



# Remote-delivered cardiac rehabilitation during COVID-19: a prospective cohort comparison of health-related quality of life outcomes and patient experiences

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## Aims

Enforced suspension and reduction of in-person cardiac rehabilitation (CR) services during the coronavirus disease-19 (COVID-19) pandemic restrictions required rapid implementation of remote delivery methods, thus enabling a cohort comparison of in-person vs. remote-delivered CR participants. This study aimed to examine the health-related quality of life (HRQL) outcomes and patient experiences comparing these delivery modes.

## Methods and results

Participants across four metropolitan CR sites receiving in-person (December 2019 to March 2020) or remote-delivered (April to October 2020) programmes were assessed for HRQL (Short Form-12) at CR entry and completion. A General Linear Model was used to adjust for baseline group differences and qualitative interviews to explore patient experiences. Participants ( $n=194$ ) had a mean age of 65.94 (SD 10.45) years, 80.9% males. Diagnoses included elective percutaneous coronary intervention (40.2%), myocardial infarction (33.5%), and coronary artery bypass grafting (26.3%). Remote-delivered CR wait times were shorter than in-person [median 14 (interquartile range, IQR 10–21) vs. 25 (IQR 16–38) days,  $P<0.001$ ], but participation by ethnic minorities was lower (13.6% vs. 35.2%,  $P<0.001$ ). Remote-delivered CR participants had equivalent benefits to in-person in all HRQL domains but more improvements than in-person in Mental Health, both domain [mean difference (MD) 3.56, 95% confidence interval (CI) 1.28, 5.82] and composite (MD 2.37, 95% CI 0.15, 4.58). From qualitative interviews ( $n=16$ ), patients valued in-person CR for direct exercise supervision and group interactions, and remote-delivered for convenience and flexibility (negotiable contact times).

## Conclusion

Remote-delivered CR implemented during COVID-19 had equivalent, sometimes better, HRQL outcomes than in-person, and shorter wait times. Participation by minority groups in remote-delivered modes are lower. Further research is needed to evaluate other patient outcomes.

## Keywords

Health-related quality of life • Patient experiences • Cardiac rehabilitation • Remote delivery • COVID-19

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## Implications for practice

- Remote-delivered cardiac rehabilitation (CR) offers an alternative method of CR delivery to achieving health-related quality of life outcomes.
- Patients report similar satisfaction with both methods but identify different strengths with each mode of delivery.
- Future research should focus on determining the efficacy, effectiveness, and cost-efficiency of different modes of delivery on exercise capacity, mortality, and hospital readmissions.

## Introduction

Cardiac rehabilitation (CR) is a Class 1, Level A recommended intervention for patients with coronary heart disease (CHD)<sup>1,2</sup> because of well-established benefits in reducing mortality and morbidity, and improving health-related quality of life (HRQL).<sup>3,4</sup> Comprehensive CR is typically outpatient-based, and delivered in-person by a multidisciplinary team.<sup>5</sup> Physical distancing restrictions implemented to reduce disease transmission during the coronavirus disease-19 (COVID-19) pandemic resulted in many services being suspended or having significantly reduced capacity and staffing, thus enforcing rapid adoption of remote delivery formats.<sup>6,7</sup>

Remote-delivered CR programmes via telehealth have been increasingly promoted as a viable option to improve access to secondary prevention support<sup>6,8</sup> and address barriers to participation related to travel and associated time demands.<sup>8</sup> Remote-delivered programmes have demonstrated efficacy and show potential for lowering costs for the healthcare system compared to in-person.<sup>9</sup> However, the need for additional staff time (group vs. individual sessions), access to adequate private office spaces, and required appropriate audio-visual equipment must also be considered. Systematic reviews have also shown that remote-delivered CR achieves comparable outcomes to in-person for reducing modifiable risk factors<sup>10</sup> and hospitalization,<sup>11</sup> and improving exercise capacity.<sup>12</sup> However, the impact on patient-focused outcomes such as HRQL and patient experiences, which provide important insights into the effect on patient's lives,<sup>13,14</sup> has not been well-investigated.

