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ORIGINAL ARTICLE

Predictors of Cardiac Rehabilitation Attendance and Completion: Analysis of 33,055 Patients from the Queensland Cardiac Outcomes Registry (2020–2022)

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Aim Cardiac rehabilitation (CR) under-attendance presents a global challenge. The Queensland Cardiac Outcomes Registry is a comprehensive clinical registry that routinely collects point-of-care CR data. We aimed to determine whether demographic, clinical, psychosocial, and behavioural characteristics of the population vary between those who (i) declined, (ii) commenced but did not complete, and (iii) completed CR.

Methods The cohort comprised 33,055 patients referred to one of 56 Queensland CR services extracted from the Queensland Cardiac Outcomes Registry (2020–2022). Bivariate and multivariable logistic regression analyses were used to identify factors associated with CR non-attendance and non-completion.

Results Over the study period, 12,152 patients (37%) declined CR, 11,621 (35%) initiated but did not complete CR, and 9,282 (28%) completed CR. Significant predictors of CR non-attendance were aged ≥75 years (adjusted odds ratio [aOR] 1.51; 95% confidence interval [CI] 1.42–1.61), Indigenous status (aOR 1.65; 95% CI 1.50–1.81), living regionally (aOR 1.76; 95% CI 1.65–1.87) or remotely (aOR 2.33; 95% CI 1.92–2.82), and having arrhythmia (aOR 2.38; 95% CI 2.07–2.73), heart failure (aOR 1.54; 95% CI 1.37–1.74), non-ST-elevation myocardial infarction (aOR 1.30; 95% CI 1.21–1.40) or unstable angina (aOR 1.24; 95% CI 1.1.13–1.37). Significant predictors of CR non-completion were age <55 years (aOR 1.55; 95% CI 1.37–1.75), Indigenous status (aOR 1.60; 95% CI 1.29–1.98), living regionally (aOR 1.29; 95% CI 1.12–1.48), obesity (aOR 1.14; 95% CI 1.01–1.28), being a current (aOR 1.97; 95% CI 1.70–2.27) or former smoker (aOR:1.22, 95% CI 1.11–1.33) and having low social support (aOR 1.58; 95% CI 1.24–2.02).

Conclusion As one of the largest studies of CR participation to date, these findings can now be applied to develop targeted, co-designed initiatives to enhance CR participation, especially among First Nations populations, smokers, those with limited social support, people living regionally/remotely, patients with arrhythmia and heart failure, and those in varying age groups.

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Keywords Cardiac rehabilitation • Registry • Participation

Introduction

Cardiac rehabilitation (CR) is critical for the contemporary management of a range of cardiac conditions. However, CR attendance rates are frequently reported as low, particularly among patients at the highest risk of repeat events [1]. Due to a lack of secondary prevention service data collection systems in Australia, research on determinants of CR participation and completion has been limited. In recent years, states have actively worked towards developing more standardised approaches to collecting and reporting data [2] which has been supported by the development of national quality indicators [3]. Through data linkage, South Australia has provided the most recent and comprehensive analysis on CR utilisation to date; identifying reduced admissions and mortality in those who do attend and large gaps in referral of eligible patients [4].

The Queensland Cardiac Outcomes Registry (QCOR) was established by the Queensland Cardiac Clinical Network in 2012 and is renowned for its comprehensive cardiac service data. In the most recent annual report (2022), 56 public outpatient CR sites participated (95% of known public services) [5]. In-built data linkage across inpatient and outpatient cardiac settings across Queensland, in addition to readmission information, makes QCOR unique internationally [6].

Determining levels of CR uptake across the state of Queensland will assist policymakers, researchers and care providers in understanding where service access gaps exist and where new models of care (e.g., telehealth) may have the greatest impact. Therefore, the aim of this study was to determine whether demographic, clinical, psychosocial, and behavioural characteristics of the population vary between those who (i) declined CR, (ii) commenced but did not complete CR, and (iii) completed CR.

