Rapid real-world implementation of pulmonary telerehabilitation: good fortune or COVID-19 luck?

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To the Editor:

Pulmonary rehabilitation (PR) is a recommended component of care for people with chronic respiratory disease [1], with benefits supported by robust evidence [2]. As a result of significant barriers to attending outpatient PR, alternative models of programme delivery have been increasingly studied [3]. Current evidence suggests that telerehabilitation delivered in clinical trial settings achieves similar outcomes to traditional centre-based PR [4, 5]. However, pre-coronavirus disease 2019 (COVID-19), real-world implementation of telerehabilitation was limited to models making use of minimal equipment and without real-time supervision of exercise training [6] or those that required patients to attend a centre to undertake rehabilitation [7]. This may be a consequence of limited knowledge and confidence of health professionals in programme implementation and adaptation of programmes to their local context [8], or the delay between evidence generation and clinical implementation [9]. The aim of this process evaluation was to prospectively describe the implementation of a home-based, advanced technology telerehabilitation programme into a real-world clinical service within the context of the COVID-19 pandemic. We specifically sought to address the question "what factors are associated with clinical implementation of a programme of telerehabilitation for people with chronic respiratory disease?"

From August 2016 to May 2020 we conducted a randomised controlled equivalence trial comparing home-based telerehabilitation to centre-based PR [5]. In response to COVID-19 restrictions on in-person delivery of PR, commencing in September 2020 individuals referred to PR at Alfred Health (Melbourne, Australia) were offered the option of an 8-week home-based telerehabilitation programme comprising one home-visit followed by twice weekly virtual group sessions which encompassed exercise training with real-time supervision and self-management education. According to our published model [5], and using resources procured during the clinical trial, equipment for videoconferencing and exercise training, including an exercise bike, tablet device and monitoring equipment was provided to patients, as necessary. All participants were prescribed an individually tailored training programme of both aerobic and resistance exercise. Disease-specific education and self-management training topics were individualised based on patient-identified need. In a departure from trial procedures, all participants undertaking real-world telerehabilitation were required to have their own internet (WiFi) access. Standard PR assessments [3] were conducted pre- and post-programme, and programme completion was defined as undertaking ⩾70% of prescribed sessions. Real-world implementation was evaluated against the RE-AIM framework (reach, effectiveness, adoption, implementation, maintenance) [10] with assessment outcomes guided by the framework and determined *a priori*.

Statistical analyses were conducted using IBM SPSS statistics (version 29.0; IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as mean±SD or median (interquartile range). Categorical variables are reported descriptively (n, %). Clinical outcomes were analysed using paired t-tests or the nonparametric equivalent, depending upon distribution. Ethics approval to report the implementation evaluation was received prospectively (Alfred Health HREC project 723/20), including waiver of the requirement for informed consent.

Reach was determined by total number of PR referrals, participant characteristics, attendance and completion of assessments and rehabilitation sessions (table 1). In the 33-month evaluation period to June

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"Real-world" telerehabilitation achieves clinically meaningful outcomes for patients and may improve access to pulmonary rehabilitation, but implementation into practice may have been aided by COVID-19-related support for telehealth https://bit.ly/3NqYdCC

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TABLE 1 Outcome data according to the RE-AIM (reach, effectiveness, adoption, implementation, maintenance) framework