Assessing HRQL and patient experiences helps in refining CR programmes to improve participation and satisfaction, especially given the longstanding suboptimal overall CR uptake.<sup>15</sup> Using patient-centred research approaches focuses attention on determining which CR delivery method or component yields the most value from patients' perspectives.<sup>13,14</sup> The immediate and almost complete move from in-person to remote delivery that occurred internationally in March 2020 provides natural comparison cohorts to investigate these effects. Therefore, this study aimed to compare HRQL outcomes and experiences from in-person vs. remote-delivered CR.

## Methods

All reporting adhered to the STROBE Statement (Strengthening the Reporting of Observational Studies in Epidemiology).<sup>16</sup> The COREQ checklist (Consolidated Criteria for Reporting Qualitative Research) guided the rigour of qualitative reporting.<sup>17</sup>

## Study design

The study used a prospective observational cohort design comparing data from two naturally occurring modes of CR delivery at two time periods: traditional in-person (December 2019 to March 2020) and remote-delivered CR during COVID-19 pandemic restrictions (April to October 2020). A descriptive, qualitative study design was added to capture patient experiences of their CR programme.<sup>18</sup> Patients commencing in-person CR had an initial assessment and at least two supervised exercise sessions. There was a 2-week suspension of the programme during the enforcement of COVID 19 restrictions, and the small number of patients ( $n = 6$ ) affected by this transition period were asked to complete the rest of their sessions remotely. Patients in the remote delivery group received 100% telehealth-delivered CR.

## Study setting

This study was conducted across four publicly funded CR services (one tertiary referral and two district hospitals, and one community health centre) in one large metropolitan health district in Sydney, Australia. In these CR services, eligible patients were systematically screened by CR staff and referred to CR during hospital admission. A comprehensive initial CR assessment typically occurred 2–4 weeks after hospital discharge and includes medical history, review of current medications, risk factor profile, exercise and lifestyle behaviours, anxiety and depression screening, and exercise capacity to enable tailored exercise prescription. The exercise training sessions of 60 min occurred two to three times/week for 6–8 weeks. Education classes were delivered weekly by a multidisciplinary team with comprehensive secondary prevention content. At programme completion, patients have a comprehensive re-assessment and an individualized ongoing management plan discussed. For remote delivery, the initial assessment, progression of the exercise programme and completion assessment occurred via telephone or videoconferencing on a fortnightly basis with contact times negotiated with the patient. Education sessions were also offered weekly in small groups using videoconferences, covering the same contents as in-person, and were in addition to the fortnightly contacts. Communication method depended on patient's preference, capability, and technical resources available.

## Ethical considerations

Human Research Ethics and Governance Committee (HREC) approval was granted for all participating sites in this study (Ref. 2019/PID14063) and conforms with the principles outlined in the Declaration of Helsinki.<sup>19</sup>

## Recruitment

The CR staff screened potential patients for eligibility during the initial assessment. Participants were provided study information and an opportunity to discuss before giving written informed consent, in-person or by email or post.

Eligibility criteria included: (i) a referral diagnosis of CHD including myocardial infarction (MI) with or without percutaneous coronary intervention (PCI), elective PCI, and coronary artery bypass grafting (CABG), (ii) sufficient English proficiency to provide informed consent and complete the questionnaires, and (iii) no dementia diagnosis.

For the qualitative study, a purposive subsample of 16 patients completing the CR programme were invited to share their experiences via individual interview, seeking maximum variation for participating site, age, sex, and mode of delivery. Sampling concluded when data were rich and major themes well-saturated.

## Data collection

### Socio-demographic and clinical variables

All participating staff received training to standardize data collection methods. Data were extracted from the patient's CR records using a data form at CR entry for socio-demographic variables (age, sex, ethnicity, family status, education, and employment), clinical variables [primary reason for referral, comorbidities, hospital length of stay (LOS)], and CR wait time (days from hospital discharge to initial CR assessment). Data directly collected from patients occurred via a paper-based version (in-person) or by post, email, or an online survey link (remote-delivered).

