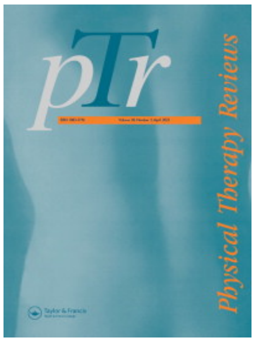

Physical Therapy Reviews

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/yptr20

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Connie Lombardo & Md Shahidul Islam

To cite this article: Connie Lombardo & Md Shahidul Islam (23 Oct 2023): Stroke survivors' acceptance and satisfaction of telerehabilitation delivery of physiotherapy services: a systematic review, Physical Therapy Reviews, DOI: 10.1080/10833196.2023.2271301

To link to this article: https://doi.org/10.1080/10833196.2023.2271301

Published online: 23 Oct 2023.

PHYSICAL THERAPY REVIEWS
https://doi.org/10.1080/10833196.2023.2271301

Stroke survivors' acceptance and satisfaction of telerehabilitation delivery of physiotherapy services: a systematic review

Connie Lombardo[a] and Md Shahidul Islam[b]

[a]Physiotherapy Department, Barwon Health, McKellar Centre, North Geelong, Victoria, Australia; [b]Senior Lecturer in Health, Course Coordinator, Health Management Programs, School of Health, University of New England, Armidale, New South Wales, Australia

ABSTRACT

Introduction: Telerehabilitation has been explored as a solution to several of the barriers to stroke rehabilitation access, and as a necessary alternative to in-person rehabilitation in response to the COVID-19 pandemic. This review aims to explore stroke survivors' acceptance and satisfaction of telerehabilitation delivery of physiotherapy services.
Methods: A systematic search using key terms relating to stroke and telerehabilitation was completed of the following electronic databases in July 2021: CINAHL complete (EBSCOhost), Embase (Ovid), Informit, ProQuest, PubMed, ScienceDirect, SCOPUS and SpringerLink. Studies of stroke survivors participating in physiotherapy *via* telerehabilitation were evaluated for acceptance, usability, and satisfaction outcomes. Duplicates were removed and inclusion criteria applied. Studies were included if they were published between 2010 and July 2021 with an intervention that included a technology element, a component of weightbearing/standing/lower limb exercises, and monitoring from a therapist throughout the intervention period. The included articles were then appraised and categorised into four subgroups.
Results: There were 980 studies initially identified, with eight studies involving 209 participants meeting the criteria for inclusion in this review. There was significant heterogeneity in the included studies across eligibility criteria, intervention parameters, telerehabilitation systems and outcome measures. Overall, stroke survivors had high levels of satisfaction and found physiotherapy delivered via telerehabilitation generally acceptable and easy to use.
Conclusions: Findings of this review indicate stroke survivors are accepting and satisfied with telerehabilitation as a delivery method for physiotherapy. Telerehabilitation in this population may be an effective and acceptable alternative to in-person rehabilitation and ameliorate access barriers associated with COVID-19 restrictions.

ARTICLE HISTORY
Received 23 September 2022
Accepted 13 September 2023

KEYWORDS
Telerehabilitation; stroke rehabilitation; physical therapy; patient acceptance of health care; health services accessibility

Introduction

Stroke is a leading cause of mortality and morbidity, with approximately nine million people having a stroke worldwide each year [1, 2]. Almost half a million Australians are living with the effects of stroke [1]. This number has been projected to almost double by 2050, with medical advancements over the past few decades resulting in significant improvements in the stroke survival rate [1]. Stroke is a neurological condition that can influence multiple domains of an individual's life, including impairments in body structures and functions, activity limitations, and participation restrictions [2, 3]. Stroke is the main cause of long-term disability in the adult population, with many survivors experiencing a broad range of issues that persist and impact upon their quality of life and independence [4, 5]. Stroke-related sequelae include mental impairments such as cognition, mood and communication, as well as physical impairments [6]. Motor system impairments are the most common deficits post stroke, affecting more than 80% of stroke survivors [7]. Motor system impairments can result in profound challenges for stroke survivors, impacting self-care, mobility, balance and dexterity [8]. The evidence suggests that high intensities of therapy is fundamental for successful rehabilitation and better outcomes in stroke survivors [7, 9].

Despite the literature demonstrating the effectiveness of stroke rehabilitation in reducing disability and burden of care, research suggests that many patients do not receive the recommended optimal therapy intensity post stroke [7]. There are several potential barriers to the achievement of this, including access to rehabilitation as a result of financial resources,

CONTACT Md Shahidul Islam mislam27@une.edu.au Senior Lecturer in Health, Course Coordinator, Health Management Programs, School of Health, University of New England, Armidale, New South Wales, 2351, Australia.

transport logistics, geographical location and compliance [7, 10]. Stroke survivors residing in rural and remote areas experience particular difficulty in accessing specialised rehabilitation services [11]. Access to stroke rehabilitation has been more problematic as a result of restrictions associated with the COVID-19 pandemic [12]. The coronavirus disease 2019 (COVID-19) was recognised as a global health pandemic in March 2020 [12]. In order to mitigate the pressure on health systems, many governments across the world enforced restrictions on mobility of the population in the form of lockdowns and social distancing measures [12]. Many in-person healthcare services were suspended, necessitating a novel approach to service delivery in the form of telehealth-delivered rehabilitation [13].

Telerehabilitation has been explored as an effective and feasible option to ameliorate several of the potential barriers to stroke survivors accessing rehabilitation services [1]. Telerehabilitation services have the potential to increase access to rehabilitation for stroke survivors unable to attend rehabilitation due to access issues such as transport and geographical location [7]. Telerehabilitation may augment traditional in-person rehabilitation services, and as a result, support greater intensity of therapy [6]. A recent systematic review suggested that telerehabilitation may be comparable to traditional stroke rehabilitation models of care across several outcomes including motor function and activities of daily living [14]. Generalisability of that review is limited by the heterogeneous interventions and outcome measures utilised in the trials [14]. Despite the promise of telerehabilitation eliminating access disparities and the potential to improve therapy intensity, adoption into clinical practice has been limited [11]. Knowledge gaps continue to exist regarding the factors affecting acceptance and adoption of telerehabilitation by stroke survivors [15].

