

# Factors Influencing Perception of, and Participation in, Pulmonary Telerehabilitation – A Scoping Review of the Literature

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## ABSTRACT

Pulmonary rehabilitation (PR) is a high-value intervention for people living with a chronic respiratory disease. Uptake and completion of PR remains low, and telerehabilitation provides an alternative model for remotely delivering PR, which may improve the reach of this intervention. While telerehabilitation is safe and likely equivalent to centre-based PR, little is known about the barriers to participation in telerehabilitation to date. This scoping review aims to better understand the factors influencing perception of and participation in telerehabilitation for people living with a chronic respiratory disease. Scopus, MEDLINE, and CINAHL were searched between July 27 to November 23, 2022. Articles were screened, and those fulfilling inclusion criteria were extracted to a standard template. Extracted data were analysed using narrative synthesis. Twenty-seven studies met the inclusion criteria. People living with a chronic respiratory disease perceive telerehabilitation to be convenient and flexible, but technically challenging and lacking in contact with clinicians and peer support. The experiences from a small number of people who have participated in these programmes counter this with praise for the therapeutic relationship they developed with their clinician and the social support they received.

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## INTRODUCTION

Pulmonary rehabilitation (PR) is a highly effective intervention in the management of chronic respiratory disorders (CRD). Despite the overwhelming evidence to support its effectiveness (McCarthy et al., 2015), uptake and completion of PR worldwide is low, with 8–50% of those referred never attending. Of those who do start PR, 10–32% do not complete the intervention (Keating et al., 2011). Barriers to attendance and completion have been widely investigated and include transport and travel (Fan et al., 2008), socioeconomic (Johnston & Williams, 2017), marital and social status (Young et al., 1999), and ethnicity (Candy et al., 2020; Spitzer et al., 2020). PR delivered remotely through technology has been proposed to improve access to care and may reduce the burden of attending centre-based programmes.

There are many different models for delivering pulmonary telerehabilitation, including telephone, videoconferencing (VC), and mobile/web-based applications (Bourne et al., 2017; Chaplin et al., 2017; Cox et al., 2018; Hansen et al., 2020; Holland et al., 2017; Tsai et al., 2017), some of which are synchronous (real time) and some asynchronous. A growing body of evidence evaluates some of these different models, including a recent Cochrane review by Cox et al. (2021), concluding that these telerehabilitation interventions are likely to be as safe and effective as traditional centre-based PR.

However, the small number of studies, low sample sizes, and methodological heterogeneity make this a cautious conclusion (Cox et al., 2021). While telerehabilitation interventions have shown promising results, this form of PR has yet to be widely implemented in clinical practice in New Zealand (Candy et al., 2022). Studies involving telerehabilitation have reported challenges in recruiting participants as high numbers decline due, reportedly, to an intervention preference for in-person PR (Holland et al., 2017). There is a lack of information regarding which, if any, patients prefer telerehabilitation and different delivery modes.

Prior to this scoping review, we conducted a preliminary search of MEDLINE and the Cochrane Database of Systematic Reviews to determine the extent of the evidence regarding factors influencing participation in telerehabilitation, and no current systematic reviews or scoping reviews were identified. A scoping review was deemed necessary since telerehabilitation is an emerging field in PR. A range of information sources were required to provide information on the barriers to uptake, the perception of, and participation in remotely delivered PR. Scoping reviews allow consideration of a range of research evidence, including qualitative and non-clinical trial data, and allow summation of all existing data. This scoping review aimed to explore the factors impacting participation in PR telerehabilitation.

## Review questions

The scoping review addressed three questions from available literature:

1. What factors influenced the uptake of PR delivered via telerehabilitation?
2. What were patient perceptions towards telerehabilitation?
3. What were the patient's experiences of participating in telerehabilitation?

## METHODS

The scoping review followed the steps detailed in the Joanna Briggs Institute manual for conducting scoping reviews (Tricco et al., 2018). A protocol was developed prior to undertaking the review. An experienced librarian gave guidance on the search strategy.

### Eligibility criteria

Due to the contemporary nature of telerehabilitation interventions, studies published from January 1, 2011 were included. Only studies published in English were included.

### Participants

We included studies of adults (> 18 years of age) living with a CRD who are eligible for referral to PR (according to Australian and New Zealand PR Guidelines (Alison et al., 2017)) including chronic obstructive pulmonary disease (COPD), interstitial lung disease, asthma, bronchiectasis, and pre- and post-lung surgery.

### Concept

Studies involving PR (as defined by the American Thoracic Society/European Respiratory Society (Spruit et al., 2013)), remotely delivered in the home via technology (telerehabilitation) were included. The technology included, but was not limited to, telephone, VC, and web-based interventions.

### Context

Because we were interested in factors impacting willingness to participate in home-based telerehabilitation, we included studies that gathered end-users participation perceptions and actual experiences of participating.

### Types of sources

We sought quantitative, qualitative studies and mixed method designs. The search strategy aimed to locate published material including non-peer reviewed sources such as editorials and conference proceedings.

### Search strategy

An initial search of MEDLINE was undertaken to identify potential keywords for the full search strategy. The keywords contained in the titles and abstracts of potentially relevant studies were used to develop a full search strategy for Scopus, MEDLINE, and CINAHL. The search strategy was adapted for each included database (see Appendix A, Table A1). The reference list of all included sources of evidence was screened for any additional studies not identified by the initial search.

