CHEST

Perceived autonomy support in telerehabilitation by people with chronic respiratory disease: a mixed methods study.

--Manuscript Draft--

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Abstract:	Background: Autonomy supportive health environments can assist patients to achieve behavior change and positively influence adherence. Telerehabilitation may increase access to rehabilitation services, but creating an autonomy supportive environment may be challenging. Question: To what degree does telerehabilitation provide an autonomy supportive environment? What is the patient experience of an 8-week telerehabilitation program? Study Design and Methods: Individuals undertaking telerehabilitation or center-based pulmonary rehabilitation within a larger randomized controlled equivalence trial completed Health Care Climate Questionnaire (HCCQ – short form) to assess perceived autonomy support. Telerehabilitation participants were invited to undertake 1:1 semi-structured interviews. Interviews were transcribed verbatim and thematically coded to identify major themes and sub-themes. Results: 136 participants (n=69 telerehabilitation) completed HCCQ and n=30 (42%) telerehabilitation participants undertook interviews. HCCQ summary scores indicated participants 'strongly agreed' the telerehabilitation environment was autonomy supportive, which was similar to center-based participants (p>0.3). Telerehabilitation interview data supported quantitative findings identifying 5 major themes, with sub-themes, being: 1) Making it easier to participate in pulmonary rehabilitation, as telerehabilitation was convenient, saved time and money and offered flexibility; 2) Receiving support in a variety of ways, including opportunities for peer-support and receiving an individualized program guided by expert staff; 3) Internal and external motivation to exercise, as a consequence of being in a supervised group, seeing results for effort and being inspired by others; 4) Achieving success, through provision of equipment and processes to prepare and support operation of equipment and technology; 5) After the rehabilitation program, continuing to exercise but dealing with feelings of loss. Interpretation: Telerehabilitation was perceived as an autonomy supportive environment, in part by making it easier to undertake pulmonary rehabilitation. Support for behavior change, understanding and motivation were derived from clinicians and patient-peers. The extent to which autonomy support translates into ongoing self-management and behavior change is not clear.
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Declaration of interests

☐The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☒The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Narelle Cox reports financial support was provided by National Health and Medical Research Council. Anne Holland, Christine McDonald, Jennifer Alison, Ajay Mahal, Richard Wootton reports financial support was provided by National Health and Medical Research Council. Christine McDonald reports a relationship with Menarini that includes: consulting or advisory. Christine McDonald reports a relationship with Astra Zeneca that includes: consulting or advisory. Christine McDonald reports a relationship with Air Liquide Healthcare that includes: non-financial support.

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Perceived autonomy support in telerehabilitation by people with chronic respiratory disease: a mixed methods study.

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Conflicts of interest:

AEH, CFM, JAA, AM, RW, as the chief-investigators, report grant funding from the National Health and Medical Research Council (NHMRC) (GNT1101616) for the conduct of the parent trial. NSC reports fellowship funding from the NHMRC (GNT1119970) to work on this trial. CFM reports fees paid to the institution from Menarini and Astra Zeneca, and in-kind trial support from Air Liquide Healthcare – all unrelated to the present work. For all other authors (JYTL, PZ, PO'H, CJH, JB, KB, ATB, BW, CM, AL, HM, HC, PC, AN, HB, EH, MC) there are no interests to declare.

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Abbreviations:

COPD – Chronic Obstructive Pulmonary Disease

ILD – Interstitial Lung Disease

HCCQ - Health Care Climate Questionnaire

Background: Autonomy supportive health environments can assist patients to achieve behavior change and positively influence adherence. Telerehabilitation may increase access to rehabilitation services, but creating an autonomy supportive environment may be challenging.

Research Question: To what degree does telerehabilitation provide an autonomy supportive environment? What is the patient experience of an 8-week telerehabilitation program?

Study Design and Methods: Individuals undertaking telerehabilitation or center-based pulmonary rehabilitation within a larger randomized controlled equivalence trial completed Health Care Climate Questionnaire (HCCQ – short form) to assess perceived autonomy support. Telerehabilitation participants were invited to undertake 1:1 semi-structured interviews. Interviews were transcribed verbatim and thematically coded to identify major themes and sub-themes.

Results: 136 participants (n=69 telerehabilitation) completed HCCQ and n=30 (42%) telerehabilitation participants undertook interviews. HCCQ summary scores indicated participants 'strongly agreed' the telerehabilitation environment was autonomy supportive, which was similar to center-based participants ($p>0.3$). Telerehabilitation interview data supported quantitative findings identifying 5 major themes, with sub-themes, being: 1) Making it easier to participate in pulmonary rehabilitation, as telerehabilitation was convenient, saved time and money and offered flexibility; 2) Receiving support in a variety of ways, including opportunities for peer-support and receiving an individualized program guided by expert staff; 3) Internal and external motivation to exercise, as a consequence of being in a supervised group, seeing results for effort and being inspired by others; 4) Achieving success, through provision of equipment and processes to prepare and support operation of equipment and technology; 5) After the rehabilitation program, continuing to exercise but dealing with feelings of loss.

