour et al., 2019). Evidence of efficacy reportedly gave clinicians confidence (Howard et al., 2020), motivating them to attend training and subsequently endorse the device with more certainty (Hamilton et al., 2019). In addition, adoption was more likely when research shows efficacy over conventional therapy (Babaiasl et al., 2016) or where there is actual practice evidence of efficacy in the clinical setting (Hamilton et al., 2019; Larsen et al., 2019).

iii) How to operate the device

> *"A lack of training and instructions provided to the end user… was a barrier to people using their assistive technology." (Howard et al., 2020, p.9)*

Technical knowledge in relation to operating the device is also required for successful adoption. Several review papers (Howard et al., 2020; Marston & Smith, 2012b; Palomares-Pecho et al., 2020) found that having knowledge to operate the device enhanced adoption and that this knowledge could be acquired through training (Glegg & Levac, 2018).

iv) How to tackle problems and access to support

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

Having the knowledge or available technical support to resolve technical issues was important to reduce frustration and facilitate adoption (Hamilton et al., 2019; Vaezipour et al., 2019).

Theme 2: Device design

> *"… improved design prevents user frustration, disengagement, and technology rejection; and will subsequently optimize the uptake of interventions in the long-term."* (Vaezipour et al., 2019, p.E80)

This theme describes the influence of device design in adoption, whether it be a positive influence, facilitating use of the device, or a negative influence, hindering its use. 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 workload.

i) Ease of learning

> *"The system should be understandable… and a self-explanatory user manual… increase the satisfaction level of users."* (Saeed et al., 2020, p.278)

When the system and instructions for use of the device are easily understood, users were more accepting of the device and willing to adopt it (Saeed et al., 2020; Xu et al., 2019). Devices

which required minimal learning facilitated adoption (Fabricatore et al., 2020; Palomares-Pecho et al., 2020), conversely, devices requiring more time to learn demand intrinsic motivation from the therapist to support them through the learning phase and may lead to more inertia in adoption (Hamilton et al., 2019).

ii) Ease of set-up and operation

"Users wanted devices that were simple to use and operate" (Howard et al., 2020, p.8)

Therapists and patients using RT favour designs which have intuitive interfaces (Alqahtani et al., 2019; Glegg & Levac, 2018; Marston & Smith, 2012) and are easy to set-up (Babaiasl et al., 2016; Hamilton et al., 2019). This often results in less time spent in set up and more time in actual use of the device for rehabilitation. When the device is easy to use it increases efficiency and effectiveness (Saeed et al., 2020) and reduces anxiety, fear and frustration (Babaiasl et al., 2016; Marasinghe, 2016; Marston & Smith, 2012).

iii) Features supporting patient engagement

"Assistive technology enabled engagement… seemed to influence acceptance positively" (Larsen et al., 2019a, p.189)

Device 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 feedback (Tadas & Coyle, 2020; Fabricatore et al., 2020; Marston & Smith, 2012). The element of fun was also highlighted in the literature, where both Ramprasad et al. (2015) and Vaezipour et al. (2019) found that gamified interventions supported engagement and adoption.

iv) Aesthetics

"Assistive technology related issues include: aesthetic appeal" (Steel & Gray, 2009)

Device attractiveness affects adoption (Hamilton et al., 2019; Steel & Gray, 2009). In addition to being pleasing to the eye, Howard et al. (2020) highlighted that aesthetics influenced the entire interaction with the RT and that poor aesthetics can lead to sense of social stigmatisation (Howard et al. 2020).

v) Supporting workload.

"The aim of rehabilitation robots is not to replace the therapist but to make her/his job easier…" (Babaiasl et al., 2016)

RT that supports the work of therapist are highly valued in the clinical setting. This support can occur through assistance with treatment planning (Aqel et al., 2019), increased quality and intensity of therapy (Islam et al., 2006), more efficient analysis of performance data (Palomares-Pecho et al., 2020) and improved clinical record keeping and report writing (Gorman & Gustafsson, 2020; Hamilton et al., 2019; Howard et al., 2020; Marston & Smith, 2012).

Theme 3: Patients' and therapists' circumstances and characteristics

The third major theme describes the individual characteristics and the social or environmental factors that influence adoption. It is underpinned by five subthemes: i) Circumstances shaping accessibility to device; ii) Demographic characteristics; iii) Attitudes and beliefs; iv) Perception of self and societal values, and; v) Patients' support network.

i) Circumstances shaping accessibility to device

"…overarching factors of assistive technologies were identified as important barriers or facilitators for the uptake and acceptance of a device by stroke survivors and carers: accessibility..." (van Ommeren et al., 2017)

The circumstances of the patient or therapist can influence whether they have access to the device, and can therefore facilitate or hinder adoption. There needs to be access to funding for the device (Larsen et al., 2019) including for both initial and maintenance costs (Babaiasl et al., 2016; Howard et al., 2020; van Ommeren et al., 2017) . The administrative process associated with accessing the device needs to be uncomplicated in order to facilitate potential users to adopt the RT (Howard et al., 2020). Gaining access to the RT also involves physical access, such as getting to the rehabilitation centre for therapy (Babaiasl et al., 2016) with individuals' support network (Chen et al., 2019).

ii) Demographic characteristics

"Personal characteristics reported throughout the literature (to) influence the use of assistive technology." (Steel & Gray, 2009)

Age, ethnicity, culture, and severity of diagnosis were among the personal characteristics which appear to influence adoption. Some authors suggested that patients in older age groups are more resistant to the use of RT (Tadas & Coyle, 2020), however other authors present contrary findings (Steel & Gray, 2009). Importantly, the age of therapists using RT does not appear to affect usage (Liu et al. (2015). Users of different ethnicities and cultures experience health services differently, and likewise, their acceptance of RT may differ (Steel & Gray, 2009). The severity of an individual's health condition may also affect how they interact with RT (Fabricatore et al., 2020; Steel & Gray, 2009) and whether they can resolve technical problems (Vaezipour et al., 2019), and thus impacting adoption.

iii) Attitudes and beliefs

> *"…the user can develop a positive attitude toward using the system, which may lead to its successful adoption."* (Saeed et al., 2020, p 278)

Patient's willingness to try (Tadas & Coyle, 2020) and therapists' willingness to adapt the device to the patient (Palomares-Pecho et al., 2020) influences adoption. However, the attitude and beliefs of an individual is largely shaped by their past experience, with poor experiences negatively affecting adoption by therapists (Howard et al., 2020). Patients' willingness to adopt RT increases with persistant encouragement and engagement from the therapist (Hamilton et al., 2019). Of note, is the importance of time and prolonged exposure to the device, which can positively impact attitudes and beliefs towards RT (Larsen et al., (2019).

iv) Perception of self and societal values

> *"The attitudes of people in society towards assistive technologies seemed to influence the incorporation process, because some participants described a feeling of being stigmatized, which negatively influenced the process"* (Larsen et al., 2019, p.189)

The patients' self-image (Larsen et al., 2019) and societal values (Howard et al., 2020) can influence adoption, either positively or negatively. Use of the device needs to be seen by the patient as empowering, without increasing stigma or embarrassment (Howard et al., 2020). A perception of societal views that are intolerant and not inclusive can hinder adoption. Therapist perceptions of their role also influence adoption; if they have a clear understanding about their role in RT usage, they are more willing to invest time and confidently adopt the technology in clinical practice (Hamilton et al., 2019).

v) Patients' support network

> *"…it is not enough for the professionals to focus on gathering information regarding the social network but, in the collaborative relationship with the older adult, it must be considered whether the older adult's social network should be involved in the assistive technology delivery process."* (Larsen et al., 2019, p.191)

The patient's support network can have a substantial impact on the adoption of RT. This support network can encompass either the collaborative therapeutic relationship between therapist and patient, and the patient's relationship with their family and friends (Hamilton et al., 2019). The attitudes of patient's significant others can influence their own perception and attitudes (Larsen et al., 2019), thus the support and positive attitude of significant others can facilitate adoption. It may help to have key members of the patient's social support group present to learn how to set up and use the device (Dahler et al., 2016). In the absence of such support, patients' adoption rate of RT can decrease drastically (Xu et al., 2019).

Theme 4: Person-centred approach

> *"When taking into account older adults' experiences of the process of becoming users of AT, indications point towards using a client-centred approach throughout the entire delivery process."* (Larsen et al., 2019)

The final theme on adoption emphasises the importance of a person-centred approach to RT provision. This theme is influenced by three subthemes, and each is interconnected with the three other major adoption themes above. The subthemes are: i) How to adapt the device; ii) Features supporting personalisation; and iii) Responding to personal characteristics of users of RT.

i) How to adapt the device

> *"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)

Therapist's knowledge of how to personalise the device to the patient facilitates adoption and is considered more important than the ease of operating or setting up the device (Hamilton et al.,2019).

ii) Features supporting personalisation

"The level of personalisation of the technology was a particularly relevant design feature implemented to facilitate engagement… in terms of how much a technology fits the persons-with-dementia's (PwDs) habitual practices and preferences, and uses personal information to tailor contents and prompts/instructions."(Fabricatore et al., 2020, p.1571)

Despite an individual's preference that RT can be adjusted to their cognitive and physical function (van Ommeren et al., 2017), much of the technology is inadequate in this regard, and this affects therapists' ability to provide individualised treatment (Hamilton et al., 2019). Thus devices with the ability to be personalised are preferred, and can encourage adoption by both patients and therapists (Ramprasad et al., 2015; Tadas & Coyle, 2020). In addition, adoption can be supported by design features which take into account personal preferences, such as the preferred genre of therapeutic video games (Marston & Smith, 2012), and which allow for personalised activities, feedback and motivational cues (van Ommeren et al., 2017; Xu et al., 2019).

iii) Responding to personal characteristics of users of RT

"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., 2020)

As stated in theme three above, the personal characteristics of the user can influence adoption. To facilitate adoption, the therapist must use a person-centred approach to respond to these characteristics. This is achieved by providing input during RT use to optimise safety, provide just-the-right challenge, give feedback and ensure the correct movement is practiced (Hamilton et al., 2019). The willingness of the therapist to also cater to individual patient preferences was also found to be important (Palomares-Pecho et al., 2020).