### Screening, data extraction, and synthesis

All identified citations were uploaded into EndNote 20.4 and duplicates removed. Titles (and abstracts where available) were screened for assessment against the inclusion criteria by the

primary author. After title and abstract screening, all relevant sources were retrieved in full, and their citation details imported into an Excel file. The full text of selected citations were assessed by the primary author (SC) to determine if they met the inclusion criteria.

Data were extracted from the included papers using a standard data extraction tool (Pollock et al., 2023), including author, date, country, study design, participant characteristics, PR concept, and outcomes of interest. Data were analysed in alignment with the research questions:

1. Factors influencing uptake of telerehabilitation in studies.
2. The patient perception of telerehabilitation (including willingness to participate).
3. The patient experience of participating in telerehabilitation.

Quantitative and qualitative data syntheses were undertaken. The quantitative data included counts of studies reporting uptake of remote PR. The number of participants declining participation was converted to rates and percentages, and, where possible, counts of reasons for declining across the studies were collated. Qualitative data reporting included descriptions of studies and delivery methods used. Themes relating to barriers and enablers derived from the qualitative studies have been reported through narrative synthesis (Lisy & Porritt, 2016). Data were first analysed by organising the studies based on the research question they addressed. Data were extracted by reading and collating the stated themes and subthemes, along with recording descriptions of themes with supporting quotes. The studies were then re-read to identify any other concepts or potential themes that may arise across the studies. The primary author grouped similar themes and then discussed and refined these with JR and DT until a consensus on final themes was reached. Final themes were grouped and reported as barriers and enablers to participation.

## RESULTS

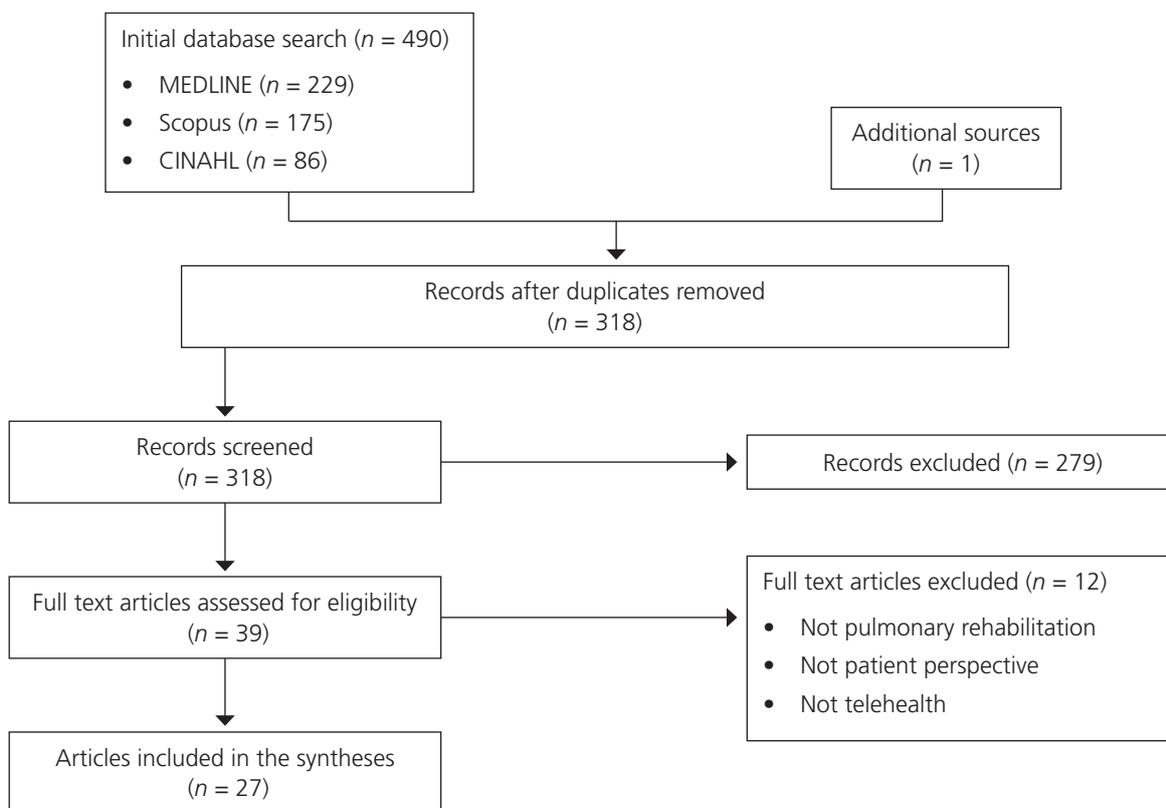
The initial search yielded a total of 490 potentially relevant papers. When duplicates were removed and titles/abstracts screened, 39 full papers were retrieved, of which 27 were included in the final analysis. Figure 1 details the flow of included and excluded studies.

