

Comparison of Clinically Meaningful Improvements After Center-Based and Home-Based Telerehabilitation in People With COPD

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BACKGROUND: Response to pulmonary rehabilitation is not equal for all participants and may vary across health outcomes for any one individual. Alternative methods of pulmonary rehabilitation delivery, for example, telerehabilitation, may improve program access, but also could affect response to rehabilitation.

RESEARCH QUESTION: What is the rate of clinical response to home-based telerehabilitation compared with center-based pulmonary rehabilitation, and are any participant baseline characteristics associated with pulmonary rehabilitation response relative to the model of delivery?

STUDY DESIGN AND METHODS: In this secondary analysis of 2 randomized controlled trials, participants were categorized as responders or nonresponders according to achievement of the minimal important difference (MID) for each outcome of interest at end rehabilitation and after the 12-month follow-up (change from baseline). Outcomes of interest were functional exercise capacity (6-minute walk distance; MID, 30 m), health-related quality of life (chronic respiratory disease questionnaire [CRQ]: MID, 2.5, 2, 3.5, and 2 points for the dyspnea, fatigue, emotion, and mastery domains, respectively; CRQ total score MID, 10 points); and symptoms (modified Medical Research Council [mMRC]: MID, -1 point).

RESULTS: Two hundred sixty-six individuals with COPD were included in the analysis. The proportion of responders was not different between center-based pulmonary rehabilitation and home-based telerehabilitation at either end rehabilitation or 12-month follow-up for any outcome (range, 39%-62%). In a binary logistic regression analysis, baseline outcome values, but not participant demographic characteristics, were associated most commonly with responder status. The relative risk of program noncompletion in the center-based group was nearly 4 times greater than for telerehabilitation (center-based pulmonary rehabilitation: n = 79 [58%] vs home-based telerehabilitation: n = 116 [90%]; relative risk, 3.89; 95% CI, 2.28-6.63).

INTERPRETATION: Responder status to pulmonary rehabilitation was not different between center-based and home-based telerehabilitation. The ability to identify patient characteristics that confer greater potential for rehabilitation response or better suitability for a particular model of rehabilitation remains a challenge. CHEST 2024; ■(■):■-■

KEY WORDS: COPD; minimal important difference; pulmonary rehabilitation; telehealth; telerehabilitation

Take-Home Points

Study Question: What is the rate of clinical response to home-based telerehabilitation compared with center-based pulmonary rehabilitation and are participant baseline characteristics, program completion, or program location associated with rehabilitation response?

Results: The proportion of responders to rehabilitation is not different between center-based and home-based telerehabilitation programs; however, the risk of program noncompletion is 4 times higher for center-based rehabilitation.

Interpretation: Responder status to pulmonary rehabilitation was not different between center-based and home-based telerehabilitation, although rehabilitation completion was higher for home-based telerehabilitation. Identifying participant features that confer greater potential for rehabilitation response, or better suitability for a particular model of rehabilitation, remains a challenge.

Pulmonary rehabilitation consistently has been demonstrated to improve symptoms, function, and quality of life for people with chronic respiratory disease across multiple clinical trials.¹⁻⁴ Similar findings are emerging for studies of pulmonary rehabilitation delivered remotely by telerehabilitation, even with substantial heterogeneity in delivery models.⁵ However, individual patients do not always respond to rehabilitation to the same extent,⁶ with responses to rehabilitation spanning from improvements that exceed the minimal important difference (MID) to worsening of outcomes for some patients at the end of rehabilitation.^{7,8} Whether the proportion of individuals who respond to pulmonary rehabilitation or the patient features associated with greater likelihood of responding vary across the different models of rehabilitation delivery is not well established.