Stage 2: Thematic analysis of articles on sustained use of rehabilitation technology

The codes derived from the one systematic review and seven primary research studies that investigated sustained use were analysed and mapped against the four themes and related subthemes generated from the adoption literature in Stage 1. **Error! Reference source not found.** provides details of this mapping process by summarising the factors influencing adoption and sustained use and identifying themes and subthemes that are common to both sets of literature, and those that are unique. This mapping process retained the four adoption themes and subthemes.

In addition, a new, fifth theme was revealed, as well as new subthemes which aligned with the previously reported adoption themes. **Error! Reference source not found.** illustrates the themes and subthemes for factors affecting sustained use of RT. The final themes which illustrate the factors influencing the sustained use of RT are: (1) Knowledge; (2) Device design; (3) Personal characteristics of patients and therapists; (4) Person-centred approach; and lastly a new theme, 5) Wider systemic conditions. A supplementary table (Supplementary File 3) showing indicative quotes for each code is provided below.

Theme 1: Knowledge

> *"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)*

The role of knowledge in supporting the sustained use of RT echoed the findings of the adoption thematic analysis. However, the first subtheme, 'what is available' did not play a significant role in the sustained use literature (Tuikka & Sachdeva, 2017), presumably because sustained use relates to RT that is already available. In the second subtheme of *'*pros and cons of rehabilitation technology', in addition to the knowledge of device usefulness and which RT suits the patient, the role of actual real-world use to provide evidence of efficacy was also highlighted (Porras et al., 2019). The third and fourth subthemes; "how to operate the device" and "how to tackle problem and access to support" were extended to emphasise the role of the patient and carer. The carer and patient's knowledge of how to operate the device and the importance of training them to develop competency in device operation (Boot et al., 2020) were highlighted in the sustained use literature. Similarly, the importance of the patient and carer, rather than just the therapist, having the skills to resolve technical issues and access available support (Tuikka & Sachdeva, 2017) was integrated into the subtheme of "how to tackle problems and access to support".

Theme 2: Device design

The sustained use literature emphasised the theme of device design that had been identified in the adoption literature. The first three subthemes, i) Ease of learning, ii) Ease of set-up and operation,, and iii) Features supporting patient engagement, were echoed and remained largely unchanged. Pandey et al. (2017) identified that devices which can provide instructions that are easily understood or able to sustain the engagement of the patient through provision of reminders can facilitate continuous use. Porras et al. (2019) identified that an easy set-up and user-friendly interface continued to be important for sustained use. However, Liu et al. (2015) found that while some

technologies are difficult to use or hard to learn, this may not affect a therapist's continued use, provided the device is able to deliver the expected outcomes

For the last subtheme, 'supporting workload', different factors were emphasised in the adoption and sustained use literature. The adoption literature emphasised supporting the therapists workload, while the sustained use literature focused on supporting both the carers and therapists. In the sustained use literature, the use of RT to support treatment planning was highlighted; for example, Chua & Kuah (2017) reported data collected from the RT could be used to inform modifications to the treatment programme.

"Functional database results were used to guide program modification" (Chua & Kuah, 2017, p.S155)

Boot et al. (2020) found that if devices reduced the time and effort required of the carer, sustained use was more likely.

"Time was an important factor for carers to provide AP support on a daily basis" (Boot et al., 2020, p.180)

Theme 3: Patients' and therapists' circumstances and characteristics

This third major theme sees a number of changes to the subthemes, when comparisons are made between the adoption and sustained use literature. A new subtheme of "individual preferences" was added, two subthemes were reinforced with new considerations ("Attitudes and beliefs" and "demographic characteristics"), and one theme was modified("Perception of self and societal values"). The subtheme related to the "patient's support network" remained unchanged. There was insufficient data to support two subthemes from the adoption literature of "responding to personal characteristics of users of RT" and "circumstances influence accessibility to device".

The new subtheme of "individual preferences" reflects how the preferences of therapists and patients influence sustained use (Matthew-Maich et al. (2016). These preferences include the individual's interest and perceived autonomy in using the technology and the type of feedback which can best reinforce ongoing use (Matthew-Maich et al. (2016). In relation to the existing subtheme of "demographic characteristics", a newly identified characteristic was the patient's cognitive impairment which may affect their technological literacy (Matthew-Maich et al., 2016). Low technological literacy led to an inability to use RT independently, affecting the individual's willingness to continue using the device (Matthew-Maich et al., 2016). Within the existing subtheme of "attitudes and beliefs", as with the adoption literature, past experience shaped attitudes towards sustained use (Tuikka & Sachdeva, 2017). In addition to this, an adoptive mindset was found to be

important for sustained use (Chua & Kuah, 2017). This adoptive mindset refers to being able to work around limitations of the existing workflow and system to make the RT workable for both patients and therapists (Porras et al., 2019; Chua & Kuah, 2017). For the subtheme on "perception of self and societal values", patients sustained use of RT continued to be affected by their perceptions of societal values (Boot et al., 2020). However, Liu et al. (2015) found that therapists were not affected by social pressure from colleagues to use RT, unless usage was mandated.

Theme 4: Person-centred approach

The importance of a person-centred approach to the sustained use of RT echoed the findings in the adoption literature. The subthemes "therapist knowledge of how to adapt the device" and "Device design which supports personalisation" remained unchanged. However, the subtheme of 'responding to personal characteristics of users of RT', was not supported by the sustained use literature. Instead, the "therapist attitude and beliefs", has become the interconnection between the major theme on "Patients and therapists' circumstances and characteristics" and the "Person-centred approach" theme (see **Error! Reference source not found.**). In this subtheme the empathetic and person-centred attitude of the therapist is core to what the therapist does and supports the therapist to continue to work on ways to improve the patient's experience using the RT (Chua & Kuah, 2017).

Theme 5: Wider systemic conditions

> *"Conditions outside the control of the individual played a major role for the person to use the AP (assistive product)." (Boot et al., 2020, p.179)*

This new major theme sets the context in which sustained use is supported by various factors at different levels of an organisation. This theme is formed by three subthemes: i) Organisation operational support; ii) Strategic direction and policies support operation; and iii) Government and funding policies drive organisation priorities.

i) Organisation operational support

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

Several studies found that the available operational support influenced sustained use. This included the provision of additional time to set up or store the device outside of the stipulated time

spent using the RT (Chua & Kuah, 2017). The presence of passionate leaders and clinician champions within the organsiation helped to drive the use of RT (Matthew-Maich et al., 2016). 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 (Chua & Kuah, 2017; Porras et al., 2019).

ii) Strategic direction and policies support operation

> *"…the gap between policy and implementation was enormous and that there was a need for improving guidance on how to obtain access to tailored assistive products relevant to individual needs."*(Boot et al., 2020, p.178)

The strategic direction of an organisation and its supporting policies can drive the sustained use of RT. The development of a strategic business plan that facilitates implementation and sustained use of RT is possible but requires secure and sustainable funding (Matthew-Maich et al., 2016). Policies may include ways to use RT to overcome manpower shortfalls (Chua & Kuah, 2017).

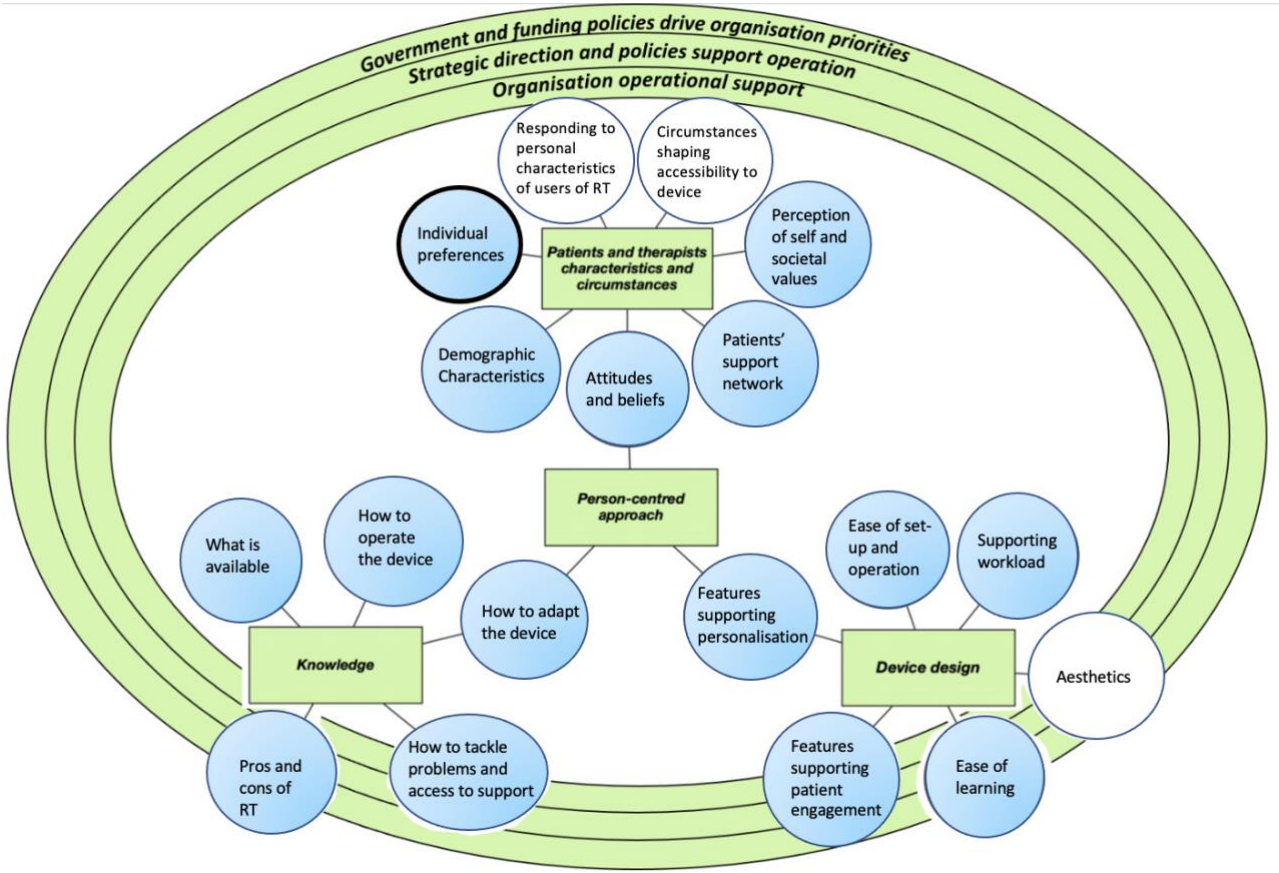
iii) Government and funding policies drive organisation priorities

> *"…access and continuous use are influenced by different barriers and facilitators. These different influences should be taken into account in country policies and frameworks that seek to implement the UNCRPD (United Nations Convention on the Rights of Persons with Disabilities) through assistive technology." (Boot et al., 2020, p.173)*

When the organisation's plan aligns with broader government policies or direction, there will be less resistance and more funding to support the purchase and ongoing use of the RT in the clinical setting (Boot et al., 2020). For example, budgeting of recurrent RT operational costs to correspond with government funding cycles, resulted in less disruption in the sustained use of RT and in the delivery of a telehealth programme with mobile applications (Matthew-Maich et al., 2016). See **Error! Reference source not found.** for the mapping of the sustained use data onto the adoption and Table 5 for a summary of mapping of themes, subthemes and codes affecting adoption and sustained use.