### Included studies

The review included 27 studies involving 2094 participants with sample sizes ranging from 10 to 254. The mean age of participants in the studies ranged from 54 to 73 years, and 48% of the participants across all the studies were female. Studies included people living with COPD ( $n = 19$ ) or CRD ( $n = 7$ ), and one study did not specify. Three different methods of remotely delivered home-based telerehabilitation were detailed in the studies: telephone support ( $n = 2$ ), supervised group exercise and education using video conferencing facilities ( $n = 11$ ), and web-based programmes ( $n = 11$ ). A combination of differing modes of technology were described in two studies, and a further study did not describe the method of delivering telerehabilitation. The design of included studies were eight randomised control trials (RCT), seven non-randomised trials, four survey designs, and eight mixed methods studies (survey

**Figure 1**

*Flow Diagram of Studies Included in Scoping Review*



and interviews). The characteristics of the included studies can be seen in Appendix B, Table B1.

### **Uptake of telerehabilitation**

Data on the uptake rate of telerehabilitation was extracted from both RCTs and non-randomised clinical trials but pooled separately. The reasons why participants did not participate are not clearly defined in all studies, and studies used different methodologies for recruitment, making direct comparison difficult.

### **Randomised control trials**

A total of 3289 participants from eight RCTs were screened for inclusion in the RCTs, of which 2399 (73%) were either deemed ineligible or declined uptake (Appendix B, Table B2). In the seven studies that documented the number of patients who declined, six studies documented the reasons for declining. Five studies reported excluding between 4% and 26% of the participants screened due to patients' stated preference for centre-based rehabilitation and declining participation (Chaplin et al., 2017; Cox et al., 2018; Hansen et al., 2020; Holland et al., 2017; Tsai et al., 2017). Other reported reasons for declining telerehabilitation included lack of digital competence, not having a suitable home environment, or the perceived time commitment.

### **Non-randomised studies**

Six observational studies were identified offering telerehabilitation to participants under different circumstances:

1. During the COVID pandemic when centre-based PR were closed (Grosbois et al., 2021; Lewis et al., 2021).
2. To bridge the gap to centre-based PR for patients with an acute exacerbation of COPD (Houchen-Wolloff et al., 2021).
3. While on PR waiting lists (Marquis et al., 2015; Simonjy et al., 2019).

Across the included non-randomised studies, between 12 and 95% of the patients screened declined participation (Appendix B, Table B3).

### **Intention to participate in telerehabilitation**

The intent or willingness of people living with a CRD to participate in telerehabilitation was explored in four studies (Almojaibel et al., 2020; Polgar et al., 2022; Seidman et al., 2017; Skibdal et al., 2022). Three studies surveyed current centre-based PR participants (Almojaibel et al., 2020; Polgar et al., 2022; Seidman et al., 2017) and one study surveyed participants after declining centre-based PR (Skibdal et al., 2022). Studies found those who wished to engage with telerehabilitation, perceived telerehabilitation would result in clinical benefits (Almojaibel, 2016; Almojaibel et al., 2021), had a higher education level (Seidman et al., 2017), and had greater familiarity with, and access to, digital devices (Seidman et al., 2017; Skibdal et al., 2022). The observation studies used different definitions of the telerehabilitation intervention to participants, which may have impacted the patient perception,

with one describing VC and the other via telephone, text messaging, or VC.

### **Participant preference**

Two studies reported on the patient preference for how PR is delivered. Nolan et al. (2019) reported only 10% of participants opted for home-based PR when given the option of centre-based PR or home-based PR with weekly telephone calls. Chaplin et al. (2017) conducted a RCT comparing centre-based with web-based PR, but surveyed consented participants on their preference for centre-based or web-based PR prior to group randomisation; 38% stated a preference for the web-based PR intervention.

### **The patient perception of telerehabilitation**

Data regarding patients' perception of telerehabilitation was gathered from people who had a range of prior experience and knowledge of centre-based PR; some had or were attending centre-based PR (Bairapareddy et al., 2021; Dobson et al., 2019; Inskip et al., 2018; Seidman et al., 2017), had been referred to PR (Polgar et al., 2022) or had declined PR (Dobson et al., 2019; Inskip et al., 2018; Skibdal et al., 2022). One study did not state participant's prior participation in centre-based PR (Alwashmi et al., 2020). None of the participants in any of the studies had prior experience with telerehabilitation.

Data were collated from five studies employing surveys, patient interviews, and focus groups. Participants in all the studies perceived telerehabilitation to be more convenient than centre-based PR with reduced time, travel, and financial burden. Synthesis of these studies identified several factors that appear to play a role in influencing the patient perception of telerehabilitation. These factors have been described as barriers and enablers and are discussed below and summarised in Table 1.

### **Perceived barriers to participation in telerehabilitation**

#### **Technical competence**

Technical competence was reported by all studies as a perceived barrier to telerehabilitation with up to 39% of participants reporting they believed they would not have the necessary technical skills to partake in telerehabilitation (Alwashmi et al., 2020; Bairapareddy et al., 2021; Dobson et al., 2019; Inskip et al., 2018; Polgar et al., 2022). Age and education level were shown to be associated with technical confidence (Seidman et al., 2017; Skibdal et al., 2022).