	Outcome
Reach: the extent to which the intervention reaches the target population	
Total number of people referred to PR	1166
Initial assessments completed	422 (36)
Number commenced telerehabilitation	66 (16)
Participant characteristics	
Male:female	37:29
Age years	60±11
Diagnosis	
COPD	13 (20)
ILD	18 (27)
Bronchiectasis	6 (9)
Asthma	2 (3)
Pulmonary hypertension	4 (6)
Post-COVID-19	13 (20)
Other	10 (15)
FEV_1 L	2.02±0.9
FEV_1 % predicted	68.7±27.3
FVC L	3.23±1.47
FVC % predicted	81.9±21.6
Smoking status	
Current	2 (3)
Quit	41 (62)
Never	22 (33)
Unknown	1 (2)
BMI $kg \cdot m^{-2}$	29.2±5.9
Prior experience of videoconferencing	57 (95)
Number of home-visits completed	62 (including 9 remote home-visits)
Programme completers for primary PR (⩾70% prescribed sessions)	47 (73)
Effectiveness: the impact of an intervention on important outcomes	
Clinical outcomes change from baseline	
CRQ dyspnoea domain[#]	3.7 (0.9–6.4)[+,*]
CRQ emotion domain[#]	3.2 (0.5–5.8)[+,*]
CRQ fatigue domain[#]	2.1 (0–4.2)[+,*]
CRQ mastery domain[#]	1.6 (−0.0–3.2)
mMRC dyspnoea scale[¶]	Baseline 2 (1–3) *versus* end PR 1 (1–2)[+,*]
HADS Anxiety[¶]	Baseline 5 (2–9) *versus* end PR 5 (1–9)
HADS Depression[¶]	Baseline 5 (3–9) *versus* end PR 3 (1–6)
CAT[#]	−0.6 (−2.2–1.1)
6MWD[#]	20 (6–34)*
Adverse events	2
Adoption: organisational support to deliver the intervention	
New staff trained to deliver telerehabilitation	8
New staff trained to undertake home-visits	4
Implementation: at both the setting and individual level: fidelity of intervention delivery; intervention adaptations	
Delivery of programme components	
Home-visits undertaken	62
Time for home-visits min	92±28
Total time for home-visits (visit+travel) min	136±63
Number to attend ⩾1 education session	17 (26)
Programme adaptations	All participants supplied own WiFi 25 (38%) supplied own exercise equipment or internet-enabled device
Number of telerehabilitation sessions completed per participant[¶]	14 (11–16)
Maintenance: the extent to which a programme or policy becomes institutionalised or part of the routine organisational practices and policies	
Ongoing programme delivery	Purchase of 8 dedicated telerehabilitation kits
Ongoing home exercise programme prescribed/referred	64 (97)

Data are presented as n, n (%) or mean±SD, unless otherwise stated. PR: pulmonary rehabilitation; ILD: interstitial lung disease; COVID-19: coronavirus disease 2019; FEV_1: forced expiratory volume in 1 s; FVC: forced vital capacity; BMI: body mass index; CRQ: Chronic Respiratory Disease Questionnaire; mMRC: modified Medical Research Council; HADS: Hospital Anxiety and Depression Scale; CAT: COPD Assessment Test; 6MWD: 6-min walk distance. [#]: mean difference (95% CI); [¶]: median (interquartile range); [+]: exceeds minimal important difference. *: $p<0.05$.

2023, 1166 people were referred with 422 initial assessments conducted (36% of those referred). 66 programmes of telerehabilitation were embarked upon (16% of all initial assessments), representing 60 unique individuals who undertook a total of 777 sessions. Telerehabilitation was undertaken twice in the evaluation period by six individuals. 42 post-rehabilitation assessments were completed (reasons for noncompletion: self-discharge n=5 (after range 1–10 telerehabilitation sessions); received lung transplant n=2; failed to start programme n=3; transitioned to centre-based PR n=1; did not attend assessment n=8; medically unable n=3; ongoing maintenance attendee n=1; assessment completed as part of other clinical trial n=1). 73% (n=47) of participants achieved programme completion.

Effectiveness was evaluated by clinical outcomes and the occurrence of adverse events. Participants demonstrated statistically significant and clinically meaningful improvements in quality of life (Chronic Respiratory Disease questionnaire) and symptoms (modified Medical Research Council scale) (table 1). In addition, a significant improvement in exercise capacity from baseline was demonstrated (mean change in 6-min walk distance 20 m), although this did not exceed the minimal important difference (table 1). Adverse events were reported for two participants who each had a single episode of dizziness during exercise (cycle) training, resulting in increased rest periods during session or cessation of training for that day.

Adoption was demonstrated by the training of staff in the programme model. Eight new staff members were trained to deliver telerehabilitation, with four trained to deliver the home-visit component of the intervention.