Figure 4

Themes related to the sustained use of rehabilitation technology



Note. Figure illustrates the mapping of the sustained use data onto the adoption themes. The four adoption themes (green) were retained. Blue subthemes are those that were common to both the adoption and sustained use literature. The blue subthemes with a bolded circular rim is a new subtheme for sustained use. White subthemes were found in adoption but not evident in the sustained use literature. The new fifth major theme that supports sustained use is depicted by the three circles encompassing the other themes.

Table 5

Summary of mapping of themes, subthemes and codes affecting adoption and sustained use

Subthemes (New subthemes are bold)	**Mapping adoption vs sustained use**	**Adoption codes**	**Sustained use codes (New subthemes are bold)**
Theme 1: Knowledge			
What is available	Common	- Knowledge of device availability	- Knowledge of device availability
Pros and cons of rehabilitation technology	Common	Knowledge of device usefulness Knowledge of which RT suits the patient *Research evidence:* - Efficacy evidence motivating training attendance and clinician endorsement - Efficacy evidence gives confidence - Efficacy evidence shows advantage over conventional therapy *Practice evidence:* - Evidence on effectiveness shown in actual clinical practice	Knowledge of device usefulness Knowledge of which RT suits the patient *Practice evidence:* - Evidence on effectiveness shown in actual clinical practice
How to operate the device	Common	- Therapist knowing how to operate the devices enhances adoption - Training assist in developing therapist's competency in operating and adapting devices	**- Patient and carer knowledge of how to operate the device**
How to tackle problems and access to support	Common	- Knowledge to resolve or compensate for technical issues - Knowledge about available technical support	**- Patient and carer knowledge about available technical support**

Subthemes **(New subthemes are bold)**	**Mapping adoption vs sustained use**	**Adoption codes**	**Sustained use codes** **(New subthemes are bold)**
Theme 2: Device design			
Ease of learning	Common	- Device is understandable - Device which is easy to learn supports use	- Device is understandable - Device which is easy to learn supports use
Ease of set-up and operation	Common	- Ease of set-up or use with intuitive user interface - Easy to use devices avoids development of negative emotions thus optimising adoption - Safe and easy to handle devices supports adoption	- Ease of set-up or use with intuitive user interface **- Easy to use devices may not support sustained use (for therapist)**
Features supporting patient engagement	Common	- Device facilitates motivation and engagement - Element of fun supports engagement - Through monitoring device provides reminders and feedback - Individual's emotions when supported facilitates engagement and adoption	- Through monitoring device provides reminders and feedback
Aesthetics	Adoption only	- Device attractiveness affects adoption	- No data identified
Support workload	Common	- Providing information that informs treatment planning - Complements conventional practice - Automation of reports of and information supports administrative work - Reducing therapist workload and effort	- Providing information that informs treatment planning **- Reducing carer workload and effort**

Subthemes **(New subthemes are bold)**	**Mapping adoption vs sustained use**	**Adoption codes**	**Sustained use codes** **(New subthemes are bold)**
Theme 3: Patients and therapists circumstances and characteristics			
Circumstances shaping accessibility to device	Adoption only	- Cost and funding for the device - Administrative processes to acquire the device - Access to the rehabilitation setting - Portable devices enhances access	No data identified
Demographic characteristics	Common	- Age - Ethnicity - Severity of diagnosis	**- Technological literacy limited by cognitive impairment**
Attitudes and beliefs	Common	- A motivated attitude influences adoption - Past experiences shapes attitude towards use	**- An adoptive attitude affects sustained use** - Past experiences shapes attitude towards use
Individual preferences	**Sustained use only**	No data identified	**- Preferences affects sustained use**
Perception of self and societal values	Adoption only	- Perceived own role in rehabilitation affects RT use - Perception of own self-image affects adoption - Perceived societal values influence adoption	- Perceived societal values influence sustained use
Patients support network	Common	- Attitudes of patient's social network - Social support - Collaborative therapeutic relationship	- Attitudes of patient's social network - Social support - Collaborative therapeutic relationship

Subthemes **(New subthemes are bold)**	**Mapping adoption vs sustained use**	**Adoption codes**	**Sustained use codes** **(New subthemes are bold)**
Theme 4: Person-centred approach			
Therapist knowledge of how to adapt the device	Common	- Knowing how to personalise the devices to the patients	- Knowing how to personalise the devices to the patients
Device design which supports personalisation	Common	- A device ability to support personalisation - Personalisation features	- A device ability to support personalisation - Personalisation features
Responding to personal characteristics of users of RT affects adoption	Adoption only	- Input from therapist that address personal characteristic supports adoption - Catering to personal preferences influence adoption	
Therapists attitudes and beliefs	**Sustained use only**		**- Therapist person-centred, empathetic attitude**
Theme 5: Wider systemic conditions			
Organisation operational support	**Sustained use only**	No data identified	**- Provision of additional time for set-up** **- Passionate leaders and team to drive usage** **- Workflow redesign to integrate RT** **- Emergency protocols/drills developed for adverse events during RT use**
Strategic direction and policies support operation	**Sustained use only**	No data identified	**- Adopt a strategic business-focused plan** **- Addressing manpower shortfall**

Subthemes (New subthemes are bold)	Mapping adoption vs sustained use	Adoption codes	Sustained use codes (New subthemes are bold)
Government and funding policies drive organisation priorities	**Sustained use only**	No data identified	**- Government direction drives organisation adoption** **- Government funding cycles affects ongoing costs coverage of RT usage**

Mapping of thematic analysis against decision-making processes within practice context

A mapping exercise (see **Error! Reference source not found.**) was undertaken to compare the results of the thematic analysis on adoption and sustained use against the processes used at the Jurong Community Hospital to acquire and implement RT (Figure 1, Chapter 2: Practice context). This analysis revealed that while some of the themes were partially addressed within the evaluation and implementation process, the extent and rigour of the process was limited. Of those themes which were addressed only a few factors identified in the subthemes were considered. Table 6 provides an overview of this analysis. The current acquisition workflow lacks specific processes that might ensure the factors affecting adoption and sustained use are addressed. Thus, the current processes are insufficient to optimise adoption and sustained use of RT.

Table 6

Decision making process within practice context mapped against themes generated

Process	Themes				
	Knowledge	Device Design	Characteristics and Circumstances	Person centred approach	Wider systemic conditions
Step 1					
Step 2					
Step 3					
Step 4					
Step 5					
Step 6					
Step 7					
Step 8					
Step 9					
Step 10					
Step 11					
Step 12					

Note. Black cells represent themes not relevant at the respective step of the process. Coloured cells represent themes which are relevant and should be addressed where green cells indicate more than half of the related sub-themes are addressed, yellow less than half of the sub-themes are addressed, orange only one sub-theme is addressed, and red no sub-themes are addressed

Chapter 5: Discussion

This scoping review has examined the factors influencing adoption and sustained use of RT in clinical practice. Whilst there is a of body of research examining the adoption of specific types of RT in specific populations, this is the first review to examine the adoption of RT more broadly with a focus on end-user perspectives and practices that can enhance sustained use. The four key themes that influence adoption include: i) the importance of knowledge development, ii) device design, and iii) assessing and addressing an individual's circumstances and characteristics as part of a iv) holistic person-centred approach. These findings provide evidence to inform the successful adoption of RT in clinical practice. The dearth of research exploring sustained use necessitated an abductive approach to data analysis, informed by prior findings related to the adoption of RT. Analysis of the sustained use literature identified that additional wider systemic conditions and engaging patients and carers affect the sustained use of RT in clinical practice. The discussion section of this review serves to: (1) discuss each theme with reference to relevant literature in related fields, highlighting what influences adoption and sustained use and the differences between them; and (2) explore the implications of the findings for various stakeholders, RT design, clinical practice and future research.

What influences the adoption and sustained use of RT in clinical practice?

Knowledge

The first theme illustrated how knowledge development facilitates adoption of RT. Therapists need to develop knowledge in the area of RT availability (Dahler et al., 2016; Howard et al., 2020); the disadvantages and advantages of RT (Glegg & Levac, 2018; Howard et al., 2020; Marston & Smith, 2012; Steel & Gray, 2009); how to operate the RT (Howard et al., 2020; Marston & Smith, 2012b; Palomares-Pecho et al., 2020); and how to address technical problems associated with RT use (Hamilton et al., 2019; Vaezipour et al., 2019). Howard et al. (2020) have stressed that knowledge of how to operate the device is not sufficient on its own to support adoption. Therapists also need to develop additional clinical expertise, including how to customise the RT and modify its use to meet patients' individual needs (Hamilton et al., 2019). Specialist knowledge in this area is especially important when patients needs or the RT itself are complex. The findings within this theme emphasise the importance of practical knowledge to support sustained use of RT and echo implementation science that has explored the translation of research into practice (Wensing, 2015) and evaluated methods to promote the uptake of research findings into routine clinical practice

(Grimshaw et al., 2012). Implementation science literature emphasises the importance of ensuring that clinicians have the knowledge and expertise surrounding an intervention to enable smooth implementation (Zidarov et al., 2013).