### Health-related quality of life

Patients' HRQL was assessed using the 12-item Short Form Health Survey version 2 (SF-12v2) at CR entry and at completion. The SF-12v2 is a self-administered questionnaire that captures eight domains of HRQL: Physical Functioning, Role Physical, Bodily Pain, General Health, Vitality, Social Functioning, Role Emotional, and Mental Health, summarized into a Physical Health Component Score (PCS) and a Mental Health Component Score (MCS).<sup>20</sup> Scores range from 0 to 100 (higher scores means better health), with a mean of 50 and a standard deviation (SD) of 10 based on the US general population normative sample.<sup>20</sup> The SF-12v2 has well-established validity and reliability in cardiac populations<sup>21</sup> and has demonstrated responsiveness to change in patients with CHD.<sup>22</sup> Minimal clinically important difference benchmarks according to expert consensus are 5 points for Physical Functioning, General Health, and Mental Health, 6.25 for Role Physical and Vitality, 8.33 for Role Emotional, 10 for Bodily Pain, and 12.5 for Social Functioning domains,<sup>23</sup> two points for PCS and three for MCS.<sup>20</sup>

### Patient experiences

One trained male investigator external to the CR programme (DC) conducted the semi-structured interviews. All interviews were individual and occurred in-person in a private CR space, or via telephone or videoconferencing, and each lasted for about 30–45 min. A pilot-tested interview guide with open-ended questions was used to explore patient experiences of the programme they attended, particularly in relation to CR delivery format. The interview guide was based on observations and feedback from previous patients who had recently completed CR, who we have engaged in this study as consumer representatives or patient partners. These consumers contributed to the research design and preparation. Interviews were audiotaped and transcribed verbatim.

## Data analysis

### Statistical analysis

To summarize patient characteristics, descriptive statistics were used: frequency and percentage for categorical variables, and mean, SD, or median, interquartile range (IQR) for continuous variables. Only patients with paired HRQL data at CR entry and completion were analysed. Independent samples *t*-test and  $\chi^2$  test were used to compare baseline

variables, and paired *t*-tests to compare HRQL change scores (from CR entry to completion) for each delivery mode group. Given the differences in HRQL scores at CR entry between in-person and remote-delivered group, change scores from CR entry to completion were analysed for outcomes.

We used a General Linear Model (GLM), which simultaneously analyses several multiple linear regression models,<sup>24</sup> to determine differences in HRQL scores at completion between in-person and remote-delivered, adjusting for known confounders, specifically, baseline HRQL scores, age, sex, ethnicity, education, employment, family status, diagnosis, hospital LOS, and wait time. All data were analysed using IBM SPSS Statistics v26 (IBM Corp., Armonk, NY, USA). Statistical significance was set at  $P < 0.05$ .

A sample of 118 patients was required for the GLM analysis for change in HRQL with a medium effect size (0.15),  $\alpha$  of 0.05, power  $(1 - \beta)$  of 80% and 10 predictor variables: scores at CR entry, age, sex, ethnicity, education, employment, family status, diagnosis, hospital LOS, and wait time. Sample size was calculated using GPower v3.1.7. The data underlying this article are available in the article and in its online supplementary material.

### Qualitative analysis

Thematic analysis was used to examine patient experiences.<sup>25</sup> An inductive approach was used to explore the data and identify recurring patterns or concepts about the participants' experiences with their CR programme and the way it was delivered. Initial patterns were identified and coded manually, along with field notes, then the coded extracts were grouped and discussed with members of the research team to ensure that the properties of each theme clearly reflected their meaning. The relationships of the individual themes were further examined to ensure congruence between them. Qualitative participants are referred to by pseudonym.