Despite the theoretical benefits of telerehabilitation, there have been limited studies on patient acceptance and satisfaction of this service delivery method [16, 17]. Patient satisfaction is a key factor in the successful implementation of technology, and influences their intention to adopt telerehabilitation services [18]. The success of tele-services within healthcare is therefore highly dependent upon the ability to engage patients [19]. The literature strongly suggests exploring the factors influencing user acceptance and adoption of telerehabilitation [12].

This review aims to explore the factors influencing stroke survivors' acceptance and satisfaction of telerehabilitation delivery of physiotherapy services. The primary purpose of this project is to inform patient-centric telerehabilitation service design and implementation in the outpatient and community setting and consolidate telerehabilitation as an enduring rehabilitation option for stroke survivors. The findings of this review will be of benefit to healthcare providers, health services managers, adult stroke patients, their caregivers, family members and the wider community.

Material and methods

Search strategy

This systematic literature review was completed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidance 2020.

A systematic search was completed of the following electronic databases in July 2021: CINAHL complete (EBSCOhost), Embase (Ovid), Informit, ProQuest, PubMed, ScienceDirect, SCOPUS and SpringerLink. These databases were selected due to their focus on literature related to allied health, biomedical sciences, science and technology. The search strategy for this review utilised the Population, Intervention, Comparison, Outcome (PICO) format to relate search terms to the population and intervention of interest [20]. The key search terms used to source articles related to the research question were: (telerehab* OR tele-rehab* OR telehealth OR tele-services) AND (stroke). Limitations on database searches included having 'stroke' in the title, peer reviewed journals only, and articles published after 2010. One reviewer independently screened the titles and abstracts of the articles initially identified through these database searches to identify relevant studies and remove duplicates. Full text copies of relevant studies were retrieved and reviewed by one reviewer using predetermined eligibility criteria (Table 1). Manual searching of reference lists from included studies and relevant systematic reviews was also undertaken to identify potential additional sources. Eight articles met the eligibility criteria for this literature review. Figure 1 is a PRISMA flow diagram for the search strategy used in this review [21].

Eligibility criteria; population

Studies were included in this review if participants had a diagnosis of a stroke, were adults (18 years or over), and were living in the community at home. Studies were not excluded based on type of stroke (ischaemic or haemorrhagic), whether it was their first or a recurrent stroke, severity of stroke, or time elapsed since stroke. Studies were also not excluded based on whether the participant had a caregiver at home or not. Participants under the age of 18, without a stroke diagnosis, or currently residing in an

Table 1. Eligibility criteria for inclusion in review.

	Inclusion criteria	Exclusion criteria
Population	• Diagnoses of stroke (ischaemic or haemorrhagic) • First or recurrent stroke • $\geq$18 years • Any amount of time post stroke • Any level of disability • Lives at home • +/- caregiver at home	• Currently residing in acute hospital or inpatient rehabilitation or residential care facility
Intervention	• Completed remotely at home • Physiotherapy/exercise-based intervention that includes weightbearing/standing/lower limb exercises • Technology component • Supervision/monitoring/feedback from physiotherapist throughout intervention	• Completed remotely with health professional present • Aimed at upper limb/arm function only • Virtual reality or robotics only
Comparison	Any	Nil exclusion criteria
Outcome	• Reported patient acceptance, usability, or satisfaction related outcomes • Perceptions of patients	• Perceptions of health professionals only
Publication type	• Published primary research studies (quantitative or qualitative research designs) • Published in English language • Peer reviewed journal • Published from 2010 onward	• Systematic reviews • Literature reviews • Meta-analyses • Conference papers • Protocols • Letters • No full text available

acute hospital, inpatient rehabilitation or a residential facility were excluded from this review.

Intervention

The objective of this review was to explore the acceptance and satisfaction of stroke survivors of a home based telerehabilitation program, therefore, interventions were required to be delivered remotely into the participant's home. Interventions also needed to be physiotherapy and exercise-based, and include some weightbearing, standing or lower limb exercises. Interventions were also required to include a component of technology such as phone, video, videoconference, or phone applications by which physiotherapists were able to supervise, monitor and provide feedback to participants regularly throughout the intervention period. Interventions were not excluded based on a minimum or maximum intervention timeframe. Interventions delivered elsewhere, such as a healthcare facility or community centre were excluded. Interventions delivered in the home, but that involved the presence of a health professional were also excluded. Interventions that exclusively targeted other impairments such as arm function, speech or cognition were excluded, as were interventions that consisted solely of virtual reality or robotics. Those interventions that did not include technology-based supervision or monitoring by a physiotherapist were also excluded, as this was the purpose of the review.

Outcomes measures

Primary outcomes of the telerehabilitation intervention targeted in this review were: telerehabilitation acceptance, usability, satisfaction, and factors such as participant attendance and adherence. Validated, modified, and newly developed outcome measures were included. Outcome measures included, but were not limited to, the Technology Acceptance Model (TAM), System Usability Scale (SUS), Stroke Specific Patient Satisfaction with Care (SSPSC) and Physical Activity Enjoyment Scale (PACES). Studies that explored perceptions of a combination of stroke survivors, caregivers and health professionals were included if the stroke survivors' data was separated. Studies were excluded if they did not measure or report on one of the domains of interest in this review. Studies that explored solely the perceptions of health professionals or caregivers were also excluded.

Study selection

Studies included in this review were primary research studies (quantitative or qualitative), peer reviewed, and published in the English language between 2010 and July 2021. Unpublished papers, systematic reviews, literature reviews, meta-analyses, conference abstracts, research protocols and letters were excluded from this review, as were studies not published in the English language or without full text available. This review was also restricted to studies published from 2010 onward due to the significant advances and literature on this topic over the past decade. Eligibility criteria for inclusion in the review are summarised in Table 1.