The importance of knowledge in supporting RT adoption and sustained use may go some way to explaining the low rates of adoption and sustained use of RT seen in clinical practice (Dyb et al., 2021), even when research studies provide strong evidence of clinical efficacy (Damschroder et al., 2009). While research evidence of efficacy is an important source of knowledge influencing adoption of RT (Babaiasl et al., 2016; Hamilton et al., 2019; Howard et al., 2020), other domains of knowledge, such as operating (Boot et al., 2020) and resolving technical issues (Tuikka & Sachdeva, 2017), appear equally important in supporting sustained use. A lack of technical knowledge and support may lead to clinician and patient frustration and subsequent abandonment (Vaezipour et al., 2019).

Device Design

The second theme highlights the importance of the RT device design in relation to ease of learning (Fabricatore et al., 2020; Palomares-Pecho et al., 2020), set-up (Porras et al., 2019), operation (Pandey et al. 2017), and having device features which support patient engagement (Ramprasad et al., 2015; Vaezipour et al., 2019). These themes are congruent with factors that enhance usability emphasised in rehabilitation technology literature (Hamilton et al., 2021; Kaleshtari et al., 2016), particularly in relation to ease of set-up, learning and understanding of the device.

In addition to addressing the usability of RT, this review emphasises that the device also needs to have features which are capable of engaging the patient (Ramprasad et al., 2015; Vaezipour et al., 2019), to facilitate adoption and sustained use. This is in line with findings from rehabilitation and healthcare studies that have highlighted the significance of patient engagement to improve participation (Pallesen et al., 2018) and health outcomes (Gigliotti & Jarrott, 2019). Patient engagement in rehabilitation is conceptualised by Bright et al. (2015) as a co-constructed state and process, in which the patient collaborates with the therapist, resulting in active, committed and invested participation in the intervention process. Importantly, Bright et al. (2015) stresses the significance and importance of the therapist's engagement in the RT adoption process. Thus, in addition to devices having features that enhance patient engagement, therapists should be mindful of their role in supporting engagement; this could be through addressing knowledge gaps, as identified in the previous theme, and performing person-centred assessments to customise the device to the patient's unique characteristics. In terms of specific device features that can facilitate engagement with RT, the findings in this review suggest device features should include: the presence of the element of fun through gamification (Vaezipour et al., 2019); the provision of customisable reminders and feedback to encourage adherence (Tadas & Coyle, 2020); and lastly, the facilitation of emotional engagement through consistent reassurance and encouragement with the use of friendly voices to convey messages (Fabricatore et al., 2020).

Patient and therapist circumstances and characteristics

In the third theme that arose from this study, the patient's and therapist's characteristics were found to influence adoption and sustained use of RT. This included patient and therapist circumstances around access to RT (Babaiasl et al., 2016; Howard et al., 2020; van Ommeren et al., 2017), and personal characteristics in terms of demographics (Steel & Gray, 2009), attitudes and beliefs (Saeed et al., 2020), perception of self (Larsen et al., 2019), societal values (Howard et al., 2020) and support network (Hamilton et al., 2019). Personal and societal circumstances which influence access to RT are analogous with accessbility issues to healthcare services in general (Khan & Bhardwaj, 1994; Zuurmond et al., 2019). Factors such as cost, location, culture, gender, values, autonomy, health literacy and carer support are identified in both bodies of literature (Frumence et al., 2017; Larsen et al., 2019; Núñez et al., 2021; Tadas & Coyle, 2020). Importantly, RT may also ameliorate healthcare access issues by allowing for virtual access (Núñez et al., 2021) with distant monitoring and consultations (Chatto et al., 2018; Galiano-Castillo et al., 2016). For example, wearable RT can be used for teleheath cardiac rehabilitation and chronic disease management, which can minimise physical access issues (Elnady et al., 2018; Howard et al., 2020; McDougall &

Pearson, 2020). However, it is worthy of note that issues with technology literacy or technical malfunctions may compromise this advantage of RT.

The attitudes and beliefs of patient's and therapist's drive their behaviours towards RT (Hirani & Newman, 2005), and that in turn affects their access to devices and general health outcomes (Christensen et al., 2010; Sobel, 1995). It is well established in rehabilitation literature that the attitudes and beliefs of the therapist have a strong association with their clinical management of patients in conditions such as low backpain (Darlow et al., 2012) and cardiovascular disease (Hirani & Newman, 2005). The findings from this scoping review expands on this concept. A motivated attitude of the therapist drives positive intention and behaviour to facilitate the adoption of RT (Palomares-Pecho et al., 2020; Tadas & Coyle, 2020) while an adaptive and empathetic attitude sustains use (Chua & Kuah, 2017). An empathetic attitude may enable the therapist to journey with the patient through a course of treatment using RT for a longer period of time and enable the therapist to support the patient to weather some of the challenges which may arise. Continuous use of RT is supported through an adoptive attitude by therapists which can help with driving active workflow changes to increase efficiency and efficacy, and increasing resilience against setbacks (Chua & Kuah, 2017).

Findings on the factors affecting adoption and sustained use from the "personal characteristics and circumstances" theme can also be viewed through the World Health Organisation's International Classification of Functioning, Disability and Health (ICF) model. The ICF model emphasises the interaction of functioning, personal and environmental factors (Steel et al., 2011). RT is a potential mediating agent that can address the functional limitations of a person in their context, reducing the impact of his/ her "disability", and maximising engagement in activities and participation in social roles. As noted in the ICF framework and the findings of this review, the use of RT to maximise function cannot occur without influence by personal and environmental factors. The personal factors such as demographics characteristics (age, ethnicity and medical diagnosis (Steel & Gray, 2009; Tadas & Coyle, 2020), cognitive function (Matthew-Maich et al., 2016), attitudes and beliefs (Saeed et al., 2020) and perception of self (Larsen et al., 2019) and societal values (Howard et al., 2020), shapes an individual's behaviour and their engagement with RT. These factors can determine whether the RT is used or not, potentially influencing functional outcomes. By considering the factors at play through the lens of a framework like the ICF, we can gain a clearer understanding of the complexity of RT usage. Additionally, consideration of the various components of the ICF can provide useful insights into other potential barriers and facilitators that can facilitate adoption and sustained use of RT.

Person-centred rehabilitation

The fourth theme on the person-centred approach emphasises the importance of adapting the device to an individual's needs (Howard et al., 2020; Hamilton et al., 2019)), having a device which supports personalisation (van Ommeren et al., 2017), catering to personal preferences (Hamilton et al., 2019; Palomares-Pecho et al., 2020), and having a therapist with a person-centred attitude (Chua & Kuah, 2017) in promoting adoption and sustained use. This theme is also reflected in the wider literature about person-centred care (Federici et al., 2014; Moore et al., 2017). While there is no standardised definition of person-centred care, its focus is on the needs of the person with consideration of his or her values, circumstances, hopes and aspirations (Rogers, 1957). This approach involves partnership between the patient and the service provider (Santana, 2017). This theme is strongly linked to the need for a collaborative therapeutic relationship between the therapist and patient as identified in the previous theme. The characteristics of person-centred care, such as supporting and identifying individual unique needs through personalisation (van Ommeren et al., 2017) and demonstration of empathy (Chua & Kuah, 2017), were evident in the adoption and sustained use literature. Other literature investigating the use of e-health technology in healthcare has noted that when the technology focused on providing person-centred care initiatives, the outcome tends to be positive with no complaints on quality or user interfaces complexity (Dyb et al., 2021). Additionally, person centred care Is not limited to the patient; it also includes families and carers. This reinforces the findings of this review, in which subthemes underlying sustained use were expanded to include carers as well as the importance the patient's support network.

Wider systemic conditions

The fifth theme on wider systemic conditions highlighted the need for organisational support (Liu et al., 2015), strategic direction and policies (Matthew-Maich et al., 2016) and the alignment of an organisation's priorities with government policies (Boot et al., 2020) to support sustained use. These systemic conditions act as external factors which support or hinder sustained use (Baker & Moon, 2010; Lewis et al., 2012). Malalignment at any level can result in abandonment of the RT (Cruz et al., 2016). This theme resonate with the socio-ecological model (SEM) as first introduced by Urie Bronfenbrenner (Bronfenbrenner, 1979). Bronfenbrenner's model described the interplay of systems and environmental factors which include individual, interpersonal, organisational, community and policy factors that influence an individual's health (Roy et al., 2011). Similarly, this review's findings suggest that a complex interaction of the various systems must take place for sustained use to occur. These findings provide important insights into possible reasons for the unfortunate collapse of innovation in the rehabilitation context when wider systemic factors have not been considered.

How do the factors that influence sustained use differ from those that influence adoption?

A key finding of this scoping review is that while the four main themes of knowledge, device design, users characteristics and circumstances and a person-centred approach continue to be present from adoption to sustained use, the emphasis shifts, and some new factors come into play. This indicates that there are universal issues which influence both the initial adoption and ongoing sustained use of RT, but also some specific factors that are required for sustained use.

Factors that are consistent across the adoption and sustained use relate mainly to device usability and design (Porras et al., 2019; Howard et al., 2020) , knowledge of suitability (Steel & Gray, 2009; Porras et al., 2019), efficacy and effectiveness (Vaezipour et al., 2019; Larsen et al., 2019; Hamilton et al., 2019; Porras et al., 2019), need for customisation (van Ommeren et al., 2017; Porras et al., 2019; Boot et al., 2020) and positive engagement (Tadas & Coyle, 2020; Pandey et al., 2017; Larsen et al., 2019; Dahler et al., 2016; Tuikka & Sachdeva, 2017; Boot et al., 2020; Hamilton et al., 2019). This suggests that carefully attending to these factors during the selection of RT and its implementation in clinical practice may pave the way to sustained use.