Interpretation: Telerehabilitation was perceived as an autonomy supportive environment, in part by making it easier to undertake pulmonary rehabilitation. Support for behavior change, understanding and motivation were derived from clinicians and patient-peers. The extent to which autonomy support translates into ongoing self-management and behavior change is not clear.

Clinical trial registration: (for parent trial) ACTRN12616000360415

Introduction:

Pulmonary rehabilitation is the cornerstone of non-pharmacological treatments for people with chronic respiratory disease.[1] A comprehensive program of individually tailored exercise and education,[2] pulmonary rehabilitation has been demonstrated to improve symptoms, physical function and quality of life in people with a variety of chronic respiratory diseases including chronic obstructive pulmonary disease (COPD),[3] bronchiectasis,[4] and interstitial lung disease (ILD).[5]

Typically, pulmonary rehabilitation programs are delivered at a center, on an outpatient basis.[6] Recent investigation of pulmonary rehabilitation programs delivered directly to the patient's home using telecommunications technology, known as telerehabilitation,[7] has found that such programs achieve clinical outcomes similar to those attained following a traditional center-based program.[8] Telerehabilitation may help to make pulmonary rehabilitation accessible for people who might otherwise not be able to attend, due to issues including those associated with travel and transport,[9,10] or where center-based services are unavailable in response to COVID-19 restrictions.[11] However, while telerehabilitation is both feasible and effective, more than 1/3 of people with chronic respiratory disease do not wish to use digital technology to undertake pulmonary rehabilitation,[12,13] and perceive they will receive better quality care when they engage with a healthcare professional in-person.[14] An often-reported difficulty associated with remote delivery of health services relates to clarity and quality of the audio and/or video connection;[15] while greater ease of communication between the patient and their health-care professional can enhance treatment adherence as well as patient satisfaction.[16]

A core, yet complex, element of pulmonary rehabilitation is providing support for behavior change, particularly as that relates to disease self-management, exercise and physical

activity participation and adoption of healthy lifestyle behaviors.[2] In healthcare, autonomy support is the creation of an environment and interactions that facilitate and encourage patients to make choices about their behavior.[17] Patients may perceive their health interaction as autonomy supportive when it provides information that supports and informs choice, helps develop and maintain intrinsic motivation, supports internalization of external motivation, and is respectful of the choices that are made.[17] An autonomy supportive environment can assist patients to commit to and achieve health-related behavior change,[18,19] and can positively influence adherence to treatment recommendations.[16] Producing and maintaining behavior change following completion of pulmonary rehabilitation is challenging even in traditional center-based programs,[20] where in-person interaction might more easily allow clinicians to empower and encourage their patients.[21] While previous evaluations of the patient experience of pulmonary rehabilitation delivered over the telephone or internet suggest patients felt supported by clinicians,[22-24] the extent to which an autonomy supportive environment can be provided during pulmonary rehabilitation delivered remotely has not previously been explored. In people with chronic respiratory disease undertaking telerehabilitation or center-based pulmonary rehabilitation we sought to describe perceived autonomy support, as well as the patient experience of an 8-week telerehabilitation program.

Methods:

Participants with a chronic respiratory disease recruited to a multi-center trial comparing center-based pulmonary rehabilitation to telerehabilitation comprised the population of interest. Inclusion criteria and procedures for the larger randomised controlled equivalence trial are detailed elsewhere.[25,26] In brief, the 8-week telerehabilitation intervention comprised one home-visit with a physiotherapist for establishment of exercise training and to ensure safety. This was followed by two sessions per week of remotely supervised group

exercise training via video-conferencing (Zoom, San Jose CA, USA). Participants undertaking telerehabilitation were provided with all necessary equipment for the 8-week rehabilitation program.[26] Equipment was collected from participants by the research team at the conclusion of the rehabilitation period.

Data collection:

Following the 8-week rehabilitation period, all participants completed an evaluation undertaken by a blinded assessor including completion of the Health Care Climate Questionnaire (HCCQ – short form)[27] to assess the degree to which they perceived the pulmonary rehabilitation environment (telerehabilitation or center-based) as autonomy supportive. The HCCQ-short form comprises 6 questions, adapted for the context of the clinical interaction, seeking feedback on the way the healthcare professional communicates with the patient, the extent to which the patient feels listened to, and how empathetically the health professional engages with the patient. Each question is answered on a 7-point Likert scale (strongly disagree = 1 to strongly agree =7) with higher scores indicating greater perceived autonomy support. An overall summary score is generated by averaging the response across all questions.[16] Telerehabilitation participants were eligible to be invited to participate in an interview if they had undertaken the telerehabilitation intervention within 6 months or following ethics approval for this sub-study (HREC15/Alfred/101 local reference 26/16, July 2018). Semi-structured interviews were undertaken to gain an in-depth understanding of participants' perceptions and experience of the telerehabilitation program. Interview questions are detailed in Figure 1. A researcher (JYTL) trained in qualitative interviewing and who was not involved in the participants' routine care, delivering the telerehabilitation intervention, nor any participant assessments conducted the interviews. Interviews were undertaken by telephone, at a time of the participant's choosing, and were audio-recorded and transcribed verbatim. All participant interviews and responses were coded to ensure participants could not be identified from their responses.

Data analysis:

Participant responses to the HCCQ were tabulated and summary scores reported using mean (standard deviation (SD)) or median (interquartile range (IQR)) as appropriate. HCCQ scores between telerehabilitation and center-based programs were compared using the Mann-Whitney U-test. Qualitative data was reviewed by two authors (NSC, JYTL) who undertook independent line-by-line iterative thematic analysis of de-identified interview transcripts.[28] Through a process of reading and re-reading the de-identified transcripts, two independent sets of descriptive codes were developed. Both re-reading and referring back to transcripts throughout the code development process enabled confirmation of the context and intent of participant responses.[29] Through a process of discussion, associated descriptive codes were grouped into sub-themes and then major themes. Representative participant quotes were extracted verbatim to serve as evidence for sub-themes. Disagreements were resolved by discussion, or arbitration with a third author, if necessary.

Results:

One hundred and forty-two participants were randomized to either center-based pulmonary rehabilitation (n=71) or telerehabilitation (n=71) throughout the duration of the trial. One participant withdrew from each group during the trial intervention period and four participants (n=1 telerehabilitation) did not complete the HCCQ, resulting in n=136 (n=69 telerehabilitation) completed HCCQs. Qualitative interviews were conducted between November 2018 and May 2019. Thirty-one participants (44% of all telerehabilitation participants) were eligible to be invited for interview. Only one participant invited to interview declined due to family circumstances. All interviews were completed by telephone with a mean (SD) duration of 23 (7) minutes. Characteristics of all participants randomized to

the telerehabilitation intervention and the 30 participants who completed an interview are presented in Table 1.

Median [IQR] HCCQ summary scores indicated participants 'strongly agreed' that the rehabilitation environment was autonomy supportive, with no difference between telerehabilitation and center-based pulmonary rehabilitation (Z=-0.48, p=0.6). Table 2 details scores for HCCQ by question.

From qualitative interviews, five major themes emerged: 1) Making it easier to participate in pulmonary rehabilitation; 2) Receiving support in a variety of ways; 3) Internal and external motivation to exercise; 4) Achieving success; 5) After the rehabilitation program. Themes and subthemes are detailed in Figure 2 and further described with illustrative quotes below.

Theme 1: Making it easier to participate in pulmonary rehabilitation

Participants described many ways in which telerehabilitation made it easier for them to be able to undertake a program of pulmonary rehabilitation (Table 3). The convenience of having exercise equipment and access to professional support without having to attend a center was viewed as being both time-saving and cost-saving. This included not having to travel considerable distances to attend a center, or having to give up paid work in order to participate in rehabilitation. Participants described feeling more comfortable exercising in their own environment than they would have in front of other people at an in-person group program. Convenient access to exercise equipment, together with being comfortable exercising, were perceived as making it easier to perform exercise more often and outside of the scheduled rehabilitation session.

Theme 2: Receiving support in a variety of ways

Participants expressed support of their undertaking telerehabilitation as coming from various sources (Table 4). Pulmonary rehabilitation staff were viewed as providing support in the form of guidance and reassurance to undertake exercise and use the equipment, as well as in their expertise in tailoring programs to individuals and providing education and resources. Staff support was considered a 'total package' and included interactions with delivery personnel bringing and collecting equipment, therapists attending the house for the initial home visit, the online therapist guiding rehabilitation sessions and physical resources provided. Participants also reported that the support of their peers during the online rehabilitation classes provided them with company and helped them to feel less alone. Being able to see and talk to other people with a common understanding of living with and managing lung disease was considered supportive, while being able to exchange tips and suggestions associated with common experiences was highly valued.

Theme 3: Motivation to exercise

The virtual group environment of telerehabilitation created external motivation for exercise by providing distraction and company during the exercise training session (Table 5). This, together with inspiration derived from watching the performances of other participants, motivated participants to exercise – often enabling them to internalize this motivation and accomplish more than they had believed themselves capable of. Knowing an experienced pulmonary rehabilitation clinician was supervising their exercise training, in real-time, created reassurance to exercise as well as motivation to demonstrate their capacity and improvement. Participants described feedback from both staff and other participants in terms of their performance and gains helped motivate them to exercise. Both feedback and

seeing results, such as being able to cycle at a higher wattage or for a longer duration before needing a rest, were key motivators for exercise.