Quality appraisal

A quality appraisal was conducted to evaluate the methodological quality of the included studies. The

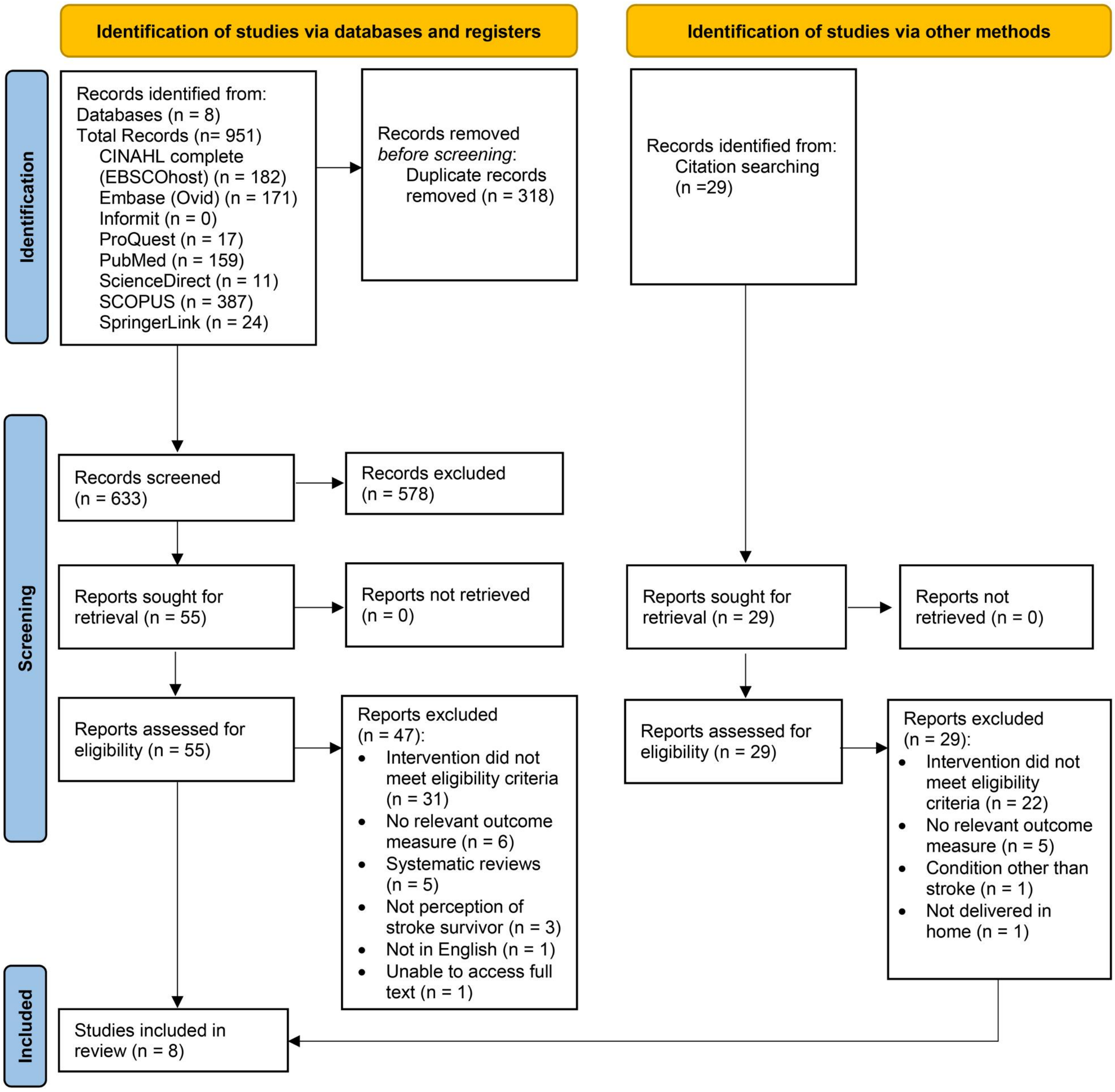

Figure 1. PRISMA flow diagram for search strategy [25].

Mixed Methods Appraisal Tool (MMAT) was utilised to assess quality of the articles included in this review. The MMAT is a common critical appraisal tool developed to assess a variety of categories of studies, including qualitative studies, quantitative studies (randomised and non-randomised), and mixed methods studies [22]. The MMAT includes two generic screening questions, in addition to five specific methodological criteria for each category of study [22]. Each criterion is rated as 'Yes' 'No' or 'Can't tell', and provides an overall evaluation of the methodological quality and risk of bias of the study [22]. Two reviewers independently applied the MMAT tool to each of the eight included studies. Notes were taken regarding justification for ratings. Any disparity between reviewer scores would be resolved by agreement between the reviewers.

Results

Search outcomes

A total of 980 records were identified. This included 951 records retrieved through electronic database searches and 29 records identified through citation searching. Out of the total records, 318 duplicates were removed. The titles and abstracts of the remaining records were then screened to assess eligibility ($n = 84$). Records were excluded if they did not meet eligibility criteria ($n = 76$). Finally, eight studies that met the inclusion criteria were included in the final synthesis (see Figure 1).

Quality of reviewed articles

There were no disagreements between ratings from the reviewers. One of the eight studies fulfilled all five quality criteria [15], with the remaining seven studies meeting four of five quality criteria [3, 16, 23–26]. One quantitative study (randomised controlled trial) did not fulfil the criterion regarding blinding [16]. Due to the nature of the intervention, blinding of participants and those collecting data was not possible in this study. Five of the remaining six quantitative (non-randomised) studies failed to account for potential confounders within their study design and analysis and therefore have an inherent risk of bias [3, 23–26]. The final quantitative (non-randomised) study did not meet the criteria for complete data, as not all outcomes were reported [27]. Table 2 presents the results from the quality appraisal of the studies included in this review.

Participant characteristics

The total number of participants across the eight studies was 209. Sample size varied from 10 [26], to 52 [16]. There was a broad age range of participants represented in the studies, with most studies including participants 18 years or older, one specifying a minimum of 21 years [15], and another a minimum of 45 years [16]. Two studies had a maximum age limit, one of 85 years [27], and one of 90 years [16]. Average time after stroke was also variable across the studies. Apart from two studies which stipulated stroke onset in the previous two years [16, 26], and one specifying a minimum of three months post stroke [24], nil other included studies placed restrictions on the time period post stroke. Given the nature of the interventions, there were also several exclusion criteria across the studies related to physical ability, communication, and cognition, such as the ability to walk independently, and ability to follow simple instructions [3, 15, 23–27]. Two studies also required the presence of a caregiver [15, 23]. Table 3 presents a summary of participant characteristics in the included studies.