Telerehabilitation is the delivery of pulmonary rehabilitation services at a distance, making use of

information technology, communication technology, or both.⁹ Such remote delivery of pulmonary rehabilitation services has the potential to broaden access to programs for people with chronic respiratory disease.¹⁰ In addition, remote models of rehabilitation delivery have been associated with greater likelihood of rehabilitation completion,⁵ an important consideration for any rehabilitation delivery model, given that program completion is associated with a 56% reduction in hospitalization in the following year (hazard ratio, 0.439; $P = .02$),¹¹ with associated health system cost savings ($> \$10,000/\text{patient}$).¹¹⁻¹³ However, telerehabilitation is not a suitable program model for all patients. Key barriers to accessing remotely delivered rehabilitation include limited access to devices and technology, lack of suitable platforms for people with vision and hearing impairments, safety concerns for those with comorbidities who are frail or live alone, and patient preference for in-person rehabilitation models.¹⁴ Understanding the phenotypic characteristics of pulmonary rehabilitation attendees that are associated with better outcomes has the potential to inform a personalized management approach to the delivery of pulmonary rehabilitation for all patients.¹⁵

This was a secondary analysis of pooled data from 2 randomized controlled equivalence trials. The aim of this study was to determine the rate of responders to home-based telerehabilitation compared with center-based pulmonary rehabilitation for key outcomes of functional exercise capacity, quality of life, and symptoms and to explore whether baseline characteristics of participants, program completion, or program location were associated with response to pulmonary rehabilitation. We hypothesized that the proportion of responders to pulmonary rehabilitation would be the same regardless of model of rehabilitation delivery (home-based telerehabilitation or center-based pulmonary rehabilitation) and that particular patient characteristics would be associated with rehabilitation responders that would differ based on method of delivery (home-based telerehabilitation or center-based pulmonary rehabilitation).

ABBREVIATIONS: 6MWD = 6-minute walk distance; MID = minimal important difference

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Study Design and Methods

This secondary analysis incorporated participants from 1 of 2 randomized controlled trials of home-based telerehabilitation (telephone or videoconferencing) compared with center-based pulmonary rehabilitation (Alfred Health Human Research Ethics Committee project approval Identifiers: 261/11, H2011/04364, and HREC15/Alfred/101) between 2012 and 2020.^{11,16} In one of the original trials, only people with COPD were recruited (n = 166), whereas in the other, people with a chronic respiratory disease, including COPD, interstitial lung disease, bronchiectasis, or asthma, were eligible for inclusion (total cohort, n = 142; total with COPD, n = 100). For the purposes of this analysis, only participants with a diagnosis of COPD were included (n = 266). To be included in either of the two parent trials, participants were those who received a diagnosis of a chronic respiratory disease, were referred to outpatient pulmonary rehabilitation, and had not completed pulmonary rehabilitation within the previous 18 months (unless they had experienced a respiratory exacerbation requiring hospitalization).

The rehabilitation interventions and findings of the between-group comparisons have been described extensively.^{11,16} In short, all programs were of 8 weeks' duration, in keeping with recommended standards.¹⁷ Center-based pulmonary rehabilitation comprised 2 in-person sessions per week. Two models of home-based telerehabilitation were evaluated, one delivered by telephone and the other by video. Both comprised a home visit with a physiotherapist for the first session. After the home visit, home-based telerehabilitation via videoconferencing continued with 2 sessions per week with real-time supervision of exercise training, whereas home-based telerehabilitation via telephone consisted of 7 once-weekly telephone calls for exercise progression and goal setting with a physiotherapist trained in motivational interviewing. Education and self-management training were individualized to all participants and were available either in a group or one-on-one based on a rehabilitation model of delivery and patient needs.^{11,16} In addition, all participants were provided with printed and online self-management education resources produced by Lung Foundation Australia.¹⁸

Data are presented as number (percentage), mean (SD), or median (interquartile range), depending on distribution of normality. The number of participants

randomized and the number with end rehabilitation assessments and 12-month assessments are reported by outcome of interest. The primary outcome for this analysis was the number of responders for functional exercise capacity, quality of life, and symptoms for each model of delivery (home-based telerehabilitation vs center-based pulmonary rehabilitation) at end rehabilitation. Home-based telerehabilitation outcomes from the two trials (telephone or videoconferencing) were pooled for analysis because both models met the definition of telerehabilitation.⁵ The responder analysis involved categorizing participants as responders or nonresponders according to achievement of the MID for each outcome of interest. Change from baseline to end rehabilitation and baseline to 12 months indicated responder status at each time point. The MID for evaluation was 30 m for the 6-minute walk distance (6MWD)¹⁹; 0.5 points per domain item of the chronic respiratory disease questionnaire representing 2.5 points, 2 points, 3.5 points, and 2 points for the dyspnea, fatigue, emotion, and mastery domains, respectively, and 10 points for chronic respiratory disease questionnaire total score²⁰; and -1 point for the modified Medical Research Council score.²¹