Theme 4: Achieving success

Participants felt that the telerehabilitation program structure created optimal conditions for them to achieve rehabilitation success (Table 6). The provision of instruction guides, in-person demonstration and remote staff support via telephone were all factors that made participants feel comfortable and confident to manage the equipment and technology, even when they had little prior experience. While there were technology and equipment malfunctions, participants felt these did not detract from their overall experience and valued the staff assistance in supporting them to overcome these issues in a timely fashion. Communication about the program and what to expect, details of logistics associated with equipment delivery and home-visit scheduling, and the provision of equipment and resources were all valued in the telerehabilitation experience and helped participants achieve success. Resounding agreement amongst participants as to how uncomfortable they found the bike seat was one factor that participants felt, if improved, would further increase enjoyment and capacity to succeed in the telerehabilitation program.

Theme 5: After the rehabilitation program

Although participants were aware from the outset that the telerehabilitation equipment would be returned to the research team at the conclusion of the 8-week rehabilitation period, they described feelings of sadness at seeing the equipment go from their home (Table 7). Many participants reported feeling both confident and comfortable to exercise on their own at the conclusion of the telerehabilitation program, with a number motivated to purchase their own equipment for ongoing use. Although participants described feeling that

their experience of telerehabilitation helped them to form good habits for exercise participation and being physically active, for some the end of the program and removal of equipment was associated with diminished motivation to continue exercising. Overall, participants were positive about their experience of telerehabilitation, demonstrated by their willingness to recommend it to others, however many would have preferred if the program had continued beyond its pre-specified 8-week duration.

Discussion:

This study describes the perceptions of autonomy support during pulmonary rehabilitation and experiences of participants undertaking a supervised home-based telerehabilitation program. Participants undertaking pulmonary rehabilitation (telerehabilitation or center-based) reported high levels of autonomy support. This was reinforced by themes emerging from interviews of telerehabilitation participants including feeling supported by other participants and staff, increased ease of access to rehabilitation services, and motivation for exercise during and after the program.

An autonomy supportive environment empowers people to act with willingness, purpose and meaning,[30] and in people with chronic illness is associated with enhanced program engagement, and achievement and maintenance of improved health outcomes.[27] When delivered using digital technology, healthcare consultations can encourage autonomy support by removing travel associated burden, as well as fostering confidence due to the participant being in a familiar environment.[31] Travel and transport logistics are widely reported barriers to attending center-based pulmonary-rehabilitation,[9,10] and participants in this study valued being able to undertake telerehabilitation in their home for saving both time and money which would have been associated with traveling to a center-based program. Another feature of the model of telerehabilitation under investigation that

participants felt supported their willingness and ability to undertake rehabilitation was the provision of both exercise and technology equipment, and associated program processes. Participants valued the simple and reliable equipment, clear documentation to support its use, and good communication with research staff relating to equipment delivery. Patient satisfaction derived from these program processes may also have contributed to intervention adherence and motivation for behavior change.[27] In addition, access to expert staff, trained in the delivery of telerehabilitation, was a contributor to participants feeling supported during their program. Previously, healthcare professionals have reported apprehension about delivering telerehabilitation, particularly around management and troubleshooting of technology equipment.[32,33] The experiences of participants in this study support the need for model-specific training and skill development for healthcare professionals to deliver remote telerehabilitation, in order to ensure program success and patient satisfaction.

While telerehabilitation programs can alleviate burden associated with travel, the home-based nature of these programs means participants will likely have fewer opportunities for engaging with other participants and clinicians than would happen in a face-to-face group environment, and will be largely reliant on their intrinsic motivation. When delivering pulmonary rehabilitation remotely, creating a virtual group environment has been identified as important by patients[32] as there is fear of a loss of the social interaction typically achieved at traditional center-based programs.[34] Concerted efforts to create a virtual group environment may also help to overcome beliefs that telehealth delivered interventions are a sub-standard service or that clinicians are not putting in as much effort as they would in an in-person environment.[35] The participants in this study felt that the model of telerehabilitation, using video-conferencing in a virtual group, gave them the feeling of being in a group, which provided support and company, as well as motivation and encouragement to exercise. These findings are in keeping with other studies that used video-conferencing to

deliver telerehabilitation suggesting that concerns over limited social interaction in telerehabilitation are ameliorated when real-time video-conferencing is utilized with multiple participants in a session. Being able to see and speak to others with similar lived experience was valuable to participants and also served as a source of inspiration and motivation. Greater perceived social support is associated with better self-efficacy and improved self-care, [36] and may have contributed to the positive perception of autonomy support. Whether, and to what extent, people with chronic respiratory disease consider fellow patients as 'important others',[18] alongside family and friends, in terms of providing extra-treatment support for ongoing disease management was not specifically evaluated.