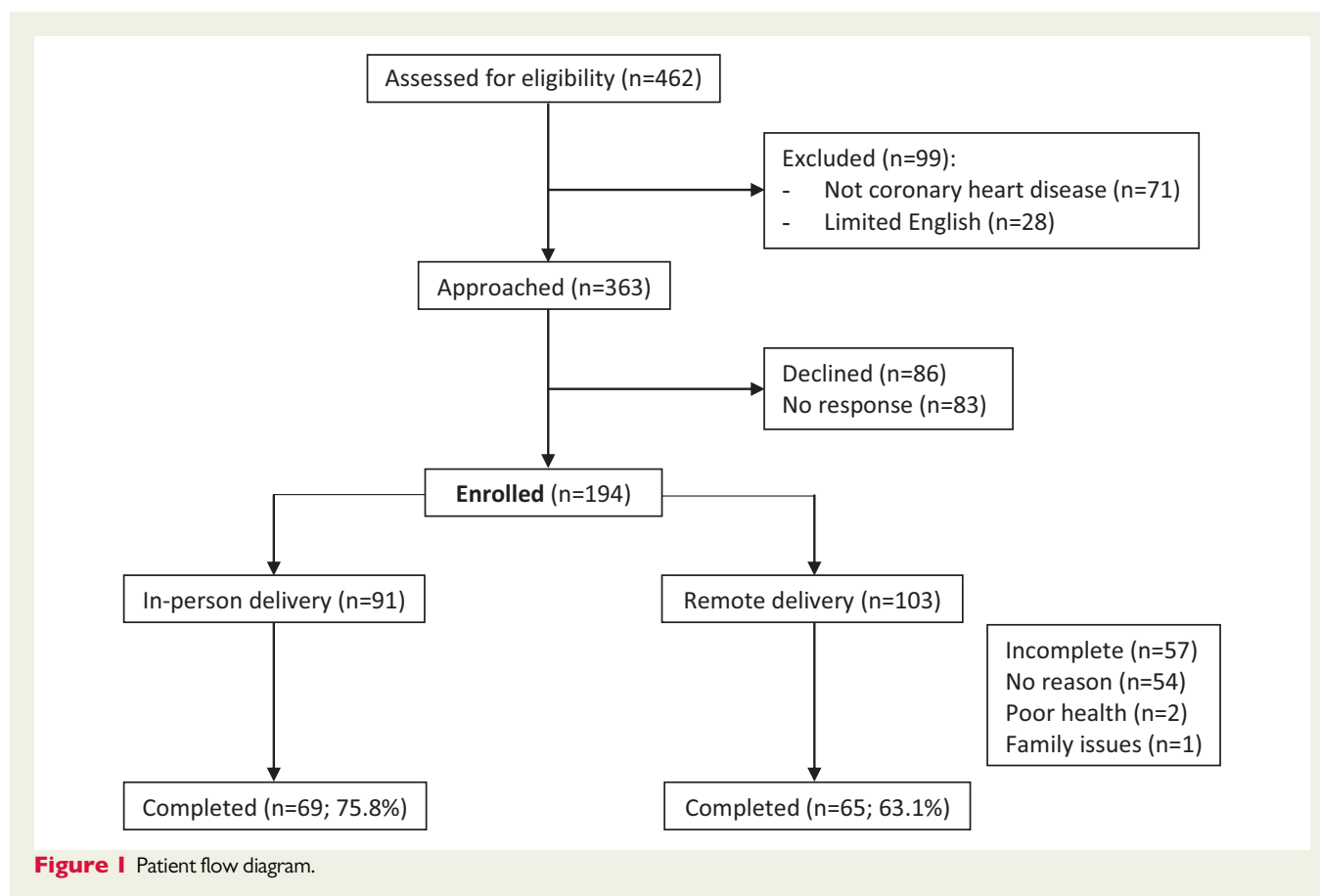
## Results

Of the 462 patients referred to CR, 194 were enrolled; the remainder did not meet the eligibility criteria ( $n = 99$ ), declined participation ( $n = 86$ ), or did not respond to the invitation ( $n = 83$ ) (Figure 1). Of the patients enrolled, 91 (46.9%) commenced in-person and 103 (53.1%) commenced remote-delivered CR.

### Sample characteristics

Patients had a mean age of 65.94 (SD 10.46) years and 80.9% were male (Table 1). The majority (80.0%) were married or had an intimate partner and 33.5% were employed full-time. Participants were White (76.4%) or from an ethnic minority background (23.6%) and university was the highest education level reached for 50.3%. Referral diagnosis included elective PCI (40.2%), CABG (26.3%) and MI (33.5%)—either with PCI (29.9%) or medically managed (3.6%). Cardiovascular disease risk factors were common, especially hypertension (98.5%) and hypercholesterolaemia (77.1%). The mean hospital LOS was 4.51 (SD 4.99) days.

Remote-delivered CR wait times were shorter than in-person by 11 days [median 14 (IQR 10–21) vs. 25 (IQR 16–38) days,  $P < 0.001$ ], but participation by ethnic minorities was much lower (13.6% vs. 35.2%,  $P < 0.001$ ). Overall programme completion rate was 69.1%, lower for remote-delivered CR than in-person (63.1% vs. 75.8%,  $P = 0.03$ ) (Figure 1).