Risk ratios for the achievement of a clinically meaningful change in outcomes of interest at end rehabilitation, with 95% CIs, were calculated. The number of participants who achieved the MID for key outcomes (ie, responders) at end rehabilitation and 12 months of follow-up was compared between home-based telerehabilitation and center-based pulmonary rehabilitation using χ^2 tests.

Binary logistic regression (responder vs nonresponder) was used to detect predictors of response for 6MWD and chronic respiratory questionnaire, including location of pulmonary rehabilitation (home-based telerehabilitation vs center-based pulmonary rehabilitation). Demographic characteristics were determined a priori (age, sex, disease severity [FEV₁ % predicted]), breathlessness (baseline chronic respiratory questionnaire dyspnea domain score), and controlling for baseline test performance. Rehabilitation completer status (yes vs no) also was considered in determining predictors of response, with program completion defined as attendance at $\geq 70\%$ of prescribed sessions. The relative risk of noncompletion in the center-based pulmonary rehabilitation group was compared with that in the home-based telerehabilitation group.

Results

The total number of participants with COPD was 266. Of these, 166 individuals were randomized in the study of home-based telerehabilitation via telephone compared with center-based pulmonary rehabilitation, and 100 individuals in the study were randomized to home-based telerehabilitation via videoconferencing compared with center-based pulmonary rehabilitation. Typical travel distance from home to the center for participants undertaking center-based pulmonary rehabilitation was a median of 8 km (range, 1-100 km) and for telerehabilitation was a median of 10 km (range, 1-115 km). The primary method of transportation to attend center-based programs was by car.

Characteristics of included participants are presented in Table 1. Disease severity, number of comorbid

TABLE 1] Characteristics of Participants

Characteristic	Center-Based PR (n = 136)	Telerehabilitation (n = 130)
Age, y	68 (10)	69 (9)
Male/female sex, No.	63/73	57/73
Smoking status		
Current	25 (18%)	21 (16%)
Former	109 (80%)	108 (83%)
Unknown	2 (1%)	1 (1%)
FEV ₁		
L	1.3 (0.6)	1.3 (0.5)
% Predicted	51 (21)	51 (20)
FVC		
L	2.8 (0.9)	2.8 (0.8)
% Predicted	82 (23)	80 (20)
FEV ₁ to FVC ratio, %	47 (16)	47 (16)
BMI, kg/m ²	27 (6)	28 (7)
LTOT	9 (7%)	10 (8%)
No. of comorbidities	4 (2-5)	4 (2-5)
6MWD, m	413 (99)	394 (119)
CRQ score		
Dyspnea scale	15 (6)	14 (5)
Fatigue scale	15 (5)	14 (6)
Emotion scale	32 (9)	32 (10)
Mastery scale	19 (5)	19 (6)
Total	81 (20)	80 (21)
mMRC score	2 (1-2)	2 (1-3)
PRAISE	47 (8)	48 (7)

Data are presented as No.(%), mean (SD), or median (interquartile range). 6MWD = 6-minute walk distance; CRQ = chronic respiratory disease questionnaire; LTOT = long-term oxygen therapy; mMRC = modified Medical Research Council; PR = pulmonary rehabilitation; PRAISE = Pulmonary Rehabilitation Adapted Index of Self-Efficacy.

conditions, and previous smoking history were similar across groups and trials. The number of participants randomized and data available for each outcome measure by group and time point (end rehabilitation, 12-month follow-up) are presented in Table 2. Because the volume of missing data was relatively small and was similar between groups, multiple imputation was not performed. The proportion of responders for functional exercise capacity, health-related quality of life, and symptoms was not different between center-based pulmonary rehabilitation and home-based telerehabilitation at either end rehabilitation or the 12-month follow-up (Table 3). No difference was found between groups at end rehabilitation in the relative risk of being a responder for any outcome (e-Table 1).