Description of the intervention

The types of telerehabilitation systems and technologies varied considerably across the studies. Some studies incorporated simple telephone/voice calls [16, 25, 27], while others involved videoconferencing/video calls [15, 24], or a combination of the two [3, 24]. Pre-recorded videos of exercise sessions were delivered to participants' phones or emails in some studies [3, 23, 24]. More sophisticated technology in the form of an in-home messaging device (IHMD) [16], and novel sensor/biofeedback technology systems were also employed [15, 26, 27]. Technology such as remote vital signs monitoring of blood pressure, heart rate and electrocardiogram were also incorporated into some studies [23,24]. Direct supervision (*via* videoconference) of any or all exercise sessions by therapists was rare [23,24]. Most studies did not involve any direct supervision by therapists *via* videoconference, with participants remotely monitored instead through regular video calls [3, 15, 25], voice calls [16, 27], an IHMD [16], and *via* an application [26]. Table 3 presents an overview of the characteristics of the telerehabilitation systems and interventions employed in the included studies.

Parameters of the intervention

There was a significant amount of heterogeneity between the included studies with regards to intervention parameters (frequency, duration, and length). The duration of the intervention ranged from a minimum of four weeks [26], to a maximum of 22 weeks [3]. The most common duration was 12 weeks [9, 15, 16, 23, 25, 27]. The frequency of the telerehabilitation intervention also varied, ranging from daily [16, 26], to five times a week [15, 25], three times a week [27,28], two times a week [3], and once a week [23]. Interventions varied from a minimum of 10 min [24], to a maximum of 60 min [25]. Table 3 presents an overview of the parameters of the interventions of the included studies.

Outcome measures

The included studies employed a diverse range of outcome measures to evaluate the acceptance, experience, and satisfaction of stroke survivors with telerehabilitation. Technology acceptance and familiarity was assessed through the use of the Technology Acceptance Model (TAM) questionnaire [27], and *via* a technical familiarity questionnaire [24]. Telerehabilitation usability was evaluated with the technology usability questionnaire [24], the System Usability Scale (SUS) [26], and through interview questions that assessed how user-friendly the equipment was deemed by participants [26]. Participant satisfaction was another primary outcome appraised through a myriad of measures. Several studies utilised novel Likert scale type telehealth satisfaction questionnaires [23–25]. The Stroke Specific Patient Satisfaction with Care (SSPSC) scale and in-depth interviews were also employed to establish satisfaction with components of the telerehabilitation program [16]. The Physical Activity Enjoyment Scale [28], and perceived benefit of activity Likert scale were also utilised to evaluate participant satisfaction with the intervention [26]. Participant acceptance was also measured through questionnaires related to attendance, adherence,

Table 2. Quality appraisal of included studies using the Mixed methods appraisal Tool (MMAT) version 2018.[26].

Study	1. Qualitative				Methodological quality criteria		
	Screening question	Screening question	1.1	1.2	1.3	1.4	1.5
	Are there clear research questions?	Do the collected data allow to address the research questions?	Is the qualitative approach appropriate to answer the research question?	Are the qualitative data collection methods adequate to address the research question?	Are the findings adequately derived from	Is the interpretation of results sufficiently substantiated by data?	Is there coherence between qualitative data sources, collection, analysis and interpretation?
Tyagi et al. [15]	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	1. Quantitative randomised controlled trials						
	Screening question	Screening question	2.1	2.2	2.3	2.4	2.5
			Is randomization appropriately performed?	Are the groups comparable at baseline?	Are there complete outcome data?	Are outcome assessors blinded to the intervention provided?	Did the participants adhere to the assigned intervention?
Chumbler et al. [16]	Yes	Yes	Yes	Yes	Yes	No	Yes
	1. Quantitative non-randomised studies						
	Screening question	Screening question	3.1	3.2	3.3	3.4	3.5
			Are the participants representative of the target population?	Are measurements appropriate regarding both the outcome and intervention (or exposure)?	Are there complete outcome data?	Are the confounders accounted for in the design and analysis?	During the study period, is the intervention administered (or exposure occurred) as intended?
Bellomo et al. [27]	Yes	Yes	Yes	Yes	No	Yes	Yes
Bernocchi et al. [23]	Yes	Yes	Yes	Yes	Yes	No	Yes
Galloway et al. [24]	Yes	Yes	Yes	Yes	Yes	No	Yes
Sarfo et al. [25]	Yes	Yes	Yes	Yes	Yes	No	Yes
Simpson et al. [26]	Yes	Yes	Yes	Yes	Yes	No	Yes
Torriani-Pasin et al. [3]	Yes	Yes	Yes	Yes	Yes	No	Yes

Table 3. Methodological characteristics of reviewed studies.

Author (year) journal	Title/study design	Participant characteristics	Telerehabilitation system/technology	Intervention parameters and contents
Bellomo et al. [27] (2020) *Journal of Central Nervous System Disease*	The WeReha Project for an Innovative Home-Based Exercise Training in Chronic Stroke Patients: A Clinical Study.	25 chronic stroke patients from outpatient neurological service. Inclusion: • 18 to 85 years of age • First episode of ischaemic stroke • Able to walk indoors independently or with supervision Exclusion: • Previous strokes • Bilateral UL weakness • Modified Ashworth Scale (MAS) >2 • Aphasia/ communication difficulties • Mini Mental State Examination (MMSE) <24)	**Sensors/biofeedback technology** WeReha device: • Android tablet with dedicated software, inertial Bluetooth sensors, kit of elastic bands with Velcro pocket and assortment of smart objects. • Video guided exercise and visual/ voiced/ringing biofeedback. **Voice calls** with physiotherapist.	**Intervention duration/frequency/length** 12-week physiotherapy program.At least 3×15 min (minimum) sessions per week. **Contents of intervention** Balance exercises, upper and lower limb exercises in sitting or standing with specific motor tasks using WeReha device. Weekly phone review with physiotherapist. Informative training session held with patient and caregiver (30–60 min).
Bernocchi et al. [23] (2016) *Topics in Stroke Rehabilitation*	Home-based telesurveillance and rehabilitation after stroke: a real-life study. Single group pre-post pilot study.	26 post stroke patients: 15 subacute (time since stroke 112 ± 39 days), 11 chronic (time since stroke 470 ± 145 days). Inclusion: • >18 years of age • Ischaemic or haemorrhagic stroke • Functional UL deficit Exclusion: • Cognitive deficits and/or absence of caregiver	**Pre-recorded exercises on video** **Videoconferencing and/or voice calls** with physiotherapist. **Voice calls** with nurse-tutor.	**Intervention duration/frequency/length** 3-month physiotherapy program.Individual prescribed daily activities/time allocated. **Contents of intervention** Functional exercises including sit-to-stand, stairs, turning, ADLs. Physiotherapist supervised patient's program at least once per week through videoconference. Nurse tutor provided structured phone support and monitoring of disease status.
Chumbler et al. [16] (2015) *Journal of Telemedicine and Telecare*	A randomized controlled trial on Stroke telerehabilitation: The effects on falls self-efficacy and satisfaction with care. Randomised, multisite, single-blinded trial.	52 veterans /stroke survivors. Inclusion: • Ischaemic or haemorrhagic stroke in past two years	**Voice calls** with physiotherapist or occupational therapist. **In-Home Messaging Device (IHMD)**	**Intervention duration/frequency/length** 3 month home based exercise program. Randomised to STeleR ($n = 23$) or usual care. **Contents of intervention** Intervention group. STeleR home based training in exercises and adaptive strategies following standard stroke rehabilitation. 3 x home televisits, 5 telephone calls, daily in-home messaging device over 3 months to instruct patients in home exercises. Control group. Usual care: not contacted other than for initial recruitment and to obtain data. Could receive any services provided as part of usual care.