**Table 1** Sample characteristics compared for delivery mode (N = 194)

Characteristic	In-person (n = 91)	Remote-delivered (n = 103)	P-value
	n (%)	n (%)	
Age, years (mean, $\pm$ SD)	65.45 ( $\pm$ 11.33)	66.37 ( $\pm$ 9.65)	0.54
Male	72 (79.1%)	85 (82.5%)	0.55
Ethnic minority	32 (35.2%)	14 (13.6%)	<0.001
Married/partnered	71 (78.0%)	85 (82.5%)	0.43
Education-University level	37 (40.7%)	55 (53.4%)	0.08
Employed	39 (42.9%)	44 (42.7%)	0.98
Primary reason for referral			
Elective PCI	32 (35.2%)	46 (44.7%)	0.30
Myocardial infarction $\pm$ PCI	31 (34.0%)	34 (33.0%)	
CABG	28 (30.8%)	23 (22.3%)	
Hospital LOS, days (mean, $\pm$ SD)	4.87 ( $\pm$ 4.63)	4.18 ( $\pm$ 5.29)	0.34
Wait time, days (median, IQR)	25 (16–38)	14 (10–21)	<0.001

CABG, coronary artery bypass graft; LOS, length of stay; PCI, percutaneous coronary intervention.

At CR entry, remote delivery participants had higher HRQL scores in all domains and summary scores compared to in-person CR (Table 2), with statistically significant mean differences (MDs) for General Health ( $P < 0.01$ ), Vitality ( $P = 0.04$ ), Role Emotional ( $P = 0.02$ ), Mental Health ( $P = 0.02$ ) domains, and MCS ( $P = 0.01$ ).

### Cardiac rehabilitation health-related quality of life outcomes compared for delivery modes

All HRQL domains and summary scores improved significantly from CR entry to completion for both groups, except for Role Emotional domain

**Table 2** HRQL scores at CR entry for in-person vs. remote-delivered CR (N = 194)

Outcome	In-person (n = 91)	Remote-delivered (n = 103)	P-value
	Mean ( $\pm$ SD)	Mean ( $\pm$ SD)	
PF	43.59 ( $\pm$ 10.70)	45.90 ( $\pm$ 9.83)	0.12
RP	48.15 ( $\pm$ 9.15)	50.11 ( $\pm$ 8.23)	0.12
BP	48.91 ( $\pm$ 9.07)	51.25 ( $\pm$ 8.88)	0.07
GH	47.07 ( $\pm$ 10.38)	51.50 ( $\pm$ 8.66)	0.001
VT	50.71 ( $\pm$ 7.97)	52.98 ( $\pm$ 7.46)	0.04
SF	46.43 ( $\pm$ 10.55)	49.13 ( $\pm$ 10.02)	0.07
RE	51.20 ( $\pm$ 8.95)	53.66 ( $\pm$ 5.19)	0.02
MH	50.57 ( $\pm$ 7.96)	53.18 ( $\pm$ 7.30)	0.02
<b>PCS</b>	45.25 ( $\pm$ 8.83)	47.76 ( $\pm$ 8.79)	0.05
<b>MCS</b>	51.86 ( $\pm$ 7.43)	54.38 ( $\pm$ 6.45)	0.01

BP, Bodily Pain; CR, cardiac rehabilitation; GH, General Health; MCS, Mental Health Component Score; MH, Mental Health; PCS, Physical Health Component Score; PF, Physical Functioning; RE, Role Emotional; RP, Role Physical; SF, Social Functioning; VT, Vitality.