Participants in the present study valued having equipment provided to them to support their completion of pulmonary rehabilitation. While this may have supported autonomy in terms of exercise behavior, it also created a sense of loss when the program was over and equipment was returned to the research team. It is unclear if this sense of loss was related solely to the ending of program and the removal of equipment or, rather, reflected the loss of the company and support of their virtual group peers and the clinicians. It is possible that simpler models of telerehabilitation, incorporating virtual group interaction via video-conferencing but with limited equipment requirements, may help to alleviate the sense of loss described at the end of the program and create confidence to exercise without specialist equipment. In a program using hand weights, resistance bands and a single step to deliver group-based telerehabilitation via video-conferencing, Hansen and colleagues[37] found no difference in functional exercise capacity, quality of life or physical activity between people with COPD undertaking telerehabilitation and those attending center-based pulmonary rehabilitation. Perceived autonomy support and capacity for behavior change were not assessed. If the identified group dynamics as described in the present work are also achieved with reduced equipment requirements, longer programs or bursts of

maintenance therapy delivered via telerehabilitation to support maintenance of behavior change may be feasible.

Strengths of the present study are that it describes perceived autonomy support of the largest sample of participant experiences of telerehabilitation delivered in a virtual group over the internet. The experiences described are also of participants with a variety of chronic respiratory diseases, from both metropolitan and rural locations. That participants perceived telerehabilitation created an autonomous supportive environment may help to overcome concerns that remotely delivered rehabilitation does not sufficiently replicate the traditional center-based pulmonary rehabilitation environment.[38]

In the present study, participants were those randomized to either telerehabilitation or center-based pulmonary rehabilitation, at least 70% of whom were naïve to pulmonary rehabilitation. As such, perception of autonomy and participant experiences primarily reflect only the exposure intervention, without experience of the alternative rehabilitation model. In addition, only patient participants provided evaluations and interviews. The experiences and perceptions of telerehabilitation by carers or family members, particularly in relation to having telerehabilitation sessions delivered to their home, health professionals attending the house to establish the program and living with the supplied equipment, may have implications for patients and their willingness to engage with telerehabilitation. Although we did not explore the experiences of carers and family members, previous reports are positive, with a small sample of people whose partners were participating in remotely supervised telerehabilitation expressing a high level of satisfaction with telerehabilitation.[23] The views expressed in this study represent only a portion of all those individuals randomized to the telerehabilitation intervention. It cannot be guaranteed that the views expressed by participants who were interviewed during the latter part of the study timeline would be the same as those who undertook telerehabilitation in the earlier phase of the trial but were not

eligible for interview. However, we interviewed a large proportion of participants randomized to the telerehabilitation intervention whose characteristics were similar to all the participants who undertook telerehabilitation.

Participants from both metropolitan and rural locations thought a home-based telerehabilitation program provided an autonomy supportive environment, and made it easier for them to undertake pulmonary rehabilitation. They described feeling well supported by clinicians and their peers. The companionship and interaction with other participants and staff created a sense of belonging to a group and provided peer-support and motivation for exercise. The extent to which this perceived support translates into ongoing self-management and lifestyle behavior change as a consequence of telerehabilitation is not yet known.

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Figure legend

Figure 1. Interview guide

Figure 2. Themes and sub-themes

Table 1. Characteristics of participants

	Center-based pulmonary rehabilitation participants n=71	Telerehabilitation participants	
		All participants n=71	Interview participants n=30
Age, years	67 (9)	68 (9)	67 (7)
Male/female, n	36/35	30 / 41	19 / 11
Diagnosis, n (%)			
- COPD	50 (70)	50 (70)	22 (73)
- ILD	6 (8.5)	5 (7)	2 (7)
- Bronchiectasis	9 (13)	10 (14)	3 (10)
- Asthma	6 (8.5)	6 (8)	3 (10)
Smoking status, n (%)			
- Current smoker	8 (11)	11 (15.5)	3 (10)
- Ex smoker	53 (75)	49 (69)	23 (77)
- Never smoker	10 (14)	11 (15.5)	4 (13)
Pack years, median [IQR]	35 [14 to 53]	40 [15 to 60]	40 [15 to 55]