(*continued*)

Table 3. Continued.

Author (year) journal	Title/study design	Participant characteristics	Telerehabilitation system/technology	Intervention parameters and contents
Galloway et al. [24] (2019) *International Journal of Telerehabilitation*	The Feasibility of a Telehealth Exercise Program Aimed at Increasing Cardiorespiratory Fitness for People After Stroke. Single group pre-post clinical trial.	21 stroke survivors. Inclusion: • Ambulant • Mild-moderate impairments • >3months post stroke (On average many years post stroke)	**Videoconferencing** supervision of all exercise sessions by physiotherapist.	**Intervention duration/frequency/length** 8-week exercise program.3 days per week, 10–20 min sessions. **Contents of intervention** Participated in a home-based telehealth-supervised aerobic exercise program. individually prescribed, moderate-vigorous intensity including a variety of whole body, lower and upper body aerobic exercises. Home visit prior to commencement of intervention for risk assessment of the identified exercise space and to teach how to access video-conferencing software.
Sarfo et al. [25] (2018) *Journal of the Neurological Sciences*	Pilot trial of a tele-rehab intervention to improve outcomes after stroke in Ghana: A feasibility and user satisfaction study. Prospective, single-arm, pre-post pilot trial.	20 stroke survivors, average time post stroke 6 months. Inclusion: • Modified Rankin Scale (mRS) score of 1–4. Exclusion: • Serious medical comorbidities • Pre-existing neurological disorders • Severe uncontrolled psychiatric illness • Uncontrolled HT • History of alcoholism or drug abuse in last 6 months • Severe arthritis or orthopaedic problems limiting passive ROM • Unable to ambulate at least 50 m prior to stroke • Intermittent claudication while walking <200 m	**Pre-recorded exercises on video** **Mobile phone application** 9zest Stroke Rehabilitation App© delivered exercises. **Video calls** with physiotherapist.	**Intervention duration/frequency/length** 12 weeks individualised, goal targeted exercise program.5 days a week, 30–60 min videos. **Contents of intervention** 4 categories of program: (1) mobility, upper and lower limb strengthening, (2) dexterity to improve fine motor movements, (3) seated and standing balance exercise and (4) walking endurance. Monitored weekly by a tele-therapist *via* videoconference after data review.
Simpson et al. [26] (2020) *Topics in Stroke Rehabilitation*	Connecting patients and therapists remotely using technology is feasible and facilitates exercise adherence after stroke. Single group pre-post feasibility study.	10 stroke survivors. Inclusion: • Experienced a stroke in the past two years • > 18 years of age • Living in the community • Able to stand up from a chair independently (with or without arms) • Therapy goals related to STS exercise Exclusion: • Living in residential care • Unable to follow simple instructions • Not medically stable enough to exercise	**Sensors/biofeedback technology** Custom application (app) on a tablet connected *via* Bluetooth to a chair-based sensor. **Application** Allowed therapist to prescribe repetitions, update goals, send feedback messages.	**Intervention duration/frequency/length** 4 weeks, daily exercise intervention. Individual daily prescribed repetitions. **Contents of intervention** Functional sit-to-stand exercise. Therapist remotely monitored and provided weekly individual feedback regarding progress *via* the app.

(*continued*)

Table 3. Continued.

Author (year) journal	Title/study design	Participant characteristics	Telerehabilitation system/technology	Intervention parameters and contents
Torriani-Pasin et al. [3] (2021) *Frontiers in Psychology*	Adherence Rate, Barriers to Attend, Safety, and Overall Experience of a Remote Physical Exercise Program During the COVID-19 Pandemic for Individuals After Stroke. Longitudinal study.	36 stroke survivors. Inclusion: • Already attended a face-to-face physical exercise program for at least 6 months • Diagnosis of stroke (ischaemic or haemorrhagic) in chronic phase • >18 years of age • No orthopaedic, other neurological, and cardiac risk factors to exercise • MOCA >14 • Walking speed >0.4 m/s (home walker) Exclusion: • Cardiovascular or respiratory condition impairing performance training and/or health safety during exercise	**Pre-recorded exercise sessions on video** **Videoconferencing and/or voice calls** with a member of research team.	**Intervention duration/frequency/length** 22 weeks remote physical exercise program.2 days per week for 22 weeks, with a total of 44 sessions approximately 40 min duration. **Contents of intervention** Exercise protocol: to reduce physical inactivity, to increase physical function, such as aerobic capacity, muscle resistance, mobility, balance, and gait, and to improve balance confidence and cognition. Weekly voice or video calls to monitor and adapt exercises.
Tyagi et al. [15] (2018) *Archives of Physical Medicine and Rehabilitation*	Acceptance of Tele-Rehabilitation by Stroke Patients: Perceived Barriers and Facilitators. Qualitative study.	13 stroke survivors. Inclusion: • >21 years (mostly aged between 43 and 79) • Able to understand and follow instructions • Caregiver support • Completed the TR program. (Also included their caregivers and tele-therapists)	**Sensors/biofeedback technology** Exercises delivered *via* iPad-based system. TR system consists of (1) hardware-iPad, exercise bands, portable sensors, and BP monitoring machine, (2) software: data management system, (3) exercises and resistance bands. Follow exercises displayed on screen and get instant feedback. **Videoconferencing** with physiotherapist.	**Intervention duration/frequency/length** 12 weeks program.5 times per week. **Contents of intervention** Intervention group. STARS (Singapore Tele-technology Aided Rehabilitation in Stroke) trial: home based physical therapy telerehabilitation program-set of exercises for different levels of functional ability. Weekly facetime session with tele-therapist to provide feedback and modify exercise prescription.

perceived barriers and overall experience of the telerehabilitation program [3]. Participant interviews focused on perceived barriers and facilitators of telerehabilitation were also conducted [15] Table 4 provides a summary of the outcomes of patient acceptance, experience and satisfaction, as well as other miscellaneous outcomes for the included studies.