**Table 3** Comparison of HRQL change scores (CR entry to completion) between in-person and remote-delivered (n = 194)

Outcome	In-person (n = 91)			Remote-delivered (n = 103)			Mean difference (95% CI) at completion, in-person vs. remote-delivered <sup>a</sup>	P-value
	Mean change	% change from entry (95% CI)	P-value	Mean change	% change from entry (95% CI)	P-value		
PF	6.96	16.05 (4.75–9.17)	<0.001	5.84	12.64 (3.58–8.10)	<0.001	−0.82 (−3.35, 1.71)	0.52
RP	6.01	12.60 (4.08–7.94)	<0.001	5.38	10.81 (3.18–7.59)	<0.001	0.15 (−1.78, 2.08)	0.88
BP	4.18	8.49 (2.16–6.20)	<0.001	3.69	7.27 (1.36–6.02)	0.002	−0.31 (−2.53, 1.91)	0.78
GH	3.20	6.84 (1.20–5.19)	0.002	3.49	6.81 (1.52–5.47)	0.001	1.69 (−0.78, 4.15)	0.18
VT	3.28	6.55 (1.03–5.52)	0.005	3.43	6.42 (1.56–5.30)	0.001	1.18 (−1.39, 3.76)	0.37
SF	3.61	7.81 (0.67–6.55)	0.02	3.91	8.05 (1.09–6.73)	0.007	2.14 (−1.24, 5.53)	0.21
RE	2.71	5.32 (0.99–4.43)	0.002	0.79	1.47 (−0.36–1.94)	0.18	−0.33 (−1.99, 1.33)	0.70
MH	2.83	5.66 (1.11–4.54)	0.002	3.74	6.98 (2.12–5.35)	<0.001	3.56 (1.28, 5.82)	0.002
<b>PCS</b>	6.11	13.51 (4.30–7.92)	<0.001	5.51	11.62 (3.45–7.56)	<0.001	−0.73 (−2.82, 1.36)	0.49
<b>MCS</b>	1.49	2.9 (−0.19–3.18)	0.08	1.59	2.91 (0.12–3.07)	0.03	2.37 (0.15, 4.58)	0.04

BP, Bodily Pain; CR, cardiac rehabilitation; GH, General Health; MCS, Mental Health Component Score; MH, Mental Health; PCS, Physical Health Component Score; PF, Physical Functioning; RE, Role Emotional; RP, Role Physical; SF, Social Functioning; VT, Vitality.

<sup>a</sup>Difference between groups at CR completion adjusted for scores at CR entry, age, sex, ethnicity, education, employment, family status, diagnosis, hospital length of stay, and wait time.

in the remote-delivered group (Table 3). After adjusting for potential confounders in the GLM (scores at CR entry, age, sex, ethnicity, education, employment, family status, diagnosis, hospital LOS, and wait time), the

HRQL scores at completion for remote-delivered CR were significantly higher than in-person for Mental Health domain [MD 3.56, 95% confidence interval (CI) 1.28, 5.82] and MCS (MD 2.37, 95% CI 0.15, 4.58). For

both delivery modes, the greatest improvements (>10% from CR entry to completion) occurred for Physical Functioning and Role Physical domains and PCS.

## Patient experiences for in-person and remote-delivered

Sixteen patients representing all recruiting sites, took part in the interview: in-person [ $n=9$  (6 males and 3 females)] and remote-delivered [ $n=7$  (5 males and 2 females)]. Participant ages ranged from 47 to 81 (mean 67) years.

Patient experiences of CR were positive overall with some evidence of differences in programme experiences. In-person delivery was appreciated because of the direct availability of the expert CR professional staff and the opportunity to interact with other cardiac patients; whereas patients appreciated remote delivery because it was easily accessible from the home that fitted into their lives and eliminated travel difficulties and the associated time demands.

In-person CR participants valued direct contact with expert staff while exercising. The staff could engage with patients through conversations and incidental interactions and answer questions as they arose.

*It was good to have them (CR staff) to be able to talk to, because they were there, freely available for us all to talk to if you needed. I thought that was probably the most valuable aspect. (Billie, 66, F, in-person)*

In contrast, three of seven remote delivery participants expressed the need for more guidance and closer supervision during exercise, particularly when trying to perform more challenging exercises.

*Well, because some of the exercises were quite difficult, I would have liked some more tuition... I did plenty of walking by myself. But as to the exercises, I wasn't really all that sure (if I was doing them correctly). (Milan, 75, M, remote)*

Participants who experienced the transition from in-person to remote delivery discussed corresponding contrast in experiences. Jack commented that while the emailed resources and follow-up coaching were helpful, remote delivery lacked the direct prompting and encouragement from the exercise professionals during exercise. Furthermore, while participants could set their own exercise intensity standards in remote delivery, they missed the direct motivation by staff to push themselves further.