#### **Device and data access**

An inability to access the required digital device and/or limited data access was reported as a perceived barrier to telerehabilitation (Alwashmi et al., 2020; Bairapareddy et al., 2021; Dobson et al., 2019; Polgar et al., 2022; Seidman et al., 2017). Four studies explored device access and found that the most ubiquitous device was a mobile phone, with ownership rates between 73% and 88% of the cohorts sampled (Almojaibel, 2016; Almojaibel et al., 2021; Alwashmi et al., 2020; Dobson et al., 2019; Seidman et al., 2017). However, the same studies showed smartphone ownership rates were 23–66%, with many participants reporting limited ability to use many of the functions the device provided. Two studies explored predictors of access to a device, and both found that smartphone ownership (like technical competence) was

directly related to education level defined as beyond high school (Alwashmi et al., 2020; Seidman et al., 2017). In an implementation study conducted during the COVID-19 pandemic, 75% of the participants who transitioned to remotely delivered PR could not participate in VC classes due to lack of device access, and could only receive telephone support (Grosbois et al., 2021).

#### **Supervision and contact with a healthcare professional**

Direct contact with a clinician was discussed in seven reviewed studies (Alwashmi et al., 2020; Bairapareddy et al., 2021; Dobson et al., 2019; Inskip et al., 2018; Polgar et al., 2022; Seidman et al., 2017; Skibdal et al., 2022). A dominant theme in three studies was participants reporting a lack of supervision or contact with a clinician as a potential downside of telerehabilitation (Dobson et al., 2019; Seidman et al., 2017; Skibdal et al., 2022). Survey participants reported that while telerehabilitation might offer a more convenient way of communicating with their clinician, they thought the clinician may lack a good understanding of their health condition (Bairapareddy et al., 2021) or would prefer "in-person" contact with a physiotherapist (Seidman et al., 2017).

#### **Peer support**

Studies found that peer support and social connections were considered important components of centre-based PR, with the potential lack of peer support perceived a drawback to participation in telerehabilitation for many participants (Dobson et al., 2019; Inskip et al., 2018; Seidman et al., 2017; Skibdal et al., 2022). Pulmonary telerehabilitation delivered through group-based VC sessions may minimise the absence of peer support by allowing for sharing experiences of living with COPD (Skibdal et al., 2022).

#### **Other barriers**

The length of time a participant has lived with their CRD and the degree of symptom burden were identified as perceived barriers to participation (Almojaibel, 2016; Almojaibel et al., 2021; Skibdal et al., 2022). These studies suggested that the greater the duration and severity of the disease, the greater the perception of no benefit from telerehabilitation PR.

Language was reported as a potential barrier to participation in telerehabilitation, with the option of the intervention being delivered in other languages required in order to partake (Bairapareddy et al., 2021; Dobson et al., 2019; Houchen-Wolloff et al., 2021). In addition to these barriers, participants also reported caution around the security and privacy of data transmitted through technology potentially impacting their participation (Alwashmi et al., 2020; Bairapareddy et al., 2021; Dobson et al., 2019).

#### **Perceived enablers to participation in telerehabilitation**

Factors that were perceived to positively influence uptake of telerehabilitation were less commonly reported in the literature; however, understanding the benefits gained and the perceived usefulness of remote PR was shown to impact willingness to participate (Almojaibel et al., 2021; Alwashmi et al., 2020; Skibdal et al., 2022). Components participants wished to see included in telerehabilitation programmes were regular communication with a clinician (Bairapareddy et al., 2021;

**Table 1**  
Barriers and Enablers to Uptake of Telerehabilitation in Studies

Barriers and enablers		Author (date)											
		Almojaibel et al. (2021)	Alwashmi et al. (2020)	Bairapareddy et al. (2021)	Dobson et al. (2019)	Inskip et al. (2018)	Polgar et al. (2022)	Seidman et al. (2017)	Skibdal et al. (2022)	Chaplin et al. (2017)	Houchen-Wolloff et al. (2021)	Simoný et al. (2019)	Lewis et al. (2021)
Barriers	Technical competence of participant	●	●	●	●	●	●	●	●	●	●	●	●
	Reduced interaction with healthcare professional		●	●	●	●	●	●	●				
	Lack of peer support/social interaction				●	●		●	●			●	
	Personal preference of participant		●		●		●		●	●	●		●
	Cultural/language			●	●						●		
	Access to a device and data		●	●	●			●					
	Privacy/security of health information		●	●	●								
	Lack of monitoring available (heart rate, SpO2)			●		●							
	Participant education level							●					
	Duration of CRD	●											
	Space/environment/equipment									●			
	Impact of co-morbidities									●	●		
	Enablers	Perceived usefulness	●	●						●			
Ease of use			●		●								
Availability of technical support			●										
Less burden compared with centre-based				●	●			●	●				
Flexible/timing					●			●	●				
Family involvement					●								
Cultural considerations		●											
Feeling safe in own environment									●				
Receiving feedback and monitoring					●	●							

Note. CRD = chronic respiratory disease; SpO2 = peripheral oxygen saturations.

● = enabler; ● = barrier.

Skibdal et al., 2022), and monitoring and feedback on their rehabilitation performance (Dobson et al., 2019; Inskip et al., 2018).