Summary of outcomes

Outcomes were categorised into four subgroups: technology acceptance, telerehabilitation usability, telerehabilitation satisfaction, and attendance/adherence factors. Table 4 provides a summary of the main findings.

Technology acceptance and familiarity

The Technology Acceptance Model (TAM) employed in the Bellomo et al. [27] study is one of the most commonly used outcomes for describing an individual's acceptance of technology [29]. The TAM has four subscales: perceived ease of use, perceived utility, attitude towards new technologies and attitude towards the use of new technologies [27]. Mean scores in each of these subscales indicated a positive acceptance of the technology by participants, particularly the value for ease of use [27]. In contrast, challenges with technology, predominantly issues with internet connectivity and reliability, were common in the other studies reviewed [15, 24, 25]. Over half (12/20) of the participants in the Sarfo et al. [25] study described internet connectivity and stability as a challenge, almost half of the participants encountered connectivity issues in the Tyagi et al. [15] study, and some participants made negative comments regarding internet speed and reliability in the Galloway et al. [24] study. Other barriers included perceived difficulties with equipment set up, adjustment and use [15]. The IHMD used in the Chumbler et al. [16] trial was reported by some participants to be confusing, repetitive, and not useful, with a small percentage of participants (9%) in the Galloway et al. [24] study disliking some aspect of the technology, in particular, the heart rate monitor.

Telerehabilitation usability

Usability refers to ease of use or convenience, and was specifically measured as an outcome in two of the included studies. The System Usability Scale (SUS) is a scale from 0–100, with a rating >70 indicating that the technology is acceptable [30]. Participants in the Simpson et al. [26] study perceived the telerehabilitation system as having good usability (79%). Similarly, 95% of participants favourably rated (agreed or strongly agreed) the usability of the telerehabilitation system in the Galloway et al. [24] study. Despite this, a small number (25%) of participants reported being unable to use the system independently [24]. Perceived and actual usability of the technology and telerehabilitation systems may be important in acceptance and adoption of this rehabilitation delivery method [24].

Telerehabilitation satisfaction

The most reported outcome of relevance in this review was participant satisfaction. The instruments utilised to measure satisfaction varied between the studies, and included satisfaction questionnaires or scales [16, 23–25], and in-depth interviews [15,16]. Despite the heterogeneity of the outcome measures, overall, participants were generally satisfied with telerehabilitation. Participants in the Galloway et al. [24] study had particularly favourable results, with 100% of participants reporting that they felt safe during their sessions and would use the telehealth program again. Most participants would recommend telerehabilitation to other stroke survivors, and more than half reported a preference for the home based intervention even if transport had been available [24]. Perceived benefits of the telerehabilitation program included improvements in motivation, confidence, computer skills and fitness, as well as convenience [24]. The majority of participants (81%) reported no negative comments regarding the intervention.

Similarly, all participants involved in the Bernocchi et al. [23] study reported satisfaction with the program (60% very satisfied, 40% satisfied). Access to the service was considered by most participants to have been helpful for the participant and their family [23]. All participants in the Sarfo et al. [25] study reported that they would use the telerehabilitation intervention again in the future, with 90% rating their satisfaction with the program as 'excellent' or 'very good'. The Stroke-Specific Patient Satisfaction with Care (SSPSC) scale [31] was utilised in one study [16]. Satisfaction scores increased in the home based care dimension for the intervention group and declined in the usual care group, however, there was no difference in satisfaction between the groups [16]. This was the only randomised controlled trial to compare telerehabilitation to usual care in this review.

The in-depth exit interviews conducted in the Chumbler et al. [16] study discovered that all participants found the home based intervention helpful. Almost all participants (22/23) were satisfied, and comfortable communicating with their therapists *via* videoconference. Facilitators identified in the Tyagi et al. [15] interviews included relative affordability

Table 4. Outcome measures and main findings of reviewed studies.

Author	Outcome measure	Main findings	Limitations
Bellomo et al. [27]	Relevant Technology Acceptance Model (TAM) questionnaire. Other • Berg Balance Scale (BBS) • Barthel Index (BI) • Fugl-Meyer scale (FM) • Modified Rankin scale (mRS)	Results 22/25 completed the study. *Technology acceptance* Technology Acceptance Model (TAM) questionnaire:Mean scores for subscales • TAM A (perceived ease of use): 42/49 • TAM B: (perceived utility): 35/42 • TAM C: (attitude toward new technologies): 23/35 • TAM D: (attitude towards the use of new technologies): 23/28 TAM A (ease of use) highest average value. TAM A and TAM C were also significantly related to the BI scores.	Lack of control group, therefore no comparison. No satisfaction outcome measure.
Bernocchi et al. [23]	Relevant Ad hoc 10 item satisfaction questionnaire focusing on: quality of overall program, acceptance of technology used, efficiency of nurse-tutor and physiotherapist. Other • Tinetti scale • BBS • Motricity Index • NHPT • 6MWT • Modified Barthel Index • Beck Depression Inventory (BDI) • Family Strain Questionnaire (FSQ-SF)	Results 23/26 completed the study. *Satisfaction outcomes* Questionnaire on satisfaction: • Overall patient evaluation of the service 100% satisfaction (60% very satisfied, 40% satisfied). • The relationship with nurse tutor was excellent for 67% and good for 33% of patients. • Access to the service was considered to have helped the patient and their family very much (27%), a lot (40%), and enough (27%).	Lack of control group, therefore no comparison. Not a formal standardised satisfaction outcome measure or reported results.
Chumbler et al. [16]	Relevant • Stroke-Specific Patient Satisfaction with Care (SSPSC) scale to measure the participant satisfaction. • Telephone exit interviews with participants (in-depth questionnaires) regarding satisfaction with components of study/program. Other • Falls Efficacy Scale (FES)	Results of 52 patients enrolled, 48 completed baseline assessments, 44 completed 3-month survey, and 40 completed 6-month survey. *Satisfaction outcomes* SSPSC:Total score increased from 9.3 to 11 in the intervention group and declined in the UC group, a difference approaching significance. Exit interviews: • 22 of 23 respondents in intervention group were satisfied with the in-home intervention-convenient, comfortable being videotaped and talking with their therapists *via* videoconference. • All 23 felt the exercise training was useful. • 17 of 23 indicated they applied what they learned from the exercise training daily. The IHMD was reported by some to be too repetitive, confusing, not useful.	Compared period of telerehabilitation following a period of usual care as opposed to telerehabilitation versus usual care comparison. Study sample predominantly males. Only intervention participants examined in qualitative study.
Galloway et al. [24]	Relevant • Participant satisfaction questionnaire regarding telehealth delivery, content of exercise sessions and	Results 21 participants completed this study. *Technology related outcomes*	Lack of control group, therefore no comparison. Sample included ambulant people with mild-moderate