In a binary logistic regression analysis, rehabilitation model (center-based pulmonary rehabilitation vs home-based telerehabilitation) did not predict responder status for functional exercise capacity, symptoms, or quality of life (e-Table 3). Baseline outcome values, but not participant demographic characteristics, were associated most consistently with responder status. Pulmonary rehabilitation completion was associated with a > 2 times greater likelihood of 6MWD response. The relative risk of program noncompletion in the center-based pulmonary rehabilitation group was nearly 4 times greater than for home-based telerehabilitation (pulmonary rehabilitation completion: center-based, n = 79 [58%] vs home-based telerehabilitation, n = 116 [90%]; relative risk, 3.89; 95% CI, 2.28-6.63).

To explore whether method of home-based telerehabilitation delivery (videoconferencing vs telephone) was associated with responder status, a post hoc analysis by type of telerehabilitation (telephone vs videoconferencing) also was completed. The proportion of responders for functional exercise capacity, quality of life, or symptoms was not different when method of telerehabilitation (telephone vs videoconferencing) was considered (Fig 1), nor was the relative risk of being a responder (e-Table 2).

Discussion

This analysis demonstrated that the responder rate for pulmonary rehabilitation is not different between models of program delivery (center-based pulmonary rehabilitation vs home-based telerehabilitation), nor for method of telerehabilitation delivery. For the core rehabilitation outcomes of functional exercise capacity, health-related quality of life, and symptoms,²³ baseline

TABLE 2] Number of Participants Randomized and With Assessment Data by Outcome

Outcome	MID	Center-Based PR			Telerehabilitation		
		Randomized	End Rehabilitation Data	12 -Month Data	Randomized	End Rehabilitation Data	12-Month Data
6MWD	30 m	136	111	89	130	111	80
CRQ-D score	2.5 points	136	127	102	130	119	98
CRQ-F score	2 points	136	126	102	130	121	99
CRQ-E score	3.5 points	136	126	102	130	121	99
CRQ-M score	2 points	136	126	102	130	121	99
CRQ total score	10 points	136	126	102	130	121	98
mMRC	-1 point	136	126	99	130	120	99

Data are presented as No. unless otherwise indicated. CRQ = chronic respiratory disease questionnaire; CRQ-D = chronic respiratory disease questionnaire dyspnea domain; CRQ-E = chronic respiratory disease questionnaire emotion domain; CRQ-F = chronic respiratory disease questionnaire fatigue domain; CRQ-M = chronic respiratory disease questionnaire mastery domain; ECT = endurance cycle test; MID = minimal important difference; mMRC = modified Medical Research Council; PR = pulmonary rehabilitation.

values were the only consistent predictors of response status. Our findings are in keeping with the one other randomized controlled trial, of modest sample size, describing response status by method of rehabilitation (center-based pulmonary rehabilitation vs video-based telerehabilitation).²⁴ Likewise, across multiple analyses, no participant characteristics that reliably predict response status at end rehabilitation were clearly identifiable,²⁵ with the exception that those with poorer baseline status typically are more likely to demonstrate improvement after rehabilitation.^{8,26,27} What intrinsic behavioral factors also contribute to successful rehabilitation response is difficult to quantify.²⁸

The proportions of rehabilitation responders across outcome measures observed in these studies range from 39% to 62% at end rehabilitation to 35% to 50% at the 12-month follow-up. These rates are similar to, albeit lower, for functional exercise capacity specifically, those reported in a UK national clinical audit evaluation of service provision in which 65% and 56% of program participants achieved meaningful improvements in functional exercise capacity and health status, respectively.²⁹ This discrepancy between rehabilitation responders in a randomized clinical trial setting and practice audit data may represent a difference in population under review. In the two studies analyzed here, 48% of people who declined to participate did so because they had a preference for rehabilitation location. Whether the proportion of patients classified as responders to pulmonary rehabilitation is enhanced when rehabilitation is undertaken in the location preferred by participants is not known. Regardless, for most outcomes, less than half of all people achieved a

clinically meaningful response to pulmonary rehabilitation, reinforcing previous descriptions of variability in rehabilitation response.³⁰ Although pulmonary rehabilitation already comprises individually tailored therapies of exercise and education,¹⁰ responder variability highlights that personalizing additional aspects of rehabilitation delivery, in response to patient evaluation and clinical judgment, may be required to give patients the greatest opportunity of achieving meaningful improvement.