### **Experiences of participation in telerehabilitation**

Eight studies explored the patient experience of participating in telerehabilitation. Data were collected through interviews (Benzo et al., 2021; Burkow et al., 2018a; Houchen-Wolloff et al., 2021; Lahham et al., 2018a; Tsai et al., 2016; Whittaker et al., 2021), focus group (Hoaas et al., 2016), and questionnaires (Benzo et al., 2021; Hoaas et al., 2016; Tsai et al., 2016). The models of delivery of PR used were telephone calls (Lahham et al., 2018b), VC (Benzo et al., 2021; Burkow et al., 2015; Hoaas et al., 2016; Simoný et al., 2019; Tsai et al., 2016), and web-based models (Houchen-Wolloff et al., 2021; Whittaker et al., 2021). The web-based models allowed participants to complete PR independently at a time convenient to them, and allowed patient-initiated interactions with clinicians, with one of the programmes offering individual VC consultations with a clinician (Houchen-Wolloff et al., 2021). Across eight studies, 178 participants reported their experiences of participating in telerehabilitation, with study sample sizes ranging from 10 to 78 participants. The mean ages of participants ranged from 55 to 69 years and 52% of participants across the studies were female. Some participants had previously attended centre-based PR and others had never attended centre-based PR. Two studies included participants who started but did not complete telerehabilitation. In nearly all the studies ( $n = 7/8$ ) exploring participation in telerehabilitation, the technical equipment was provided for participants, with the remaining study requiring participants to use their own device (Whittaker et al., 2021). See Appendix B, Table B4 for characteristics of studies included.

Telerehabilitation participants across all studies reported health benefits from the intervention and high levels of acceptability and usability when taking part in telerehabilitation. The key themes emerging from the studies reporting participants' experiences of being involved in telerehabilitation have been grouped as enablers and barriers.

### **Enablers**

#### **Communication with HCP**

Five of the eight studies reported positive experiences with the communication and support they experienced from the attending clinician while using telerehabilitation (Benzo et al., 2021; Burkow et al., 2018b; Hoaas et al., 2016; Lahham et al., 2018a; Tsai et al., 2016). This positive feedback was reported predominantly in programmes that included individual phone or VC consultations (Burkow et al., 2018b; Hoaas et al., 2016; Lahham et al., 2018a) but also for one of the group VC programmes (Tsai et al., 2016). Clinician contact was reported to be associated with improved participation (Lahham et al., 2018a) and increased health benefits (Tsai et al., 2016). The regular clinician contacts reportedly facilitated safe completion of the programme (Hoaas et al., 2016). Two studies providing optional clinician consultations reported low rates of uptake of the consult (Bourne et al., 2017; Chaplin et al., 2017), which prompted the recommendation that these consultations should be scheduled and structured, rather than optional and patient led (Simoný et al., 2019).

### **Feeling supported**

A theme of patients feeling supported with their health condition during telerehabilitation was reported in many of the studies. Participants reported support came from clinicians (Benzo et al., 2021), family and friends (Lahham et al., 2018a; Whittaker et al., 2021), and other participants in VC-based programmes (Burkow et al., 2015). Group-based education sessions enabled sharing of ideas and challenges between participants (Burkow et al., 2015). One web-based study allowed family members to register for the programme along with the person living with a respiratory condition, resulting in important benefits for both the family and participant (Whittaker et al., 2021). The study undertaken by Whittaker et al. (2021) also used personalised and tailored text messaging to inform, encourage, and support participants, and this messaging was perceived as being supportive by participants.

### **Flexibility**

A frequently reported key enabler of participation in telerehabilitation was the flexibility it provided. It allowed those with daytime commitments, such as paid employment, to participate (Hoaas et al., 2016; Lahham et al., 2018a; Tsai et al., 2016; Whittaker et al., 2021). This flexibility in training time was an important component in allowing commitment to the exercise routine (Lahham et al., 2018a).

### **Reduced burden**

Most participants across the studies reported a reduction in burden associated with telerehabilitation, which allowed participation in PR without the expense of travel and parking (Lahham et al., 2018a; Tsai et al., 2016), and reduced the time and fatigue participants associated with travelling (Burkow et al., 2018b; Hoaas et al., 2016; Tsai et al., 2016).

### **Monitoring and feedback**

Different tools for monitoring participants during telerehabilitation were described in studies. These included activity monitors to gather data on steps taken (Benzo et al., 2021; Burkow et al., 2015; Lahham et al., 2018a; Whittaker et al., 2021), and providing pulse oximeters for data on peripheral oxygen saturations and heart rates. The data were monitored real-time via VC (Lewis et al., 2021; Tsai et al., 2016) or recorded in digital diaries (step count, observations, and symptoms) (Benzo et al., 2021; Burkow et al., 2015; Hoaas et al., 2016), and was available to both the participant and clinicians. Participants perceived the data differently; some reported the data as motivational and providing a learning opportunity (Hoaas et al., 2016; Houchen-Wolloff et al., 2021), while others did not wish to view their own data, but felt it was useful for their clinician (Burkow et al., 2015).

### **Barriers to participation**

While most of the feedback was positive, participants reported aspects that made engaging in telerehabilitation challenging. Commencing the telerehabilitation programme was found to be a particularly difficult time due to their prolonged sedentary lifestyle (Lahham et al., 2018a), along with technical disruptions. While most participants reported the digital equipment was generally easy to use, internet disruptions impacted participation (Tsai et al., 2016), and there were reports of stress when the VC technology did not work (Hoaas et al., 2016), or difficulty

downloading and logging onto the app (Whittaker et al., 2021). One web-based application received feedback from participants that the programme was complex and technical challenges reduced their motivation or caused them to disengage entirely (Houchen-Wolloff et al., 2021).