FEV_1, L	1.6 (0.7)	1.5 (0.7)	1.5 (0.7)
FEV_1, %predicted	63 (26)	59 (25)	57 (25)
FVC, L	2.9 (1.1)	2.9 (0.9)	2.8 (1.0)
FVC, %predicted	86 (26)	84 (21)	79 (25)
FEV_1/FVC, %	56 (19)	54 (20)	55 (19)
BMI, kg/m^2	28 (7)	28 (6)	28 (5)
6 min walk distance, m	433 (86.7)	418.6 (117.2)	447.1 (126.6)
LTOT, n (%)	3 (4)	9 (13)	2 (7)
CRQ			
Dyspnoea	15 (5)	15 (6)	15 (7)
Fatigue	15 (5)	15(7)	16 (7)
Emotion	32 (10)	33(9)	33 (8)
Mastery	20 (5)	20 (9)	20 (6)
MMRC, median [IQR]	2 [1 to 2]	2 [1 to 3]	1.5 [1 to 2]
MMRC, n (%)			
0	1 (1)	2 (3)	0 (0)
1	37 (52)	25 (35)	15 (50)
2	21 (30)	25 (35)	9 (30)

3	11 (16)	15 (21)	3 (10)
4	1 (1)	4 (6)	3 (10)
HADS anxiety*, n (%)			
No case	66 (79)	55 (77)	26 (87)
Case	15 (21)	16 (23)	4 (13)
HADS depression*, n (%)			
No case	66 (93)	62 (87)	27 (90)
Case	5 (7)	9 (13)	3 (10)
PRAISE	47 (9)	48 (7)	47 (7)
Number of comorbidities, median [IQR]	4 [2 to 5]	3 [2 to 5]	3 [2 to 4]
Metropolitan/rural, n (%)	50 / 21 (70% / 30%)	49 / 22 (69% / 31%)	20 / 10 (67% / 33%)
Naïve to PR, n (%)	60 (85%)	52 (73%)	21 (70%)

LEGEND: Data are Mean (SD) unless indicated

n, number; COPD, chronic obstructive pulmonary disease; ILD, interstitial lung disease; FEV_1, forced expiratory volume in one second; L, liters; %predicted, percentage of predicted normal; FVC, forced vital capacity; TLCO, transfer factor of the lung for carbon monoxide; BMI, body mass index; m, meters; CPET, cardiopulmonary exercise test; VO_2max, maximum

oxygen uptake; LTOT, long-term oxygen therapy; CRQ, Chronic Respiratory disease Questionnaire; mMRC, modified Medical Research Council; HADS, Hospital Anxiety and Depression Scale; SF36-v2, Medical Outcomes Survey Short-form 36-v2; PCS, physical component summary; MCS, mental component summary; PRAISE, Pulmonary Rehabilitation Adapted Index of Self-Efficacy; METs, metabolic equivalent; PR, pulmonary rehabilitation.

*HADS case definition scoring: 0 ≤ 10 = no case; ≥11case

Table 2. Perceived autonomy support rated using HCCQ

HHCQ question	Center-based participants n=67			All telerehabilitation participants n=69			Interview participants n=30		
	Median	IQR	Range	Median	IQR	Range	Median	IQR	Range
I feel that my pulmonary rehabilitation healthcare professionals provided me with choices and options	7	6 to 7	4 to 7	7	6 to 7	1 to 7	7	6 to 7	5 to 7
I feel understood by my pulmonary rehabilitation healthcare professionals	7	7 to 7	3 to 7	7	7 to 7	4 to 7	7	7 to 7	5 to 7
My pulmonary rehabilitation healthcare professionals convey confidence in my ability to make changes	6	6 to 7	3 to 7	7	6 to 7	5 to 7	7	6 to 7	5 to 7
My pulmonary rehabilitation professionals encourage me to ask questions	6	6 to 7	2 to 7	7	6 to 7	4 to 7	7	6 to 7	4 to 7
My pulmonary rehabilitation professionals listen to how I would like to do things	6	6 to 7	3 to 7	7	6 to 7	4 to 7	7	6 to 7	4 to 7

My pulmonary rehabilitation healthcare professionals try to understand how I see things before suggesting a new way to do things	6	6 to 7	3 to 7	7	6 to 7	4 to 7	7	6 to 7	4 to 7

LEGEND: HCCQ, Health Care Climate Questionnaire.

Results are median [interquartile range (IQR)] and range. Difference between all all telerehabilitation participants and center-based participants $p>0.3^{*}$

*Mann Whitney U-test

Table 3 Theme 1: Making it easier to participate in pulmonary rehabilitation

Subtheme	Participant	Illustrative quote
Convenient, time-saving, cost-saving	29	'It was just bang, bang, bang, let's do it, and it worked really well. And I didn't have to drive for hours before or afterwards'
	13	'Once I started it I realized ...how extremely difficult it would have been to have to go down to the [hospital]..apart from the time, the financial, ah , you know, disadvantage of the petrol and all the rest of it, especially now it's gone up... it was a hell of a lot easier to do it at home.'
	9	'I really appreciated having it at home, purely because it made it so much easier for me not having to go into the hospital. Because I've got a 94-year-old mum that lives with me.'
	15	'It would have been at least $50 to $60 a week for fuel, which to go up twice a week, we wouldn't have been able to afford that'
	26	'It's very hard for us people, up in the [country] to do all these things that, you know, it, it costs to .. do exercises and things. It costs for the petrol all the time. You know, you get to the stage where, well, I'm going to pay, you know, the phone bill or the electricity bill