Evidence for telerehabilitation models of pulmonary rehabilitation delivery is not yet as extensive as the evidence that exists for center-based programs. Although clinical outcomes have been demonstrated to be similar for telerehabilitation when compared with those of center-based rehabilitation,⁵ telerehabilitation programs need to reflect the essential components of pulmonary rehabilitation,^{10,31} as was the case in this study, to ensure that patients receive quality rehabilitation. Program components of telerehabilitation models evaluated to date are heterogeneous.⁵ The nature and extent of contact between patient and clinician and equipment used for rehabilitation (minimal vs specialized exercise and technology equipment) varies widely. Even within this analysis, both video and telephone telerehabilitation were used. Despite this variability, no difference in responder rate relative to home-based telerehabilitation method of delivery was determined. Of note, in the two original randomized controlled trials, within-group improvement, particularly for functional exercise capacity, did not reach the MID (MID for 6MWD, ≥ 30 m³²). This is a common criticism of many modern pulmonary rehabilitation clinical trials. The 2015 Cochrane Review of pulmonary

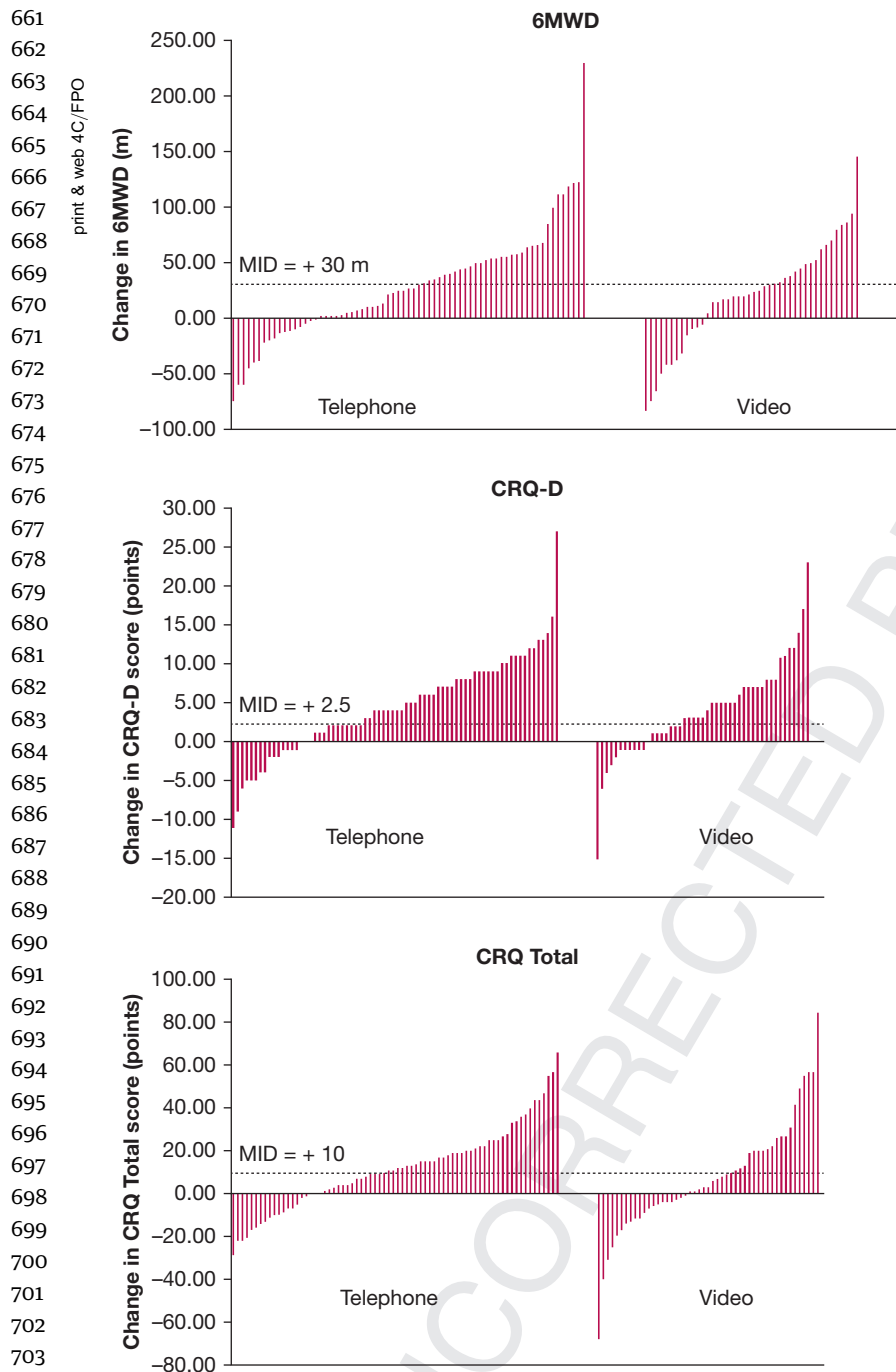
TABLE 3] Group Change Data and Responder Status at End of Rehabilitation and 12 Months