(*continued*)

Table 4. Continued.

Author	Outcome measure	Main findings	Limitations
	participant's preferred dose at completion of trial. • Technical familiarity questionnaire. • Telehealth usability and satisfaction questionnaire.	Technical familiarity questionnaire: • Mean familiarity score was 66 (out of 100). • Internet issues occurred during 5% of all sessions. *Usability* Telehealth usability questionnaire: • Most participants agreed or strongly agreed that the TH system was easy to use (95%), and easy to use after the first few sessions (95%). • 75% participants agreed that they were able to use the system by themselves. Of the 6 participants who reported not being able to use the system by themselves, 4 scored <50 in the technical familiarity scale, and the remaining 2 had a higher level of physical impairment. *Satisfaction outcomes* • All participants would use telehealth supervised exercise again. • All participants agreed or strongly agreed that they felt safe during sessions. • Most (95%) would recommend telehealth exercise session to other people who have had a stroke. • Over half the participants preferred exercising at home even if transport has been available, and most disagreed that they would have preferred to do some of the sessions without telehealth supervision. Comments on what participants liked about telehealth: 38% of comments were related to perceived benefits including motivation to exercise, self-confidence, improved fitness, and computer skills. Convenience was also rated highly (20% of comments). Comments on what participants disliked: 81% reported there was nothing they didn't like. The remainder disliked some aspect of technology, particularly HR monitors or reported issues with internet speed and reliability.	impairments who were on average many years post stroke therefore may not be representative of all stroke survivors. 42 of 66 people who expressed an interest were declined or ineligible as per criteria. Telehealth delivery impacted on recruitment for the trial.
Sarfo et al. [25]	Relevant • Satisfaction assessed using a telehealth satisfaction instrument designed for the study: 12 items corresponding to aspects of the TR experience with 11 items using 5-point Likert rating scales, and one item using 'yes' or 'no' response. Other • Stroke Levity Scale (SLS) • mRS	Results All 20 subjects completed the survey on satisfaction with the telerehabilitation intervention. *Satisfaction outcomes* • High levels of patient satisfaction reported with telerehabilitation program. (60% reported 'excellent') satisfaction with the TH system, 30% reported 'very good', 5% reported 'good' and 5% 'fair' experience.	Lack of control group, therefore no comparison. General, structured survey that did not allow for discussion.

(*continued*)

Table 4. Continued.

Author	Outcome measure	Main findings	Limitations
	• BI • National Institute of Health Stroke Scale (NIHSS) • MOCA • Fatigue severity scale • VAS (pain) • Feasibility outcomes	• All subjects reported that would use the TR intervention in the future. • Internet connectivity and stability of streaming of audio-visuals was a major challenge reported by 12/20 (60%) subjects.	
Simpson et al. [26]	Relevant • 'System Usability Scale' completed at the final visit rating the usability of the technology across 10 items. • 'Physical Activity Enjoyment Scale' rated participant enjoyment across 18 items using a 7-point Likert-scale. • 'Perceived benefit of activity' was rated across 5 questions using a simple 5-point Likert scale. Other • Short Physical Performance Battery (SPPB) • Timed 2 min repeated STS test	Results *Usability* System Usability Scale:Participants rated the system usability (79%). *Satisfaction outcomes* Physical Activity Enjoyment Scale and perceived benefit of activity: • Participants rated enjoyment at 71% • Perceived benefit of activity score rated at 80%	Pre-post study design-lack of control group, therefore no comparison. Short intervention duration (4 weeks).
Torriani-Pasin et al. [3]	Relevant • Two questionnaires (*via* weekly telephone calls) to identify attendance, barriers, safety, and overall experience related to the program.	Results 40 participants completed this study *Attendance and adherence* • Adherence rate was 86.9%. • Average individual attendance rate was 19/48 sessions. • Mean participation rate was less than half of sessions. • 10 (25%) participants attended 80% or more sessions, 13 (32.5%) attended <20% of the sessions. The main barriers for attendance were largely health condition-related barriers: • Lack of motor skills and physical fitness (20.6%). • Health condition appointments (9.5%). • Difficulty performing exercise (8%). • Lack of time (7.7%). • Presence of pain (7.2%). Environmental related barriers: • No exercise companion (11.3%). • Problems with communication and lack of knowledge to use internet devices and tools (5.4%).	Convenience sample. Lack of control group, therefore no comparison.
Tyagi et al. [15]	Relevant • Semi-structured in-depth interviews and focus group discussions regarding barriers and facilitations of TR.	Results 13 stroke survivors participated in this study. *Technology acceptance and satisfaction outcomes* Facilitators identified: • Affordability (relative advantage for not so well off). • Accessibility (eliminating need to travel and flexible nature of program). Barriers identified: • Equipment setup-related difficulties (lack of clear instructions, inconvenience associated with frequent	Included only participants who had consented to and participated in the RCT. Purposive sampling for a diverse representation makes these results more transferrable to other settings.

(*continued*)

Table 4. Continued.