Implementation at both the intervention and individual level was evaluated (table 1). An initial home-visit was completed by 62 (94%) participants, with nine undertaken remotely. To support implementation, programme adaptations included the requirement for all participants to have their own WiFi, and more than one-third (n=25, 38%) supplied their own exercise equipment or internet-enabled device. 27 (41%) participants experienced a total of 64 equipment issues (low battery charge n=5; issues with sound/audio connectivity n=22; difficulties logging on to videoconferencing session n=19; exercise equipment n=5; instruction to reposition equipment n=4; internet connectivity issues n=9).

Maintenance of programme delivery was determined at the service and individual level. The health service has opted to continue offering telerehabilitation, facilitated by COVID-19 contingency funding that enabled the purchase of eight dedicated telerehabilitation equipment kits. This equipment is now maintained and operated by the clinical service, and allowed for decommissioning of the original trial-funded equipment. Whether programme maintenance would have been achievable without funding for new equipment infrastructure is unclear. At an individual level, aside from two participants who received a lung transplant, all participants were provided with an ongoing home exercise programme or onward referral to local group exercise programmes at rehabilitation completion.

This implementation evaluation demonstrates that advanced technology telerehabilitation can be adapted to individual patient needs and local context; but does require health service support for infrastructure, which may have been opportunistically available within the prism of COVID-19 [11]. Telerehabilitation did allow for the delivery of PR when centre-based programmes were not available, with participants demonstrating clinical improvements following rehabilitation in keeping with those reported in clinical trials [4, 5]. Additionally, this real-world application of telerehabilitation indicates its utility as a programme model for a broader diagnostic group than typically studied in clinical trials [4], including in individuals recovering from COVID-19. However, whether patient, clinician, health system and payer acceptance of real-world telerehabilitation implementation can be maintained in the absence of the pandemic-driven surge for remote healthcare remains to be seen.

Despite the potential for home-based telerehabilitation to support PR access, including during the COVID-19 pandemic, programme models using both equipment and technology are not for everyone. Just 16% of all individuals assessed for PR in the evaluation period went on to undertake a programme of telerehabilitation. That multiple models of pulmonary rehabilitation were available to patients referred to our service, and patients were free to choose the model of rehabilitation most suitable to their needs in discussion with their pulmonary rehabilitation clinician may have contributed to the very modest uptake of telerehabilitation. Likewise, participants were required to have their own WiFi access at home, which may have served to limit the number of eligible candidates for telerehabilitation. Lack of access or experience of internet-enabled devices are well-established barriers to telehealth-delivered care [12]. Similarly, the frequency of technology or equipment issues experienced by participants could have implications for user experience and programme adherence with wide-scale implementation. There is a now well-established

digital divide in access to remotely delivered healthcare, with individuals from lower socioeconomic groups, ethnic minorities and non-English speaking backgrounds being less likely to take up offers of healthcare delivered *via* videoconferencing [13]. Additionally, people with chronic respiratory disease have demonstrated preference for face-to-face healthcare delivery [14], despite reporting increasing familiarity with technology and willingness to consider remotely delivered rehabilitation programme models [15]. However, the conservative uptake of telerehabilitation seen in this real-world setting (16%) is in keeping with the proportion of older people (15%) who reported engaging with telehealth consultations in a post-pandemic evaluation (December 2022); although an ongoing preference for audio-only communication was demonstrated [12].

Use of the RE-AIM framework to evaluate the clinical implementation of home-based telerehabilitation provides an objective assessment of context and resources that may be applicable in other healthcare jurisdictions looking to deliver alternative models of PR. However, the unique intersection of the COVID-19 pandemic, surge in telehealth availability and the conclusion of the phase III telerehabilitation trial in enabling rapid clinical implementation cannot be overlooked. The ongoing economic sustainability of advanced technology telerehabilitation programmes requires evaluation; however, cost-effectiveness for home-based PR has been demonstrated [16] and is primarily associated with programme completion. When compared to real-world centre-based rehabilitation programmes, where completion rates are often less than two-thirds [17], that nearly 75% of all participants achieved programme completion suggests that telerehabilitation provides an acceptable programme delivery option for those who are willing and able to participate. Additionally, clinician acceptance of telerehabilitation is still variable. While we did not qualitatively evaluate clinician experience of delivering telerehabilitation in this evaluation, clinicians have expressed a preference for face-to-face healthcare delivery and a lack of confidence in the use of technology [18]. Work to ensure the long-term feasibility and widespread acceptance of telerehabilitation is still required. Although rapid programme implementation of telerehabilitation was able to be achieved, in this instance it may have been expedited by COVID-related "good luck".