Several differences between factors influencing adoption and sustained use were found. This includes knowledge of what is available in the market (Tuikka & Sachdeva, 2017) and the ease of use of devices no longer being a strong factor in sustained use (Liu et al., 2015). In the adoption phase, a need to know what is available in the market informs decision for the choice of RT to be used in the clinical setting. However, when the device is readily available within the setting in sustained use, knowledge surrounding market availability is of less significance. Ease of use is related to ease of learning in adoption (Rusu et al., 2015). After the initial steep learning process, ease of learning become less relevant for experienced users (Dyb et al., 2021), as such perception of ease of use also improves. Another explanation may be that the benefits and efficacy of the device outweighs the inertia and effort needed to learn and use them (Liu et al., 2015). Another shift is that of aesthetic appeal of the device becomes less important in sustained use of RT. This may be because appreciation of other device design features overshadow the need for the device to be pleasant looking.

Another new subtheme that emerged in sustained use was “individual preferences” echoing that both therapists and patients value autonomy when using RT as part of their rehabilitation programme (Liu et al., 2015; Akbari et al., 2021). This is consistent with studies which found that patients prefer to choose and perform activities which provides them with the just-right challenge (Guadagnoli & Lee, 2010) and feedback (Parker, 2016),

One of the main changes between adoption and sustained use of RT is the shift away from the patient-practitioner dyad in adoption to encompass the patient, caregiver/family and practitioner in sustained use. The expansion to include carers was reflected in the subthemes of "how to operate the device", "how to tackle problems and access to support" and "supporting workload". This shift is also related to the theme of person-centred approach to rehabilitation where the care and service delivery needs to extend beyond the patient to their significant others. A failure to consider the persons support network may ultimately lead to abandonment of RT.

The new theme "wider systemic conditions" highlighted that a multi-stakeholder perspective is required for the sustained use of RT. This echoes concepts of shared-decision-making in healthcare (Stiggelbout et al., 2012; Waddell et al., 2021). To ensure the sustained use of RTs wide group of stakeholders must be involved in the development, evaluation and implementation of RT to encompass the whole eco-system (Chua & Kuah, 2017; Matthew-Maich et al., 2016). This new theme further emphasises the complexity and dynamic nature of factors influencing the individual end-users decision to continue to use a device (Braithwaite et al., 2018). This is aligned with implementation science frameworks such as the Consolidated Framework for Implementation Research (CHIR) which similarly identified major domains of implementation such as the "inner-" and "outer-setting" as contexts for which the implementation process will occur (Damschroder et al., 2009). The "outer setting" includes political, social and economic context while the "inner setting" features cultural, structural and political contexts that are intricate and interrelated (Damschroder et al., 2009).

Implications for clinical practice

Implications for therapists

The findings of this scoping review indicate that different factors affect adoption and sustained use of RT for therapists. For adoption to be successful, therapists should first examine their own values, attitude and beliefs surrounding the use of RT, which are often shaped by past experiences (Palomares-Pecho et al., 2020). By focusing on the positive past experiences, any inertia to using RT can be overcome. Subsequently, therapists need to seek knowledge of not just what is available in the market but also obtain the appropriate technical skills for operating devices and trouble-shooting when problems arise. This knowledge needs to be shared with patients and carers to empower them for sustained use. As such, skills in the communication of this knowledge also need to be attained. A thorough assessment of the needs, motivation, characteristics and learning abilities of both the patients and carers should be performed through a person-centred approach, to ensure such knowledge can be passed on. Therapists need to engage patients and carers to establish shared

goals for rehabilitation using RT and encourage feedback about their experiences to ensure proper customisation can take place. Such practices, when in place during in the adoption phases of RT, can lead to positive experiences of using RT, paving the way to sustained use. Additionally, to ensure sustained use, therapists should engage in continuing education and develop their expertise in customising the RT to address patient's and carer's needs within their unique context and environment. There also exists an additional need to look at ways to incorporate RT into work processes, for example by redesigning workspaces, workflow and processes to facilitate the smooth integration of the RT.

Implications for patients and carers

Patients and carers are important stakeholders in the adoption and sustained use of RT. To facilitate the adoption of RT, the patient and their carers should be encouraged to actively participate in the assessment of their needs and to share their concerns surrounding RT use. Active involvement in learning the purpose of the device and how to use it in the absence of the therapist, especially for devices which may be less complex or meant for self-training, will be useful in the sustained use of the RT. In addition to being an active participant in their own care, patients will benefit from engaging in conversations with previous users of the devises to gain others perspectives on the use RT.

Implications for designers and developers of RT

The findings of this study have important implications for designers of RT. Designers should place emphasis on customisability, core usability, engagement features and make sure that the product is attractive to users, at least initially. A delicate balance between aesthetics and usability needs to be struck, such that attraction to use the device at initial stages of adoption can be developed, while the device proves its effectiveness and efficiency to ensure sustained use (Saeed et al., 2020). Since knowledge development and positive experiences play an important role in adoption and sustained use, device designers and vendors need to focus on designing training and device maintenance and support packages to ensure a continued positive experiences. A system that enables users (therapist and patients) of the RT to feedback to the designers and developers should be in place. This feedback loop would allow the device to be evaluated, maintained and improved on a regular basis to ensure that it addresses the user needs. This is especially important for devices that provide continuous monitoring (Aranki et al., 2016). This will lead to better integration of the device into clinical practice (Lu et al., 2011) .

Implications for management/ decision makers of RT purchase

For the provision of RT to be person-centred, such that there is increased adoption and sustained use, a wider cultural change needs to enable person-centred care to take root and flourish. Firstly, there is a need for management to recognise and acknowledge the benefits of adopting a person-centred approach to rehabilitation and RT use. Subsequently, management should explore and utilise the guiding principles such as those outlined by Willis et al. (2016) to sustain organisational culture change through: the alignment of their vision and action; making incremental changes through a strategic and comprehensive transformation plan; fostering leadership at various levels; promoting staff engagement; creating collaborative relationships; and assessing and learning from the changes continuously.

The change process should be facilitated by management rather than controlled. Management should consider the perspectives of all end-users in the selection and adoption of RT, investing time and resources in training, and empowering therapists to amend and refine their workflow and processes so that RT can be integrated into standard practice. . Reminders to utilise the RT may be complementary for some but intrusive for others.. Active use of RT can be achieved with the right support and a stepwise approach with the appropriate work processes in place.

As the development of knowledge is essential to facilitate adoption and sustained use, ensuring adequate training time and support so that staff understand a new RT system (Glegg & Levac, 2018) and have any support needed to address technical difficulties (Tuikka & Sachdeva, 2017) is important. Additionally, accurately estimating the staff time required to adopt and sustain use of the device is imperative. This should include but is not limited to training time, familiarisation, patient set up, device cleaning, storage and maintenance activities (Chua & Kuah, 2017).

Implications for funders

Policy and funding decisions significantly impact the sustained use of RT. Several studies have identified that RT use and programmes fold when external financing ceases (Larsen et al., 2019; van Ommeren et al., 2017). When government provides clear long-term strategy and direction for how healthcare institutions should utilise technology and enact these through policy and funding guidelines, organisations are better able to align to ensure long term management of RT. When considering if funding should be disbursed to a particular project, decision makers should carefully evaluate the ongoing costs for sustained use of the device, including staffing and maintenance costs. . Those seeking funding should provide evidence regarding the effectiveness and benefits of the RT for patients, service providers and the organisation (Hamilton et al., 2019). To attract applicants for RT funding, funders should consider providing financial backing and incentives to adopt rehabilitation technology in the workplace. Providing a simple and straight forward application process with applications that can be reviewed throughout the year at designated time points and allowing funding to be extended and used to support growth, development and additional training, may promote the uptake of RT.

Practice recommendations for author's clinical setting

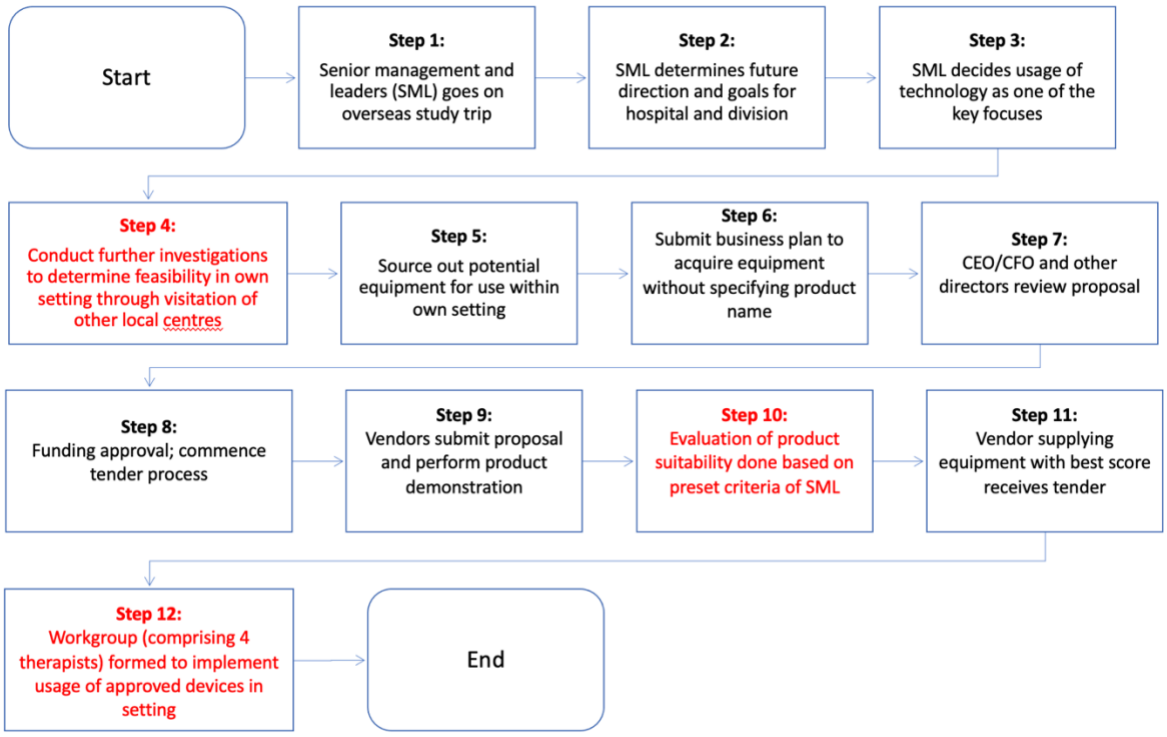
The findings of this study revealed that the RT evaluation and implementation process used in the authors practice context (refer to Chapter 2: Practice context) does not specifically address the themes or subthemes that are important for adoption and sustained use of RT. Through the mapping exercise performed in Chapter 4: opportunities for improvement were identified based on the the findings of the thematic analysis (see Figure 5

Process map with steps for improvement: While several steps in the workflow are not modifiable, three identified steps in the workflow can address issues with usability and acceptability. The following discussion will suggest improvements that could be made to these processes to guide the acquisition and implementation of RT at Jurong Community Hospital.

a) Step 4 - Conduct further investigations to determine feasibility in own setting through visitation of other local centres
b) Step 10 - Evaluation of product suitability done based on pre-set criteria by senior management leaders (SML) and
c) Step 12 - Workgroup (comprising 4 therapists) formed to implement usage of approved devices in setting.