Participants provided feedback that more variation in the exercise programme would have been beneficial, and options for adapting exercises when they were having a bad day or pain or weather limited participation (Hooas et al., 2016; Lahham et al., 2018a; Whittaker et al., 2021). The barriers and enablers to participating in telerehabilitation are summarised in Table 2.

## DISCUSSION

This scoping review has explored the literature on end-users' perceptions of telerehabilitation. This data informs our understanding of the barriers and enablers to telerehabilitation that are both anticipated and experienced by participants, and supports the need for future models to be developed through a process of co-design with potential end users to enhance the reach of PR.

This review found limited literature reporting the uptake of telerehabilitation in the clinical setting. Several pulmonary telerehabilitation studies involved randomisation, which dictates group allocation, and the studies frequently report patients' preference for centre-based rehabilitation as a reason for declining participation. It is acknowledged that recruitment to these studies was frequently from PR waitlists, with patients having an expectation of attending centre-based PR.

The most frequently reported barrier to telerehabilitation was technical competence with the devices used to deliver telerehabilitation. While this may change as technology becomes a more integral part of people's lives, the sequential surveys in the UK pre- and post-COVID have shown that despite the growing use of and confidence with technology, the appetite for telerehabilitation remains low and relatively unchanged (Polgar et al., 2020; Polgar et al., 2022). Competence with technology is associated with age, education level, and device access (Seidman et al., 2017; Skibdal et al., 2022), suggesting the possibility that providing telerehabilitation may widen the equity gap by promoting options that are not accessible to those who may need it the most. For example, a survey conducted in a UK inner city, high-poverty area showed that only 16% of people admitted to a hospital with a COPD exacerbation had computer access, and only 14% had internet access (Granger et al., 2018). A key feature of remote delivery is to reduce the burden associated with attending centre-based PR programmes and developers must ensure that those for whom this may be useful are not disadvantaged by lack of access to devices. Access to mobile phones appears most common; however, these are not always smartphones, and reports of internet data access are variable. Given the widespread ownership of mobile phones, it is the ideal device for delivery of PR.

Holland et al. (2021) recently suggested that the uptake of PR is influenced by perceptions of what participation in telerehabilitation might mean for people living with a CRD. For many participants, the perception of telerehabilitation is that it is technically challenging and beyond their digital skills.

However, in participants who have completed telerehabilitation, technical challenges were retrospectively considered minor. Differing theoretical models consider the readiness to engage with technology and support these findings. For example, The Unified Theory of Acceptance and Use of Technology (Venkatesh, 2022) model suggests that the perceived likelihood of adopting the technology is dependent on the direct effect of four key constructs, namely performance expectancy, effort expectancy, social influence, and facilitating conditions. The use of such models can assist with understanding how we can facilitate uptake by employing strategies to assist participants to understand how the telerehabilitation programme works and the potential benefits to the participant. Many of the studies included in this review provided both equipment and significant technology support, which may have positively influenced the participant experience. Ensuring the allocation of such resources in telerehabilitation programmes may be an essential part of successful implementation. Including training and support as an opt-out rather than an opt-in model for telerehabilitation participants may enhance uptake and outcomes.

Developing a therapeutic relationship with attending clinicians has been shown to be important to people living with CRD. This review showed that a lack of supervision and direct contact with staff is a perceived barrier to participation in telerehabilitation. Studies of remotely delivered PR have used differing methodologies, making it challenging to compare and identify optimal models for telerehabilitation. For example, some web-based models use "stand-alone" models with no scheduled clinician contact, while others use weekly telephone coaching and supervised group exercise and education models. Despite this, communications with clinicians were identified as an important facet of programmes by participants. Many studies report remote communication as effective and as engaging as face to face (Benzo et al., 2021). It could be argued that participants have more individual and personalised communication with a clinician in telerehabilitation models than centre-based, where they are competing with other participants for attention. The optimal clinician contact time in telerehabilitation has not been determined, but future programmes should consider scheduled, structured consultations that may evolve over time with more support required at the start of the programme.

An important part of PR is developing a support network. In centre-based PR this network is developed with peers at the programme. Studies reported concerns that telerehabilitation would not be able to provide the same peer support as centre-based (Dobson et al., 2019; Inskip et al., 2018). However, participants who completed telerehabilitation reported feeling supported in different ways to those in centre-based PR. In remotely delivered group sessions using VC facilities, social support was reported as being received through other participants in the programme (Burkow et al., 2018b; Tsai et al., 2016). For telephone and web-based models this support was received from family and friends (Lahham et al., 2018a; Simoný et al., 2019; Whittaker et al., 2021), who often participated alongside the patient and became more aware of the participant's condition and how to best provide support. In developing telerehabilitation models, consideration of support

**Table 2***Barriers and Enablers Experienced During Participation in Remotely Delivered Pulmonary Rehabilitation*

Barriers and enablers		Author (date)							
		Benzo et al. (2021)	Burkow et al. (2015)	Lahham et al. (2018b)	Hoas et al. (2016)	Houchen-Wolloff et al. (2021)	Simony et al. (2019)	Tsai et al. (2016)	Whittaker et al. (2021)
Barriers	Getting started			●					
	Variation and modification			●	●		●		●
	Technical challenges				●	●		●	●
	Not tailored								●
Enablers	Health benefits	●		●	●			●	●
	Interaction with healthcare professional	●	●	●	●		●		
	Feeling supported	●	●	●					●
	Usability of technology	●	●		●			●	
	Flexibility			●			●	●	
	Reduced burden								
	Feedback	●						●	

Note. ● = enabler; ● = barrier.

networks is vital and allowing for inclusion of family members appears beneficial.