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References

1 Global Initiative for Chronic Obstructive Lung Disease (GOLD). Global Strategy for the Diagnosis, Management and Prevention of COPD. 2023. https://goldcopd.org
2 McCarthy B, Casey D, Devane D, *et al.* Pulmonary rehabilitation for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev* 2015; 2: CD003793.
3 Holland AE, Cox NS, Houchen-Wolloff L, *et al.* Defining modern pulmonary rehabilitation. An official American Thoracic Society workshop report. *Ann Am Thorac Soc* 2021; 18: e12–e29.
4 Cox N, Dal Corso S, Hansen H, *et al.* Telerehabilitation for chronic respiratory disease. *Cochrane Database Syst Rev* 2021; 1: CD013040.
5 Cox NS, McDonald CF, Mahal A, *et al.* Telerehabilitation for chronic respiratory disease: a randomised controlled equivalence trial. *Thorax* 2022; 77: 643–651.

6 Bondarenko J, Babic C, Burge AT, *et al.* Home-based pulmonary rehabilitation: an implementation study using the RE-AIM framework. *ERJ Open Res* 2021; 7: 00469-2020.

7 Alwakeel AJ, Sicondolfo A, Robitaille C, *et al.* The accessibility, feasibility, and safety of a standardized community-based tele-pulmonary rehab program for chronic obstructive pulmonary disease: a 3-year real-world prospective study. *Ann Am Thorac Soc* 2022; 19: 39–47.

8 Cox NS, Scrivener K, Holland AE, *et al.* A brief intervention to support implementation of telerehabilitation by community rehabilitation services during COVID-19: a feasibility study. *Arch Phys Med Rehabil* 2021; 102: 789–795.

9 Eng JJ, Bird M-L, Godecke E, *et al.* Moving stroke rehabilitation research evidence into clinical practice: consensus-based core recommendations from the Stroke Recovery and Rehabilitation Roundtable. *Neurorehabil Neural Repair* 2019; 33: 935–942.

10 Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *Am J Public Health* 1999; 89: 1322–1327.

11 World Health Organization (WHO). Implementing Telemedicine Services During COVID-19: Guiding Principles and Considerations for a Stepwise Approach. 2020. www.who.int/publications/i/item/WPR-DSE-2020-032?sequence=5 Date last updated: 7 May 2021.

12 Li KY, Marquis LB, Malani PN, *et al.* Perceptions of telehealth among older U.S. adults during the COVID-19 pandemic: a national survey. *J Telemed Telecare* 2023; in press [https://doi.org/10.1177/1357633X231166031].

13 Eberly LA, Kallan MJ, Julien HM, *et al.* Patient characteristics associated with telemedicine access for primary and specialty ambulatory care during the COVID-19 pandemic. *JAMA Netw Open* 2020; 3: e2031640.

14 Alexander DS, Kiser S, North S, *et al.* Exploring community members' perceptions to adopt a Tele-COPD program in rural counties. *Explor Res Clin Soc Pharm* 2021; 2: 100023.

15 Polgar O, Patel S, Walsh JA, *et al.* Digital habits of pulmonary rehabilitation service-users following the COVID-19 pandemic. *Chron Respir Dis* 2022; 19: 14799731221075647.

16 Burge AT, Holland AE, McDonald CF, *et al.* Home-based pulmonary rehabilitation for COPD using minimal resources: an economic analysis. *Respirology* 2020; 25: 183–190.

17 Nolan CM, Kaliaraju D, Jones SE, *et al.* Home *versus* outpatient pulmonary rehabilitation in COPD: a propensity-matched cohort study. *Thorax* 2019; 74: 996–998.

18 Inskip JA, Lauscher HN, Li LC, *et al.* Patient and health care professional perspectives on using telehealth to deliver pulmonary rehabilitation. *Chron Respir Dis* 2018; 15: 71–80.