Figure 5

Process map with steps for improvement



Note. Processes in red font can be further refined with consideration of acceptability and usability of RT to increase higher adoption rate and sustained use after introduction in clinical setting.

a) Investigating feasibility of RT (prior to acquisition)

Based on the findings in this scoping review, to determine the feasibility of having RT in the workplace, SML would benefit from adopting a person-centred approach (*Theme 4: Person-centred approach*). The strategies used to determine the feasibility of RT in the practice setting (Step 4) should be extended beyond visiting other local centres. By including users of the RT, namely the patient and their carer and therapist in this step, a person-centred approach could be achieved. A thorough consideration of the user's attitudes and beliefs and needs (*Theme 3: Patient's and therapist's characteristics and circumstances*) will help to decide which RTs might be valued and useful. This person-centred approach should also include users when: 1) contributing to the design process of RT still under development that might be introduced into the clinic as part of clinical trial, and 2) reviewing which RT is available in the market.

b) Evaluation of product suitability (prior to acquisition)

As highlighted for process Step 10 the users need to be involved in setting and applying the criteria for evaluating the suitability of the RT. It is suggested that the criteria as shown in

Supplementary File 1

Document used for evaluation of Rehabilitation Technology, Jurong Community Hospital) should be refined. These criteria will benefit from including the evaluation of whether a RT is customisable, as emphasised by Howard et al. (2020) “assistive technology must be ‘adaptable’ or ‘modifiable’ to fit into everyone’s circumstances.” (*Theme 2: Device design*). In addition to this, a checklist for vendors could be developed and incorporated as part of this evaluation. This checklist could serve as a self-declaration that co-design with end-users (patients and therapists) occurred in the design process of the RT of interest. Involving end-users in the development of RT is known to enhance usability (Baudin et al., 2020). This process ensures any issues that the end-user may face can be readily considered and may in turn reduce the frustration that can occur when personalising the use of RT for individual patients.

The evaluation of product suitability is currently carried out by a panel that includes three senior therapists and a service maintenance and finance team. A greater emphasis needs to be placed on the assessment of the suitability of RT based physical needs, psychological and health beliefs. The organisation could also work towards including patients and carers by inviting them to sit in the advisory panel for evaluating the product with the existing panellists. Ensuring the opportunity to trial the device and provide feedback to the panel (*Theme 4: Patient-centred approach*) would also emphasise important user perspectives. One common practice is for vendors to loan a set of the RT of interest for a period of time (usually 2-3 months) to the clinical setting. This would allow therapists and patients to utilise the device and evaluate its suitability for use within the setting. Thus, patient perspectives could be incorporated into the decisions around which RT to purchase. This process would also enable a more accurate estimation of the time required for training, familiarisation, patient set up, device cleaning, storage and maintenance activities for both costing and workflow refinement.

c) Implementation

This step currently involves a workgroup of four therapists who are tasked with implementing the use of RT. To facilitate adoption of RT, the members of this workgroup could act as champions to encourage use of the RT, provide training about how to operate and adapt the device, and provide an avenue for technical support (Theme 1: Knowledge). Educational material with a high readability index for patient and carers can also be developed to address queries on purpose of device, how to operate and trouble-shoot them (Theme 1: Knowledge). This group could also facilitate changes to workflow so that the RT to be incorporated into current clinical practice. To increase the buy-in for staff to use the RT, an engagement session with other therapists could be

initiated to understand their perspectives on the use of RT in the clinical setting and the findings from this session could be used to draw up support plans for users of the RT. The workgroup could also play an important role in engaging with the SML and providing feedback on what other support is required to ensure that the RT use can be sustained.

Limitations

There are several limitations to this review associated with the methodology and findings of the study. One limitation lies in the selection of only review articles for the thematic analysis in Stage 1 which identified factors influencing adoption. As the primary research presented in each review articles were not checked individually, the representation of the primary data may be inaccurate, leading to potential misrepresentation. Additionally, in a meta-synthesis, the context of each individual article may be lost during the synthesis process and the context of one study may not carry over to other contexts. We have examined and reported details such as the country, population and type of assistive technology for each review, to enable the reader to establish the context for themselves. Another limitation is that only one researcher undertook coding of the data for data analysis. This may affect the trustworthiness, creditability and dependability of the review. This was mitigated by revisitation of the raw data multiple times over an extended period of time, taking reflexive notes and having multiple discussions of the codes and themes generated with the author's supervisors to yield different perspectives and insights into the data.

Furthermore, the small number of studies exploring sustained use make it likely that there are other factors, beyond those identified in this review, that influence sustained use of RT. In addition, it is acknowledged that each type of RT may have unique factors influencing its adoption and sustained use, and that these have not been explored in this study.

Recommendations for future research

Future studies should explore in greater detail the factors which affect sustained use for various types of RT. A focus on the specific and most effective strategies which can be used to facilitate sustained use for different stakeholders will also be valuable to address issues of the abandonment of RT after initial adoption. It would be interesting to find out if and how an organisational culture change towards a person-centred approach influences sustained use of RT. Knowledge about the methods and guiding principles that can promote sustained use has the potential to promote good outcomes, improve care for patients, and ease therapist and carer workload. Future research should be closely linked with implementation science research, moving beyond outlining how findings relate to practice towards translating findings into practice while scaling up and sustaining evidence-supported interventions. Future research should also explore the

economics of implementation, rather than just cost-effectiveness of the RT, which would support funding decisions.

In future, knowledge gained from this review will be shared with the clinical team and senior management of the author's organisation in the form of an executive summary and oral presentation. Additional stakeholder meetings with the management and end-users will be arranged to feedback on the findings and develop the next steps in research and practice, including discussion and actualisation of the recommendations made based on the evidence in the literature.

Conclusion

This is one of the first scoping reviews to consider factors influencing sustained use of RT. Findings from the 36 included studies highlighted several important factors to consider to ensure successful adoption and sustained use of RT. They include: (ii) focusing on device design that improves ease of learning, set-up, operation, engagement, aesthetic appeal and workload efficiency for both therapists and carers; (ii) employing a person-centred approach to the design and implementation of RT; (iii) supporting the development of knowledge for end-users (therapists, patients and their carers); (iv) considering how patient and therapist characteristics influence RT use; and finally, (v) considering the wider systemic context which influences sustained use of RT. These factors are clearly interlinked and this review suggests that in order to achieve and progress to the stage of sustained use, an organisation needs to strategise and partner with multiple stakeholders to address the factors identified from initial adoption through to the ongoing usage of RT. However, the small body of literature examining sustained use of RT calls for caution when interpreting the results and emphasises the need for further research. Future research should consider how implementation can inform RT use in rehabilitation practice to enhance its sustained use and impact.

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Supplementary File 1

Document used for evaluation of Rehabilitation Technology

Quality Scoring for Rehabilitation Technology

S/N	S/N	S/N
1	**Equipment Features (Core)**	
	(a)	Essential Functional Features (7 = Excellent; 5 = Essential; 3 = Basic; 1 = Poor)
	(b)	User Friendly (4 = Excellent; 3 = Good; 2 = Average, 1 = Poor)
	(c)	Feasibility or user study has been carried out (3 = more than 2 studies done, 1 = one study was done; 0 = no research study was completed)
	(d)	Equipment controls are durable (3 = Excellent, 2 = Good; 1 = Poor)
	(e)	Additional equipment features (2 = Yes, 0 = No)
2	**User interface (Core)**	
	(a)	The user is able to operate without referring to manual after demonstration (4 = user can operate after demonstration; 3 = user needs to refer to manual for 1st time use; 2 = user needs to refer to manual on and off; 1= user needs to refer to manual for every use.
	(b)	Easy to fit into patient's body (3 = very easy; 2 = easy; 1 = Difficult)
	(c)	Durability & Sturdy (2 = Yes; 0 = No)
3	**Infection Control**	
	(a)	Durable to disinfectant (3 = Yes; 0 = No)
	(b)	Ease of cleaning (3 = Yes; 0 = No)
4	**Safety Features & Productivity**	
	(a)	Risk of Injury to patient (4 = No Risk involved; 3 = possible or manageable risk; 2 = obvious risk; 1 = multiple obvious risks)
	(b)	Risk of injury for user/staff (4 = No Risk involved; 3 = possible or manageable risk; 2 = obvious risk; 1 = multiple obvious risks)
	(c)	Staff to patient ration required during therapy if there are more units available (4 = one staff to four patients or more; 3 = one staff to two or three patients; 2 = one staff to one patient; 1 = two staff to one patient)

	(d)	How portable is the equipment (4 = portable equipment; 3 = portable but heavy, may need two persons to relocate; 2 = similar size of a desktop PC; 1 = similar size of a single bed)
5	**Warranty and local Support**	
	(a)	Duration of warranty meets/exceeds industry standard (2 = 2 yrs. or above; 0 = Less than 2 yrs.)
	(b)	Call Support - responsiveness (1 = 2 hrs call respond or less; 0 = Above 2 hrs call respond)
	(c)	On Site Support - responsiveness (2 = 4 hours or less; 0 = Above 4 hrs on Site)
	(d)	Local Installed Sites (2 = Above 4 sites; 1 = 4 sites; 0 = less than 4 sites)
	(e)	Maintenance Capability & Experience Technical Staff (2 = Good/Experience; 1= average; 0 = Poor/No experience)
	(f)	Loaner Unit (1 = Yes; 0 = No)