*They gave me the programs, and they sent me the emails, they called me every now and then to see how I was doing, but it's not the same, it hasn't got the same intensity. Because you're actually calling the shots yourself. (Jack, 66, M, in-person)*

Furthermore, in-person group-based sessions were highly valued no matter how casual or incidental the interaction. Patients not only shared their understanding and experiences of their cardiac event or condition but also derived motivation and encouragement from each other.

*We were all there for the same reasons . . . I thought that when we had little discussions with the other people in the group to hear about their experiences, it was eye opening, and it was very good to share our experiences as well. We could encourage each other to work harder. (Drew, 81, F, in-person)*

On the other hand, participants receiving remote delivery highlighted that CR could be fitted into their lives given the direct home-based access versus the time and resources required for travel. Furthermore, contact with CR staff occurred at a time that is negotiated with the patients as opposed to the limited fixed session times available in-person, especially important when time was limited by other demands.

*It's convenient. I mean, like just now. I don't have to travel. I turn on the computer and I can start talking to you. If it was going to be on-site, then I have to be physically there . . . But this one, I was at the convenience of my home. (Owen, 73, M, remote)*

## Discussion

Our study demonstrated that remote-delivered CR not only achieves equivalent HRQL outcomes to in-person but also offers potential benefits for mental health aspects of HRQL and wait time. Patient experiences for both models were also generally positive with minimal differences, including advantages for exercise motivation and sharing experiences generated by in-person CR, and reduced travel and time burden and negotiated contact times in remote-delivered. These benefits are weighed against lower completion rates and lower participation by people from ethnic minorities.

While the overall equivalence in HRQL between groups was expected, the additional mental health gains were from remote-delivered CR were not. For instance, a meta-analysis by Huang et al.<sup>26</sup> indicated equivalent outcomes in all physical or mental score between telehealth interventions and centre-based CR. Maddison et al.<sup>8</sup> also demonstrated comparable HRQL outcomes in telerehabilitation vs. centre-based CR. Equivalent outcomes have also been demonstrated in other conditions such diabetes, wherein patients who undertook remote monitoring of physiological, symptom, and self-care behaviour data had equivalent HRQL benefits to those who did not.<sup>27</sup> Cardiac rehabilitation is a complex intervention with many interacting elements.<sup>28</sup> It is therefore difficult to pinpoint the active programme component/s, which could also differ for each patient's perspective. The additional benefits for mental health in remote delivery in our study may have been a consequence of pandemic-related isolation distress,<sup>29</sup> so remote-delivered patient communication may have been an effective and timely intervention as it was individualized. With one-on-one contacts, patients could potentially raise specific recovery concerns and be offered more personalized counselling and motivational support than in a group-based model.<sup>30</sup> Individualized and personal contact with expert professionals at regular and



patient-nominated times also meant that participation in these communication methods was more flexible and less burdensome than the in-person times. However, patients in our study also expressed that the facilitated or supervised in-person exercise produced specific physical functioning benefits, especially for those who needed closer guidance, direction, and encouragement. The group-based format of the exercises was also perceived to be valuable by patients because interacting with other people with similar experiences and common understandings of their condition enhances social support and fosters shared motivation to adopt a healthier lifestyle.<sup>31</sup> Therefore, remote-delivered CR proves to be a suitable alternative model for patients who are unable to participate in in-person programmes, particularly as other studies have demonstrated that low-risk patients could be safely managed without requiring ongoing biochemical evaluations.<sup>32</sup> Our study did not assess other important patient outcomes such as exercise capacity from remote-delivered programmes. Perhaps giving patients a choice of model to attend would be the ideal solution, and investigating patient outcomes from this should be a focus for further research.