## CONCLUSION

PR is an effective and essential component in CRD management. While centre-based programmes have proven efficacy, they are not always accessible for all. Telerehabilitation can provide a flexible and convenient programme that can reduce the burden associated with accessing a centre-based programme while still maintaining a supportive and motivating environment.

Participants have preferences for how their healthcare is delivered. A range of delivery options is required to optimise the uptake and completion of PR. For some participants, concerns about digital competence, device access, or lack of perceived benefit can restrict participation in digital options. Services should consider adequate resourcing for new models of telerehabilitation to be implemented to allow inclusivity for all participants and provide sufficient training and support to overcome technical challenges. Developing a therapeutic

relationship appears critical to programme success and strategies to enable this, such as regularly scheduled clinician interactions, must be considered to optimise the success of such programmes.

## KEY POINTS

1. Providing information on expected benefits of telerehabilitation may improve the patient's perception.
2. Provision of devices and data may allow increased inclusivity.
3. Technical support should be provided for all participants.
4. Regular scheduled clinician contact points should be provided.

## DISCLOSURES

The primary author (SC) received funding from MedTech CoRE and the Royal New Zealand Arch Masons. There are no conflicts of interest that may be perceived to interfere with or bias this study.

## PERMISSIONS

No permissions were required.

## CONTRIBUTIONS OF AUTHORS

Design conceptualisation and methodology, SC, DT and JR; validation, SC, DT and JR; formal analysis, SC, DT and JR; data curation, SC, DT and JR; writing—original draft preparation SC, review and editing, SC, DT and JR; funding acquisition, SC and DT.

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## Appendix A

**Table A1**

*Scoping Review Search Strategy*

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1	"COPD OR asthma OR bronchiectasis OR interstitial lung disease" OR "lung fibrosis" OR "chronic respiratory disease" OR "chronic lung disease"
2	Respiratory rehabilitation OR "pulmonary rehabilitation" OR "COPD rehabilitation" OR "lung rehabilitation" OR "respiratory therapy"
3	Telerehabilitation OR tele-rehabilitation OR mHealth OR "web based" OR smartphone OR App OR online OR telehealth OR "video conference" OR mobile OR home-based OR remote OR telephone
4	Barrier* OR enabler* OR challenge* OR uptake OR compliance OR adherence OR obstacle OR completion OR limitation* OR facilitator* OR success OR non-compliance OR attend OR attitude OR participation

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Note. COPD = chronic obstructive pulmonary disease.

# Appendix B

**Table B1**

Characteristics of Studies Included in the Review

Author (date) Country	Study design	Participants (n, diagnosis, age (mean (SD), sex)	PR concept	Report uptake data	Report intent/ willingness	Report barriers	Report enablers
Almojibel et al. (2021) USA	Survey	134, diagnosis not stated 66 (10.7) years Female 50%	Willingness to participate in telerehabilitation	No	Yes	Yes	Yes
Alwashmi et al. (2020) Canada	Mixed methods, survey and interviews	77 COPD 65 years Female 60%	Perceptions of web-based PR	No	No	Yes	Yes
Bairapareddy et al. (2021) India	Survey	30 COPD 54 (12) years Female 20%	Perceptions of web-based PR	No	Yes	No	No
Benzo et al. (2021) USA	RCT and interviews	78 COPD 69 (8.1) years Female 53%	Participated in web-based and telephone calls	Yes	No	Yes	Yes
Bourne et al. (2017) UK	RCT	90 COPD 70 (8.6) years Female 35%	Web-based vs centre-based	Yes	No	No	No
Burkow et al. (2015) Norway	Mixed methods, survey and interview	10 COPD 62 years Female 50%	Participated in VC and phone calls	No	No	Yes	Yes
Cerdán-De-Las-Heras et al. (2022) Denmark	RCT	54 COPD 67 (10.2) years Female 43%	Web-based vs centre-based	Yes	No	Yes	No
Chaplin et al. (2017) UK	RCT	103 COPD 66 (8.1) years Female 31%	Web-based vs centre-based	Yes	Yes	Yes	No
Cox et al. (2021) Australia	RCT	142 COPD 68 (9) years Female 56%	VC vs centre- based	Yes	No	Yes	No
Dobson et al. (2019) New Zealand	Mixed methods, survey and interview	30 CRD 73% > 65 years Female 43%	Perceptions of web-based PR	No	No	Yes	Yes
Grosbois et al. (2021) France	Retrospective audit	105 CRD 63 years Female N/A	Telephone or VC vs no PR (COVID-19)	Yes	No	Yes	No
Hansen et al. (2020) Denmark	RCT	134 COPD 68 (9) years Female 55%	VC vs centre- based	Yes	No	Yes	No
Hoas et al. (2016) Norway	Survey and focus group	10 COPD 55 years Female 50%	Participated in VC PR	No	No	Yes	Yes