		before I'm going to do some silly little exercise.'
Comfortable to exercise at home	15	'It's a great experience … and especially in the comfort of your own home. Like you didn't have to get dressed up to go out … You didn't have to travel to go there. There was the chance to be online with other people that are going through the same thing.'
	5	'I never, I never felt, insecure or concerned about my safety, not at all.'
	25	'I found it better on the internet ... I'd just be more embarrassed if I couldn't manage to keep up…Yeah, the comfort zone, you're in your own place.'
Flexibility	30	'I mean, I can only speak for myself in the sense that for me it was, it was a blessing because I work full time, and it saved me that time travelling to and from the hospital. So I was able to leave my computer at 1:00, the designated start time, switch on the iPad, hop on the bike, and start the session. So there was no, you know, I didn't have to allow for travel time, which was fantastic.'

Table 4. Theme 2: Receiving support in a variety of ways

Subtheme	Participant	Illustrative quote
Company/not alone	27	'Having everybody appear on the screen, on a constant rotation it was nice. Sort of didn't feel alone for, you know, throughout that 45 minutes. And we could all hear each other. So it was, from time to times, you know, conversation could get quite interesting or quite funny.'
	26	'It seemed like it was face-to-face'
	28	'I really liked it when they involved all of us…so it was nice to see the other participants and feel that you were part of a class'
Common experiences/peer support	11	'We're all going through the same thing. You know, it was wonderful. Well, I mean, it's not wonderful that other people weren't well either. But we understood one another. We encouraged one another.'
	23	'I think it was the face-to-face interaction with, with the iPad. You could actually see rather than just have your headphones on and hearing a voice. It was being able to interact. Also seeing other people participate as well. So it wasn't all just anonymous, there was sort of a friendliness about it. And hearing the others

		get encouraged to do their bit as well, it, it didn't make you feel like you were the only one that was having a hard time with it, or...you know, you knew you weren't the only one that was struggling to reach goals.
	26	'You can see that you're not the only one breaking down and [laugh] worn out. So, um, it gives you a, a bit more of, you know, well you're not the only one that's wretched [laugh]. There is more people out there that are, you know, the same problems and that, as what I've got. So it's good to understand their point of view when they say something about it and go, yeah, I know about that, I've got that myself.'
	29	'It was the, the getting me motivated ... conversation with somebody from a different part of the world who was doing the same thing, you know, I know I'm not unique but it's also nice to see somebody else in the same boat, you know, and yeah, you're not unique, mate [laugh].'
Tailored program	6	'I found it very difficult and I thought that the, the aims were unrealistic of what they wanted

		me to achieve. However, after the first week I thought, no, it's not unrealistic. It's very, very achievable.'
	23	'If I had a really bad day then it was, um, monitored, and it was adjusted to suit whatever was happening.'
	28	'Even though we were a combined class, each person was individually tailored to.'
Knowledge, reassurance and support of staff	22	'I constantly had questions that I, I raised about different things. Um, and in most cases the, the girls could give me a, an answer to, to what I wanted to know and, and that was good because that also stimulated a, a bit of discussion within the group. And if they didn't know they would, you know, find out the information, and then next time we had, had a session, they, they were able to, to then say, you know, this, this and this.'
	11	'Because it's not only the physical, it's emotional. And even if they didn't, they didn't think they'd be dealing with the emotional through the research, they did.'
	11	'I was quite surprised. I thought, yeah, well, it's gonna be over the internet... It's gonna be

impersonal, which, you know, they're not gonna care or anything as long as they get their research. But it wasn't like that at all. It was a very positive experience.'

Table 5. Theme 3: Internal and external motivation to exercise

Subtheme	Participant	Illustrative quote
Distraction	17	'You'd feel like, oh, I can't go on much longer, but then she'd talk and you'd listen to her, and the time sort of went quicker than you thought.'
	15	'We were talking about what we'd done at the weekend or whatever and that took your mind off actually doing the exercises. It was like being right there in the room with other people.'
Competition/inspiration	24	'Well I liked the interaction that you got. Plus there was other people there. In some cases there was three people doing the same program all at once. So you could talk to them at the same time and see how they were going and, basically it gave you a bit of a competition [laugh].'
	23	'Because obviously not everyone has the same ailments. And everyone is a bit different, different level of fitness. It was, you know, quite eye-opening to see someone that was even on oxygen at the time. And was still able to ride a bike. And that was quite inspiring to me.'