Outcome	End of Rehabilitation				12 Months				P Value (Between-Group Responder Status)
	Center-Based PR		Telerehabilitation		Center-Based PR		Telerehabilitation		
	Group Change From Baseline	Responders	Group Change From Baseline	Responders	Group Change From Baseline	Responders	Group Change From Baseline	Responders	
6MWD	18 (8-28)	44 (40)	26 (16-35)	50 (46)	2 (-16 to 19)	32 (36)	4 (-12 to 20)	29 (36)	1.000
CRQ-D score	3.4 (2.3-4.6)	72 (57)	4.3 (3.1-5.4)	72 (61)	1.7 (0.3 to 3.1)	48 (47)	1.1 (-0.3 to 2.4)	39 (40)	.372
CRQ-F score	1.4 (0.5-2.3)	69 (55)	2.1 (1.1-3.1)	62 (51)	1.5 (0.5-2.6)	57 (56)	1.3 (-0.02 to 2.5)	43 (44)	.120
CRQ-E score	2.9 (1.3-4.5)	57 (45)	2.4 (0.7-4.1)	50 (41)	2.8 (1.1-4.5)	49 (48)	2.8 (0.9-4.7)	42 (42)	.511
CRQ-M score	2.1 (1.3-2.9)	66 (52)	1.6 (0.5-2.8)	59 (49)	1.3 (0.2-2.3)	52 (51)	1.1 (-0.2 to 2.3)	43 (43)	.352
CRQ total score	9.8 (6.4-13.3)	60 (48)	10.0 (6.0-14.1)	59 (49)	7.3 (3.3-11.3)	45 (44)	6.3 (1.5-11.0)	40 (41)	.742
mMRC scale score	-0.2 (-0.3 to -0.003)	44 (35)	-0.3 (-0.4 to -0.1)	45 (38)	0.3 (0.02-0.5)	22 (22)	0.1 (-0.2 to 0.3)	32 (32)	.151

Data are presented as No. (% available assessment data) or mean (95% CI) unless otherwise indicated. P value between group responder status determined with the χ^2 test. Asymptotic significance, continuity correction. 6MWD = 6-minute walk distance; CRQ = chronic respiratory disease questionnaire; CRQ-D = chronic respiratory disease questionnaire dyspnea domain; CRQ-F = chronic respiratory disease questionnaire fatigue domain; CRQ-E = chronic respiratory disease questionnaire emotion domain; CRQ-M = chronic respiratory questionnaire mastery domain; mMRC = modified Medical Research Council; PR = pulmonary rehabilitation.

rehabilitation compared with usual care identified a mean improvement in 6MWD with rehabilitation exceeding the 30 m MID.¹ However, when a sensitivity analysis of the included trials at lower risk of bias was undertaken, a lower mean improvement was demonstrated (MD, 26 m; 95% CI, 21-32; 20 studies; n = 1,188; moderate quality evidence).¹⁷ In the two trials under consideration herein, the effect of the interventions fell largely within the 95% CI of this sensitivity analysis, suggesting that the response rates seen in our analysis may be consistent with those in previous trials, although a responder analysis is reported rarely in older studies.