Author (date) Country	Study design	Participants (n, diagnosis, age (mean (SD), sex)	PR concept	Report uptake data	Report intent/ willingness	Report barriers	Report enablers
Holland et al. (2017) Australia	RCT	166 COPD 69 (13) years Female 40%	Telephone vs centre-based	Yes	No	Yes	No
Houchen-Wolloff et al. (2021) UK	Feasibility; non- randomised and interviews for select sample	100 COPD (AE) (n = 14 interviewed) 71 (9.3) years Female 45%	Web-based vs no PR	Yes	Yes	Yes	Yes
Inskip et al. (2018) Canada	Survey and focus groups	26 CRD 71 years Female 50%	Perceptions of telerehabilitation	No	No	Yes	Yes
Lewis et al. (2021) UK	Service evaluation	17 CRD 69 (11) years Female 50%	VC and telephone call	Yes	No	Yes	Yes
Marquis et al. (2015) Canada	Observational study	26 COPD 65 (7) years Female 58%	VC	Yes	Yes	No	No
Nolan et al. (2019) UK	Non-randomised trial	154 COPD 71 (9) years Female 52%	Telephone calls	Yes	Yes	No	No
Polgar et al. (2022) UK	Survey (x 2)	99 and 101 CRD 74 years Female 47%	Perceptions of web-based PR	No	Yes	Yes	No
Seidman et al. (2017) Australia	Survey	254 CRD 73 (10) years Female 59%	Perceptions of VC delivered PR	No	Yes	Yes	Yes
Simony et al. (2019) Denmark	Non-empirical	15 COPD 62 years Female 47%	VC	Yes	No	Yes	Yes
Skibdal et al. (2022) Denmark	Mixed methods, survey and interviews	84 COPD survey, 9 COPD interviews 70 (9) years Female 53%	Perceptions of VC, telephone, or text messages	No	No	Yes	Yes
Tsai et al. (2017) Australia	RCT	37 COPD 73 (8) years Female 50%	VC vs centre- based	Yes	No	No	No
Tsai et al. (2016) Australia	Mixed methods, survey and interview	11 COPD 72 year Female 36%	Participated in VC PR	No	No	Yes	Yes
Whittaker et al. (2021) New Zealand	Feasibility study	26 CRD 70 years Female 50%	Participated in web-based PR	No	No	Yes	Yes

Note: AE = acute exacerbation, CRD = chronic respiratory disease, COPD = chronic obstructive pulmonary disease, N/A = not available, PR = pulmonary rehabilitation, RCT = randomised control trial, VC = videoconferencing.

**Table B2***Number of Participants Screened, Excluded, or Declined in Randomised Control Trials of Telerehabilitation*

Author (date)	Screened, <i>n</i>	Excluded, <i>n</i> (%)	Declined, <i>n</i>
Bourne et al. (2017)	163	73 (45%)	N/A
Cerdán-De-Las-Heras et al. (2021)	95	20 (21%)	21
Chaplin et al. (2017)	641	244 (38%)	294
Cox et al. (2021)	651	499 (77%)	246
Hansen et al. (2020)	1099	714 (65%)	251
Holland et al. (2017)	295	129 (44%)	67
Tsai et al. (2017)	128	91 (71%)	40
Benzo et al. (2021)	217	63 (29%)	33

Note. N/A = not applicable.

**Table B3***Uptake of Telerehabilitation in Observational Studies*

Author (date)	Screened, <i>n</i>	Uptake, <i>n</i> (%)
Grosbois et al. (2021)	65	57 (88%)
Houchen-Wolloff et al. (2021)	2080	100 (5%)
Lewis et al. (2021)	30	17 (57%)
Marquis et al. (2015)	77	26 (37%)
Simony et al. (2019)	28	15 (54%)
Nolan et al. (2019)	1593	154 (10%)

**Table B4***Characteristics of Studies Exploring the Participant Experiences with Remotely Delivered Pulmonary Rehabilitation*

Author (year)	Sample size ( <i>n</i> )	Age (years), <i>M</i> ( <i>SD</i> )	PR delivery mode	Participant experience of PR		Participant digital literacy at baseline	Study provision of digital equipment
				No previous PR experience	Previously attended centre-based PR		
Benzo et al. (2021)	78	69	VC			Not stated	Provided
Burkow et al. (2015)	10	62	VC	✓	✓	All regular computer users	Provided
Lahham et al. (2018b)	13	66	Telephone	✓	✓	N/A	N/A
Hoaas et al. (2016)	10	55	VC			8/10 used internet daily, 2 technology naive	Provided
Houchen-Wolloff et al. (2021)	14	71 (9)	Web-based	✓		Needed to be web literate and have email	Provided or used own
Simony et al. (2019)	15	62	VC			Not stated	Provided
Tsai et al. (2016)	11	72 (8)	VC	✓	✓	Not stated	Provided
Whittaker et al. (2021)	26	70	Web-based		✓	Not stated	Needed own mobile phone

Note. N/A = not applicable; PR = pulmonary rehabilitation; VC = video conferencing.