Author	Outcome measure	Main findings	Limitations
		adjustments/equipment setup routine). • Limited scope of exercises (exercises were repetitive). • Connectivity issues (almost half participants encountered). Preferred choice: Majority chose no clear option. Varied responses favouring TR and DR. Most patients preferring TR were relatively younger with mixed disability, participants choosing DR were older and generally had a severe disability.	

and accessibility of the telerehabilitation program. In contrast, some participants identified limited and repetitive exercises as a potential barrier for acceptance. Patient characteristics such as age, disability, and cultural context were found to influence patient perceived facilitators, barriers and overall preferred rehabilitation option [15]. Many participants reported no clear preference for telerehabilitation versus conventional in-person rehabilitation [15].

Adherence, attendance and barriers to participation

Torriani-Pasin et al. [3] evaluated the overall experience of participants completing a remote physical exercise program. This study reported a high adherence rate, with the majority of participants agreeing to take part in the program, but a mean attendance rate of less than half of all exercise sessions delivered [3]. One quarter of participants attended 80% or more sessions, with 32.5% attending less than 20% of sessions [3]. Questionnaires were conducted to explore potential barriers to attendance. The barriers highlighted in the remote exercise program were categorised into health related barriers, environmental related barriers, and pandemic related barriers [3]. Lack of motor skills and physical fitness was the biggest health related barrier reported by participants (20.6%), followed by competing appointments (9.5%), difficulty performing the exercises due to physical limitation (8%), lack of time (7.7%), and pain (7.2%). The main environmental related barrier reported was the absence of an exercise companion (11.3%), followed by communication challenges or lack of knowledge regarding technology use (5.4%). Pandemic related barriers to attendance included employment or travel commitments (4.4% and 3% respectively), or caregiver related factors (4.1%) [3].

Discussion

This review identified and evaluated a small number of published primary research studies involving physiotherapy interventions delivered remotely to stroke survivors *via* telerehabilitation systems. Overall, participants reported good acceptance, usability, and satisfaction of telerehabilitation. This is consistent with previous findings in other populations that suggest telerehabilitation is acceptable, including in older rehabilitation patients [32], chronic pain [33], total knee arthroplasty [34], and shoulder joint replacement patients [35].

The telerehabilitation technology was generally considered acceptable and easy to use. Despite this, technology related barriers were experienced by some participants, with a small number reporting that they would not be able to use the technology without assistance from a caregiver. These findings are consistent with a scoping review that reported technology related issues precluded some stroke survivors from being eligible to enrol or participate in some studies [13]. These findings are also in line with another systematic review that identified information and communication technologies and the internet as potential obstacles to participant acceptance of telerehabilitation [12]. Further to this, a systematic review on telerehabilitation based physiotherapy reported technological barriers in most of the studies [17]. These are important additional insights given technology acceptance is considered a strong facilitator for patient engagement with telehealth services [36].

Stroke survivors reported high levels of satisfaction with telerehabilitation across a range of outcome measures. Participants were satisfied with telerehabilitation, regardless of the characteristics and parameters of the interventions, such as duration of the program and technology used. Most participants agreed they would use telerehabilitation again in the future and would recommend it to other stroke survivors. These results are consistent with the findings of the Ramage et al. [13] scoping review that also reported high participant satisfaction levels in stroke survivors. Positive factors contributing to participant satisfaction such as improved access and flexibility of therapy were also in keeping with those reported by chronic pain patients [33].

Other measures of participant experience and engagement with telerehabilitation were explored in this review, such as adherence and attendance rates. Barriers to adherence and attendance identified by participants included factors such as physical and communication capabilities, and poor technology literacy. Similar patient factors were also considered potential barriers to telehealth engagement in another study [36]. Many of the studies included in this review also specified inclusion criteria such as minimum physical and cognitive function, which may have excluded some stroke survivors from being eligible to enrol.

Strengths and limitations

One limitation of this review was the small number of studies and relatively small sample sizes available in the literature. The literature search was completed in July 2021. There is a possibility that a more recent search may have yielded additional results. Quality appraisal also highlighted the pre-post design of several of the included studies as having an inherent risk of bias within their study design and analysis. Considerable heterogeneity also existed in the methodologies of the included studies, such as intervention type, intervention parameters, and outcome measures used. The exclusion of studies targeting arm function without an element of weightbearing, standing or lower limb exercise may also present a possible limitation to this review. As a result, specific recommendations regarding the optimal intervention for maximum acceptance and satisfaction of telerehabilitation cannot be made.

Participant characteristics also varied considerably between the studies with regards to age, type and severity of stroke, and chronicity of stroke. Eligibility criteria in five of the studies in this review excluded participants based on physical or cognitive capacity. Careful consideration should be given to the applicability of telerehabilitation service delivery in stroke survivors with more severe physical and cognitive impairments. The generalisability of the results of this review may be restricted because of these limitations.

Only one randomised controlled trial was included in this review comparing telerehabilitation to usual care. As a result, generalising findings regarding the acceptance and satisfaction of telerehabilitation compared to conventional in-person rehabilitation in this population should still be approached with caution. However, given the COVID-19 pandemic and inability for some stroke survivors to access in-person rehabilitation, the findings of this review are still valuable.

Further research

Significant methodological variability of the eight studies contributing to this review has highlighted the need for further research. Methodologically sound RCTs using standardised intervention parameters are recommended to evaluate telerehabilitation acceptance and satisfaction compared with conventional in-person rehabilitation in this population. Future research involving a telerehabilitation system and program that utilises readily accessible technology that is likely to be applicable to a broader range of stroke survivors is warranted.

Further research into specific subsets of stroke survivors, such as chronicity and severity would also be beneficial. Exploring acceptance and satisfaction in more defined samples may help to determine the patients most appropriate for telerehabilitation service delivery. The use of standardised, valid, and reliable outcome measures will also enable comparison across studies to obtain a stronger evidence base.

The findings of this review indicate that stroke survivors are generally accepting and satisfied with telerehabilitation as a delivery method for physiotherapy. With patient satisfaction believed to be a key influence in the adoption of telerehabilitation, these findings are encouraging for healthcare providers such as physiotherapists. Telerehabilitation in this population may be an effective and acceptable alternative to in-person rehabilitation and provide a timely solution to current therapy access barriers associated with COVID-19 restrictions.

Authors' contributions

Both authors contributed to the creation of the manuscript. CL designed and conceptualized the review, and wrote the draft manuscript. MSI was involved in designing and implementing the project as a supervisor, and read and approved the final manuscript.

Ethics approval

Ethics approval was not required for a review of the available literature.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

ORCID

Md Shahidul Islam http://orcid.org/0000-0001-8984-8689

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