Lower participation by ethnic minorities in remote-delivered CR programmes in our study is a concern because of under-utilization of CR is an already known problem in these populations.<sup>33</sup> Remote delivery addresses common barriers to CR participation by eliminating travel and reducing time demands, and caters to patient preferences by providing a programme that is accessible from the home at any time.<sup>34</sup> Remote delivery may also be appealing to known vulnerable groups such as older people and women, who may benefit from technology-based interventions where these methods are easy to use and adapted to their needs.<sup>35,36</sup> However, our results revealed that some groups such as patients from ethnic minorities may unintentionally be missing out, thus causing a paradox of reach and access. Barriers to CR utilization by ethnic minorities are complex, multi-level, and related to the individual, provider, and health system.<sup>33</sup> Of these barriers, poor proficiency in the CR delivered language is the most significant and crosses all levels.<sup>33,37</sup> Participants with significant language barriers may require the non-verbal signals from healthcare providers or seek direct clarification and additional information enabled by in-person contact.<sup>37</sup> In contrast, remote methods may create difficulties in perceiving non-verbal cues that help facilitate communication. Health and digital literacy and technological resource requirements of remote delivery may further complicate the engagement of ethnic minorities in remote methods of delivery.<sup>37</sup> Therefore, the specific needs, perceptions, and preferences of ethnic minorities in adopting remote methods of CR delivery should be explored to reduce health inequities.

Wait times were shorter by 11 days for remote delivery participants in our study. Early CR initiation in patients with CHD has been shown to improve objectively measured outcomes such as exercise capacity in in-person settings.<sup>38</sup> Shorter wait time to starting CR programmes also provides more opportunities for patients to achieve exercise benefits, and increases motivation to make lifestyle changes.<sup>38</sup> Wait time is influenced by multiple provider factors such as the availability of resources including capacity that influences class size, number of available classes, equipment, and staffing<sup>39</sup> but can also reflect patient readiness and capacity to attend.

Given patient discussions of enhanced exercise engagement with in-person and better mental health improvements in remote delivery participants, a hybrid or combination programme or providing them the choice of programme to attend may be the way forward to optimize outcomes.<sup>40</sup> Frederix *et al.*<sup>41</sup> compared a combination of in-person (6 weeks) and web-based exercise training and physical activity monitoring (6 months) to usual fully in-person programme (12 weeks), and found that the combination programme yielded better overall HRQL benefits than usual programme. However, it is important to note that the intervention they tested had a relatively longer duration than the CR programmes in our study and therefore may not be directly comparable. Implementing a hybrid programme poses challenges for existing services.<sup>40</sup> Cardiac rehabilitation is a complex intervention and changes to programme structure require redesign of existing service delivery processes including staffing, technology, and equipment requirements, as well as patient movement through the programme. Offering a combination of delivery methods with various effective components may enhance the outcomes from CR by catering to patients' needs, values, and preferences. Lastly, although evidence of cost-effectiveness of remote delivery exists,<sup>8,41</sup> the implementation in practice and the resources needed in relation to the number and frequency of contacts required remain unknown,<sup>42</sup> and warrant further investigation.

## Limitations

Although recruited from four sites, participants in this study came from one metropolitan Local Health District, therefore limiting the wider application of the results to CHD patients attending CR more generally. This study used an observational design, so cause and effect cannot be implied. The rapid move to remote delivery meant that careful planning and testing of remote interventions was less than ideal and not standardized, particularly during the acute transition phase. We also recognize that having hard endpoints such as  $VO_2$  max and a longer follow-up would have been ideal for this study. However, as reported previously, one of the goals of a remote-delivered programme is to limit unnecessary travel and patient burden. Furthermore, the ongoing government and organizational responses to the COVID-19 pandemic constrained patient physical contact. Our results give an initial insight with future research encouraged to address those issues. Lastly, we recognize that additional anthropometric, clinical, and pharmacological information would better characterize our sample population. However, the remote model used in the study did not involve direct physical contact, so these parameters could not be collected. While self-report may be used, there are many limitations to its accuracy. Future research and further development of remote-delivered programmes should address these challenges.

## Conclusion

Remote delivery of CR, despite rapid implementation enforced by the COVID-19 pandemic, achieved equivalent HRQL outcomes and even more mental health benefits and shorter wait times to in-person formats. Therefore, this study provides evidence that remote delivery is a reasonable alternative to in-person and represents an important option for patients and CR programmes to consider. Patients

identified specific and different advantages from both in-person and remote delivery. These attributes are potentially even more effective when methods are combined. Thus, a hybrid CR programme may be an approach for future evaluation. Further research is needed on the perceptions and preferences of cardiac patients from ethnic minorities, especially those with language barriers to ensure remote delivery can address their needs.

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