Supervision	1	‘I liked having contact with the, with the physiotherapist. That was very good actually, because meeting her twice a week for something, you did your exercises every day, as I said. Not to disappoint her.’
	6	‘That’s the part that I liked, is the fact that I had to come home from work, I had to get changed ready for it. Someone would be waiting to speak to me. Face to face. Like you’re looking at them on the screen. I reckon that that was the motivation.’
Seeing results/unexpected outcomes	28	‘It was validated by my respiratory specialist. It was amazing. He just was blown away … and I said, “well that’s just the rehab I’ve been doing”.’
	3	‘I go up the street and I go and do, do my shopping and everything on my own, with my little oxygen bottle. Whereas before I used to be terrified, I wouldn’t go anywhere.’
	28	‘It gave me confidence to push through in other capacities of physical exertion ... I attempted things with my walking that I had not attempted for years, or just couldn’t do.’

Table 6. Theme 4: Achieving success

Subtheme	Participant	Illustrative quote
Processes	27	'The physio who, who came to the house, she was great. No, she went through everything with me ... on the exercise bike itself it was clearly marked, you know, step one, step two, step three, step four, step five ... there was an instruction book provided with the iPad.'
	22	'They had somebody, you know, bring it to the house and set it up and, and just go through the initial stage with me.'
	6	'Had I been in a group, with a group, being explained this, how all of this worked, I wouldn't have taken it in. But because it was one on one you take it in and you understand.'
Technology	22	'Knowing that there was someone there to be able to talk to, and get any technical assistance if I needed it, was very helpful.'
	3	'It was very simple. Yeah. And that was a good thing because I'm not that technical savvy [laugh] ... If you'd had anything far more complicated than that I think it would have been a bit of a battle.'
Bike seat	17	'The worst part was the seat … absolutely cruel on the backside … I really don't know how bike

	riders do it.'
13	'As I say, my biggest, biggest, biggest problem was that blasted bike seat. Oh goodness, it was uncomfortable.'

Table 7. Theme 5: After the rehabilitation program

Subtheme	Participant	Illustrative quote
Forming habits	28	'Because it became part of your life, I, I now factored that time in, that's bike time.
Sad to see equipment go	16	'I missed it at first [laugh] because I'd gotten used to going on the bike'
	8	'I missed my equipment... I also missed the contact of having someone checking on me at least once a week to make certain I was performing'
	11	'I didn't like that [*the removal of equipment*]. I wanted to keep going and I couldn't. Like the support and the relationships had gone. When the bike had gone, they'd all, that had all gone...So that's more of the emotional stuff than anything else. So, you know, you're back to isolation.'
Desire for a longer program	1	'Obviously it can't go on forever. But, eight weeks, it was two months. If we could do another month I would have been enthusiastic about it, but anyway.'
	23	'The only thing I could probably say is I'd have liked it to have lasted longer and probably do it three days a week.'
	11	'One negative though is it [*the*

		telerehabilitation program] didn't go long enough.'
Buying own equipment	28	'I certainly did … I knew if I didn't that, that I would lose what the program had worked so hard to achieve'
	20	'I bought another bike and I continued the same thing, and I'm still doing the same thing today.'
	8	'I've gone out and purchased an exercise bike as a result of it.'
Recommendations for others	28	'I'd just really be pushing them to do it. But I would also explain to them that it's not just about bike riding. You have this personal program that is achieved through this with really skilled professionals, that, you know, tailor your program individually just for you. You won't be the same at the end of it as you were at the beginning of it. You'll be so much more improved'
	24	'I'd tell them if they didn't do it they were an idiot.'
	3	'It is the best thing that anyone can do, especially if you have a, uh, a breathing problem … It does improve your life.'

1. Can you describe for me what happened during a typical telerehabilitation session?
2. Could you tell me about any aspects of the telerehabilitation program that you liked?
3. Could you tell me about any aspects of the telerehabilitation program that you didn't like?
4. Tell me about your interaction with the physiotherapist over the internet?
5. Tell me about your interaction with other patients/participants over the internet?
6. What was it like to have the equipment delivered to your house for telerehabilitation?
    a. Follow-up: What was it like to learn how to use the equipment for telerehabilitation?
    b. Follow-up: What was it like to have the equipment removed from your house after you finished the telerehabilitation program?
7. Could you tell me about what you did for exercise after you finished telerehabilitation?
    a. Follow-up: Can you describe for me how confident you felt about exercising on your own after you finished the telerehabilitation program?
8. Other than exercise, can you describe any other ways that the telerehabilitation program helped you to manage your lung condition?
    a. Follow-up: Can you tell me about any discussions that you or your group had with the physio about managing your lung condition?
9. Is there anything else about your telerehabilitation experience that you would like to comment on?
10. If a friend of yours was referred to a telerehabilitation program, what would you tell them?

Figure 1. Interview guide