Supplementary File 2

List of themes, subthemes and factors with indicative quotes for adoption

Theme	Subtheme	Factors	Indicative Quotes	Reference
Knowledge	Knowledge of what is available	Knowledge of device availability affects adoption	"Lack of knowledge about available technologies is mentioned as a significant barrier for AT use, among elderly people as well as among professionals." (p.624)	(Dahler et al., 2016)
	Pros and cons of rehabilitation technology	Knowledge of device usefulness	"The TAM (Technology Acceptance Model) asserts that the adoption of rehabilitation technologies centers around a user's perceived ease of use and usefulness of the relevant technology, as well as social influences and intrinsic motivation." (p.E80)	(Vaezipour et al., 2019)
		Knowledge of which RT suits the patient	"Successful assessment and acceptance of AT is determined, in part, on the occupational therapist's ability to anticipate the client's future needs, and their *(therapist)* knowledge and skills and ability to teach [22]." (p.134)	(Steel & Gray, 2009)
		<u>Research evidence</u>		
		Efficacy evidence from research motivating training attendance and clinician endorsement	"Evidence of effectiveness may also facilitate therapist acceptance of technology as a rehabilitation tool, and motivate therapists who may otherwise be reluctant to engage in training." (p.1748)	(Hamilton et al., 2019)
		Efficacy evidence gives confidence	"Therapists were concerned about endorsing products that had limited evidence." (p.10)	(Howard et al., 2020)
		Efficacy evidence shows advantage over conventional therapy	"Clinicians will accept rehabilitation devices when they prove their efficacy in rehabilitation more than conventional techniques" (p.276)	(Babaiasl et al., 2016)
		<u>Practice evidence</u>		
		Efficacy evidence shown in actual clinical practice	*(for patient)* "Being competent and capable of performing daily activities with little or no help from others, seemed to enhance their (patients) confidence and self-worth." (p.	(Larsen et al., 2019)
			(for therapist) "Most therapists needed to see goal achievement or functional carryover if the technology was to be used in practice."	(Hamilton et al., 2019)

Theme	Subtheme	Factors	Indicative Quotes	Reference
	How to operate the device	Knowing how to operate the devices enhances adoption	*(In general) "*Users wanted devices that were simple to use and operate" (p.8) *(For patient) "*A mixed response of using videogame technology in conjunction with conventional therapy was identified from patients who demonstrated further assistance was required (from the therapist/spouse) to operate the equipment during the session." (p.148)	(Howard et al., 2020) (Marston & Smith, 2012)
		Training assist in developing competency in operating and adapting devices	"Managers need to make time for training and practice with new systems, and university curricula for therapy students should include clinical VR/AVG use and decision-making." (p.7)	(Glegg & Levac, 2018)
	How to tackle problems (technical issues) and access to support	Knowledge to resolve or compensate for technical issues	"However, it was recommended that to improve usability, the inclusion of a learning phase, and teach compensation strategies to deal with unexpected technical failures and errors, was important." (p. E78)	(Vaezipour et al., 2019)
		Knowledge about available technical support	"Also support and assistance after acquisition is crucial in becoming a user of AT." (p.624)	(Dahler et al., 2016)
Device design	Ease of learning	Device is understandable	"The system should be understandable and should consist of only those functionalities that are necessary." (p.278)	(Saeed et al., 2020)
		Device which is easy to learn supports use	"One therapist commented that due to limited time during a typical day they would have to learn how to use it outside these hours, and would therefore need to be very motivated to do this." (p.1747)	(Hamilton et al., 2019)
	Ease of set-up and operation	Ease of set-up or use with intuitive user interface	"The ease of set-up of their assistive technology, for example how difficult or how much of a 'hassle' a device was to set-up, would influence the user's decision to use assistive technology" (p.8)	(Howard et al., 2020)
		Easy to use devices avoids development of negative emotions thus optimising adoption	"Such an approach will facilitate improved design; prevent user frustration, disengagement, and technology rejection; and will subsequently optimize the uptake of interventions in the long-term." (p.E80)	(Vaezipour et al., 2019)

Theme	Subtheme	Factors	Indicative Quotes	Reference
		Safe and easy to handle supports adoption	"Given the extended loading times of more than sixty seconds per view and the patients' lack of technical competence, the issue of not being able to use and handle the systems implies a low device usability." (p.278)	(Saeed et al., 2020)
	Features supporting patient engagement	Device facilitates motivation and engagement	"One therapist felt that the outcomes of technology use did not need to be shown to be better than traditional therapy for it to be prescribed due to the motivational and engagement benefits" (p.1743)	(Hamilton et al., 2019)
		Element of fun supports engagement	"Overall, participants reported that the intervention, and in particular the gamified elements of the intervention, was engaging, fun, and enjoyable." (p.E70)	(Vaezipour et al., 2019)
		Through monitoring device provides reminders and feedback	"Reminders in any form were positively accepted by the patients. Text messages, although intrusive, pushed them to perform exercises, and many stated that reminders such as an alarm are needed for medication management." (p.10)	(Tadas & Coyle, 2020)
		Individual's emotions when supported facilitates engagement and adoption	"Technologies that incorporate social characteristics (e.g., use of friendly voice to convey prompt messages) and reassure the PwD were described as useful to facilitate emotional engagement and consequently improve the emotional experience" (p.1571)	(Fabricatore et al., 2020)
	Aesthetics	Device attractiveness affects adoption	"Usability requirements of the technology to optimise use by therapists included … aesthetically pleasing…." (p.1747)	(Hamilton et al., 2019)
	Support workload	Providing information that informs treatment planning	"A further benefit to therapists from using technology was to keep digital records of patient practice." (p.1746)	(Hamilton et al., 2019)
		Complements conventional practice	"The aim of rehabilitation robots is not to replace the therapist but to make her/his job easier…" (p.265)	(Babaiasl et al., 2016)
		Automation of reports of and information supports administrative work	"Moreover, support activities such as automatic reports and information analysis could help the work of the therapist; consequently, we offered more efficient support." (p.16)	(Palomares-Pecho et al., 2020)

Theme	Subtheme	Factors	Indicative Quotes	Reference
		Reducing therapist workload and effort	"Use of technologies may alleviate the necessity for a dedicated 'hands on' approach to therapy involving a specialist, and, possibly create new opportunities for a high quality, intensive mode of therapy." (p.53)	(Islam et al., 2006)
Patients and therapists circumstances and characteristics	Circumstances shaping accessibility to device	Cost and funding for the device	"Obtaining the AT, the difference in funding policies could influence the older adult's perspective of the process of becoming a user of AT. … while economics are not mentioned in the Scandinavian studies, they are mentioned in relation to accessibility in some of the studies conducted in other contexts." (p.191)	(Larsen et al., 2019)
		Administrative processes to acquire the device	"The ease of accessing assistive technology due to the paperwork and number of steps required was a barrier to acquiring the assistive technology." (p.11)	(Howard et al., 2020)
		Access to the rehabilitation setting	"when a stroke patient lives in far places, he/she cannot go to a clinic and hospital frequently." (p.276)	(Babaiasl et al., 2016)
		Portable devices enhances access	"Sometimes the size and placement of the rehabilitation system made it difficult for some patients and their family members to move around the home. Patients might discontinue using the systems that take too much space in the home" (p.14)	(Chen et al., 2019)
	Demographic characteristics	Age	"Patients in the older age group were especially resistant to use technology; some of them lacked interest and found it burdensome" (p.11)	(Tadas & Coyle, 2020)
		Ethnicity	"Ethnicity was cited as a contributing factor to AT use, as various cultures adapt differently to disability and health care...," (p.133)	(Steel & Gray, 2009)
		Severity of diagnosis	"The severity of an individual's diagnosis was regarded as an influencing factor on the use of AT…" (p.133)	(Steel & Gray, 2009)

Theme	Subtheme	Factors	Indicative Quotes	Reference
	Attitudes and beliefs	A motivated attitude influences adoption	*(for patients)* "… one study reported that patients' interest or intent to use an app for CVD management was high, despite the fact that most were older people who were unfamiliar with the information technology environment." (p.11)	(Tadas & Coyle, 2020)
			(for therapist) "Finally, this review aimed to identify the difficulties faced by therapists in the use and adoption of adaptable technologies… even their lack of interest in adapting the application to the patients' preferences impacted the results of the research." (p.15)	(Palomares-Pecho et al., 2020)
		Past experiences shapes attitude towards use	*(for patient)* "Therapist persistence in engaging patients was important as patient interest increased with use" (p.1746)	(Hamilton et al., 2019)
			(for therapist) "Past negative experiences with assistive technology influenced the acceptance of the current assistive technology by the user." (p.11)	(Howard et al., 2020)
	Perception of self and societal values	Perceived own role in rehabilitation affects RT use	*(for therapist)* "In summary, findings suggest that whilst therapists can see the benefits of using feedback-based technology, use in practice may be influenced by its perceived role, and the investment required for it to be well-designed and implemented." (p.1747)	(Hamilton et al., 2019)
		Perception of own self-image affects adoption	*(for patient)* "…when prescribing AT, it is not enough to provide training—healthcare professionals must also consider the impact use of the AT have on the older adult's self-image." (p.191)	(Larsen et al., 2019)
		Perceived societal values influence adoption	(for patient) "Users were concerned that devices looked too medical and not enough like mainstream technology; this resulted in user's feeling stigmatized and embarrassed to use the devices." (p.8)	(Howard et al., 2020)
	Patients support network	Attitudes of patient's social network affects adoption	"… sociocultural context, such as attitudes of family and friends and attitudes of people in society are interwoven in the process of becoming a user of AT." (p,191)	(Larsen et al., 2019)
		Social support affects adoption	"Furthermore, the review shows that significant others such as: family, caretakers and the institutional framework for providing and implementing technologies are important actors in the interaction between the old person and the AT." (p.628)	(Dahler et al., 2016)