The risk of failing to complete a program of pulmonary rehabilitation was significantly greater in the center-based rehabilitation group. Reports are increasingly consistent that telerehabilitation models of delivery are associated with higher program completion rates.^{5,33} This is unsurprising, especially for telerehabilitation models delivered into the home, because of addressing key patient-reported barriers to program attendance relating to travel and transport.³⁴ Patients have emphasized that the benefits of home-based telerehabilitation programs include their flexibility and convenience, while still receiving support and motivation from the clinical team and their peers.^{14,35} Despite higher completion rates with home-based telerehabilitation, program completion predicted response only for 6MWD outcome, and not for health-related quality of life or symptoms. This likely reflects the dose-response relationship associated with exercise training, whereas exercise training dose alone has little impact on perceived quality of life and symptoms.³⁶ Regardless, providing program delivery models that best support patients to complete rehabilitation is critically important, particularly given that rehabilitation completion is associated with reduced likelihood of hospital admission in the 12 months after pulmonary rehabilitation.^{11,13} Avoiding hospital admission is one of the most important treatment outcomes identified by people with COPD.³⁷ Likewise, rehabilitation completion and subsequent reduction in hospital admissions provides cost savings for the health system.^{11,13} Although costs are associated with the establishment of a telerehabilitation program, the value ascribed to telerehabilitation in terms of improved access, reduced health care use and its associated costs, and benefits accrued by patients may be considered to counterbalance the requirement for program spending.³⁸



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Figure 1 – A-C, Graphs showing the interindividual variability in change in functional capacity (ie, 6MWD) (A), symptoms (ie, CRQD) (B), and HRQOL (ie, CRQ total) (C) by telerehabilitation model at end rehabilitation. 6MWD = 6-minute walk distance; CRQ-D = chronic respiratory disease questionnaire dyspnea domain; HRQOL = health-related quality of life; MID = minimal important difference.

Both of the clinical trials that informed this analysis were undertaken in the same geographic region of Australia, which may place limitations on the generalizability of our findings. However, illustrating the diversity of the included individuals, participants were recruited from rehabilitation sites located in diverse sociodemographic metropolitan areas, as well as rural settings located > 400 km from the site of the treating telerehabilitation clinician. Additionally, we were unable

to categorize participants according to Global Initiative for Chronic Obstructive Lung Disease A, B, and E classifications because exacerbations in the year before rehabilitation were not collected as part of the baseline evaluation. However, participants did represent the spectrum of disease severity and functional status based on lung function and exercise capacity assessments. Our results are in keeping with the one other randomized clinical trial evaluation of responder status by location of

771 rehabilitation delivery,²⁴ which may help to alleviate any
772 concerns regarding applicability of our findings. In
773 addition, a recent real-world evaluation of outcomes for
774 home-based telerehabilitation (videoconferencing) and
775 center-based pulmonary rehabilitation—in which
776 patients selected their preferred rehabilitation location—
777 also reported a comparable proportion of patients (44%-
778 45%) achieving a clinically meaningful response for
779 functional capacity outcomes regardless of rehabilitation
780 delivery model.³⁹

783 Interpretation

784 Responder status to pulmonary rehabilitation was not
785 different between center-based and home-based
786 telerehabilitation models of delivery. Although center-
787 based pulmonary rehabilitation remains the gold
788 standard model of program delivery, telerehabilitation
789 models demonstrate similar clinical outcomes and
790 significantly increase the likelihood of program
791 completion.

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796 A. T. B., C. J. H., and J. B. acquired, analyzed, and interpreted the data. N. S. C. drafted the
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798 C. J. H., and J. B. provided critical appraisal
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826 completion. The ability to identify specific patient
827 characteristics that confer greater potential for
828 responding to rehabilitation or are better suited to a
829 particular model of rehabilitation delivery remains a
830 challenge.

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