Theme	Subtheme	Factors	Indicative Quotes	Reference
		Collaborative therapeutic relationship impacts on adoption	"The importance of building a strong therapist–client relationship was needed to facilitate the use of technology by patients" (p.1746)	(Hamilton et al., 2019)
Person-centred approach	Therapist knowledge of how to adapt the device	Knowing how to personalise the devices to the patients facilitates adoption	"Learning how to adapt the technology to suit individual patients was considered to be more important to therapists than setting up/handling the device." (p.1747)	(Hamilton et al., 2019)
	Device design which supports personalisation supports adoption	A device ability to support personalisation affects adoption	"Stroke survivors and carers prefer an AT which can be adjusted to their physical and cognitive status, which encourage them to use their affected limb in terms of personalized feedback and motivational cues" (p.325)	(van Ommeren et al., 2017)
		Personalisation features supports adoption	Personalization of feedback, motivational cues, activities as well as adjustability of hardware to personal preferences and needs is key for stroke survivors and carers. (p.325)	(van Ommeren et al., 2017)
	Responding to personal characteristics of users of RT affects adoption	Input from therapist that address personal characteristic supports adoption	"Therapists felt that input from them was needed to ensure that technology use improved patient outcomes and achieved therapeutic benefit. Input from therapists was needed to optimise safety, provide the right challenge, monitor and provide feedback on performance, and ensure practice of correct movements." (p.1746)	(Hamilton et al., 2019)
		Catering to personal preferences influence adoption	"… lack of interest in adapting the application to the patients' preferences impacted the results of the research" (p.15)	(Palomares-Pecho et al., 2020)

Supplementary File 3

List of themes, subthemes and factors with indicative quotes for sustained use

Theme	Subtheme	Factors	Indicative Quotes	Reference
Knowledge	What is available	Knowledge of device availability affects sustained use	"If type of behavior could be detected among other users of AT in different contexts, it might be possible to deduce that people with impairments… generally need bigger time investment with assistive technologies, and hence prefer to access and adopt assistive technology as and when they need – and not when it becomes available" (p.21)	(Tuikka & Sachdeva, 2017)
	Pros and cons of rehabilitation technology	Knowledge of device usefulness	"Recognizing VR tools: to determine the therapeutic and motor learning characteristics offered by the VR systems and environments available for treatment" (p.11)	(Porras et al., 2019)
		Knowledge of which RT suits the patient	"Matching VR tools with individual rehabilitation goals: to identify suitable VR systems/environments for the treatment of each individual." (p.11)	(Porras et al., 2019)
		<u>Practice evidence</u> Efficacy evidence shown in actual clinical practice	"…a high-level protocol for the incorporation of theory-driven VR-based rehabilitation should be designed. The protocol should follow the therapeutic validity requirements general to exercise interventions, and should be specific to VR.." (p.11)	(Porras et al., 2019)
	Patient and carer knowledge of how to operate the device	***Knowing how to operate the devices for carer/patient enhances sustained use***	"However, in most cases the carers would be the one to signal the need for follow-up or maintenance. In these situations carers could be a barrier or a facilitator; a barrier when they weren't competent to signal issues with the AP and its use, and a facilitator if they could…" (p.179)	(Boot et al., 2020)
		Training assist in developing competency in operating devices	"Carers and users did need to be trained to know how to use the AP correctly" (p.179)	(Boot et al., 2020)
Device design	Ease of learning	Device is understandable	"Moreover, studies of text messaging to improve medication adherence or exercise adherence have reported high patient satisfaction, with the vast majority of patients reporting that the short message service messages were useful and easy to understand." (p.7)	(Pandey et al., 2017)

Theme	Subtheme	Factors	Indicative Quotes	Reference
		Device which is easy to learn supports use	"In other words, the expectation of better patient outcomes and therapists' job performance over-comes the hurdles of learning to use new challenging technologies." (p.453)	(Liu et al., 2015)
	Ease of set-up and operation	Ease of set-up or use with intuitive user interface	"… many challenges related to the incorporation of VR technology as a routine therapeutic tool, mainly due to the relatively large number of degrees of freedom that the technology allows" (p.8)	(Porras et al., 2019)
		Easy to use devices may not optimising sustained use	"… therapists tend to be either neutral or disagree with the perception that new technologies are easy to use or not complicated to use (effort expectancy)…) (p.450)	(Liu et al., 2015)
	Features supporting patient engagement	Through monitoring device provides reminders and feedback	"The majority reported that these reminders were helpful in maintaining adherence to their therapies and did not find them to be overly intrusive." (p.7)	(Pandey et al., 2017)
	Supporting workload	Providing information that informs treatment planning	"Functional database results were used to guide program modification" (p.S155)	(Chua & Kuah, 2017)
		Reducing carer workload and effort	(for carer) "Time was an important factor for carers to provide AP support on a daily basis" (p.180)	(Boot et al., 2020)
Patients and therapists circumstances and characteristics	Demographic characteristics	***Technological literacy limited by cognitive impairment affects sustained use***	"Consideration of technological literacy and acceptance was particularly important when the mHealth solution involved older adults with cognitive impairment." (p.7)	(Matthew-Maich et al., 2016)
	Attitudes and beliefs	***An adoptive attitude affects sustained use***	"An adoptive team mindset accepts challenges and drives active workflow changes to increase efficacy and efficiency of working with the robot." (p.S155)	(Chua & Kuah, 2017)
		Past experiences shapes attitude towards use	"Negative experiences can generally create distrust and dissatisfaction among technology adopters, which can create further negative impact on consumption decisions." (p.20)	(Tuikka & Sachdeva, 2017)

Theme	Subtheme	Factors	Indicative Quotes	Reference
	Individual preferences	***Preferences affects sustained use***	"The user centered approach allowed researchers to obtain feedback from patients, caregivers, and HCPs who will be using the solution to address their specific needs and ideas, taking into account technology literacy and personal preferences." (p.7)	(Matthew-Maich et al., 2016)
	Perception of self and societal values	Perceived societal values	(for patients) "And mainstream AP helped to reduce stigma around AP and facilitated using AP: "P: the preference would always be for something like an iPad, because it's mainstream, people have it, it's cool, it doesn't look different". (INT_PRO_IRL_003)."" (p.179)	(Boot et al., 2020)
			(for therapist) "However, effort expectancy and social influence constructs were not important, i.e. therapists were not influenced by the degree of difficulty or social pressures to use technologies." (p.454)	(Liu et al., 2015)
	Patients support network	Attitudes of patient's social network	"While the interviews did not highlight any exclusive distrust or dissatisfaction, the interviewees were apprehensive of using new technology unless they had thoroughly reviewed it, or it had been strongly recommended by someone else." (p.20)	Tuikka & Sachdeva, 2017)
		Social support affects sustained use	"Use of AP was encouraged when the care system of the user was open to new AP. However, if carers or family were being reluctant to new AP, for example because of shame or fear, the use of AP was expected to be less." (p.179)	Boot et al., 2020)
		Collaborative therapeutic relationship impacts on sustained use	"common element – interaction – between the stakeholders….. Experiences from the adoption of AT were generally positive, as stated here: "*He trained with the speak therapist. He trained with us. He is now hundred times better with the device than me or his father.*"" (p.20)	(Tuikka & Sachdeva, 2017)
Person-centred approach	Device design which supports personalisation	A device ability to support personalisation affects sustained use	"If AP could not be customized to the individual needs, the use was not guaranteed." (p.179)	(Boot et al., 2020)

Theme	Subtheme	Factors	Indicative Quotes	Reference
		Personalisation features supports sustained use	"Regulating VR intensity/dosage: we recommend following the flow theory and balance task difficulty according to patients' motivation. Such VR properties as objective progression and external feedback are particularly useful for this aim." (p.12)	(Porras et al., 2019)
	Therapists attitudes and beliefs	***Therapist person-centred, empathetic attitude***	"Future proofing rehabilitation technology lies in the philosophies of innovation, which are borne out of empathy to improve training experiences for patients." (p.S155)	(Chua & Kuah, 2017)
	Therapist knowledge of how to adapt the device	Knowing how to personalise the devices to the patients facilitates sustained use	"Key aspects for a therapeutically valid rehabilitation approach are theoretically driven planning of training intensity, and a personalised treatment plan adapted for each individual." (p.11)	(Porras et al., 2019)
Wider systemic conditions	***Organisation operational support***	***Provision of additional time for set-up***	"Solution included an overall change of therapy duration times from usual 45 mins to 1 hr per session to accommodate this." (p.S155)	Chua & Kuah, 2017)
		Passionate leaders and team to drive usage	"Passionate teams are driven from internal forces. Such leadership forms the cornerstone for success *(of sustained use of RT)*." (p.S155)	(Chua & Kuah, 2017b)
		Workflow redesign to integrate RT	"Lokomat was situated near a gym plinth to allow patients to be examined in a supine position after RAGT to check for post- RAGT skin abrasions, a known minor adverse effect. Patients undergoing RAGT were assigned with individualized skin protection paddings and onsite storage systems to reduce consumable wastage from misplaced paddings when these were brought home." (p.S155)	Chua & Kuah, 2017)
		Emergency protocols/drills developed for adverse events during RT use	"For an effective transition to (and understanding of) implementing VR in a clinical routine manner, we advocate a fully detailed report on the clinical aspects occurring during (and between) sessions as well as adverse events such as falls" (p.13)	(Porras et al., 2019)
	Strategic direction and policies supports operation	***Addressing manpower shortfall***	"… training for RAT (robotic-assisted therapy) for all therapists and therapy aides to improve productivity, thus alleviating workload for therapists to assume supervisory or coverage roles where needed and where suitable patients could be minimally supervised during RAT." (p.S155)	Chua & Kuah, 2017)

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		Adopt a strategic business-focused plan	"The literature refers to the inertia and resistance to change that can exist within organizations, further highlighting the importance of a strategic business-focused plan for … implementing and maintaining the solution." (p.9)	(Matthew-Maich et al., 2016)
	Government and funding policies drive organisation priorities	***Government direction drives organisation adoption***	"Adoption of telehealth for community-dwelling older adults at a national level was reportedly triggered by demonstrated successes of a municipal project that simultaneously met the interests of major government stakeholders looking for fiscal efficiencies in health care delivery." (p.9)	(Matthew-Maich et al., 2016)
		Government funding cycles affects ongoing costs coverage of RT usage	"… the additional costs of privacy/ security testing, ongoing technology support/development, and software maintenance are a poor fit with government-supported funding cycles for research and development, where funds are typically delivered for a limited number of months or years." (p.12)	(Matthew-Maich et al., 2016)