Methods

Governance

Approval of the protocol and de-identified QCOR data was provided by the Human Research Ethics Committee of The University of Queensland (HREC/2022/QMS/84592). Ethical guidelines were followed according to the National Statement on Ethical Conduct in Human Research (2007, updated 2018). Data access was obtained through the completion of a data access request to the Statewide Cardiac Clinical Informatics Unit with permission also obtained by the QCOR CR subcommittee and QCOR data custodian. The funding organisations (National Heart Foundation of Australia, and the National Health and Medical Research Council) had no role in the collection of data, its analysis and interpretation, or in the right to approve or disapprove the publication of the finished manuscript. The Strengthening the Reporting of Observational Studies in Epidemiology guidelines were used to report this study [7] with a checklist included in Supplementary Material 1.

Setting

Australian CR programs are guided by a framework developed by the National Heart Foundation of Australia and the Australian Cardiovascular Health and Rehabilitation Association core components [8]. Additionally, CR delivered from Queensland public facilities adheres to Clinical Standards documenting Queensland clinical and performance indicators [9]. CR programs are conducted in either hospital outpatient or community-based settings. Initial assessments can be undertaken via telephone or in person. Programs are generally multidisciplinary in nature and involve group-based exercise training guided by a trained clinician (e.g., physiotherapist or exercise physiologist) and a lifestyle education component. Programs typically run for 4–12 weeks in duration with the number and type of sessions attended aligned to patient goals [10]. Following CR, most ongoing care and management is provided by a patient's general practitioner.

Design and Data Source

QCOR is a web-based clinical registry and quality program that commenced in 2012 (with the CR module added in 2017) and is funded by Queensland Health (the statewide health service). QCOR collects point-of-care clinical and operational data through direct entry systems including data on cardiac interventions, surgery, CR, heart failure, electrophysiology and pacing, and structural heart and cardiac outreach programs. Data collection is a blend of clinician-entered data (via the QCOR web portal) along with various data linkage activities across the various QCOR modules. All Queensland Health referrals to CR programs (n=56) occur electronically prior to or close to hospital discharge. Non-Queensland Health referrals are manually entered into QCOR upon receipt. Patient-reported outcome measures, clinical investigations and functional measures are recorded at the initial and post-program assessment. The Statewide Cardiac Clinical Informatics Unit performs data quality audits and analysis functions and maintains the registry data collections and applications. Additional details on the development of QCOR have been previously published [11] and annual reports are available online [12].

Participants

Adult patients (aged ≥18–100 years) referred to one of the 56 Queensland public CR programs between 1 January 2020 and 31 December 2022 were included. The referred population included those with ST-elevation myocardial infarction (STEMI), non-STEMI (NSTEMI), unstable angina, arrhythmia,

congestive heart failure, valve disease, stable angina and 'other' (e.g., elective admissions, cardiomyopathy, pericarditis).

Procedure

Patients are typically introduced and invited to attend CR at or shortly after hospital discharge. The initial pre-assessment session is completed either in person or by telephone. Where possible, reasons for declining are captured within QCOR. Participants complete a post-assessment report at the completion of CR. During the study period, the number of CR sessions attended was not collected within QCOR. Patients who died between hospital discharge and referral to CR were excluded from the study.

Measures

Primary outcome variables

'Declined CR' was defined as not undertaking the pre-assessment. 'Commenced CR' was defined as participation in the initial pre-assessment session. 'Completed CR' was defined as the submission of a post-assessment report.

Covariates

The following sociodemographic, clinical, psychosocial, and behavioural variables were included as covariates:

- *Sociodemographic* characteristics assessed were age (grouped into <55, 55–64, 65–74 and ≥75 years), sex (male/female), interpreter required (yes/no), Indigenous status (Indigenous including Aboriginal, Torres Strait Islander or both/non-Indigenous), workforce status (employed at time of event/not in the workforce including those retired, on the pension or home duties), geographic location (major city, inner regional, outer regional, remote, very remote) based on the Australian Statistical Geography Standard classifications [13] and derived from patient home postcode.
- *Clinical variables:* Classification of a principal cardiac event in QCOR is based on the International Classification of Diseases, Tenth Revision-Australian Modification diagnosis coding [14] and includes STEMI, NSTEMI, unstable angina, arrhythmia, congestive heart failure, valve disease, stable angina or other. Procedure information captures the most recent cardiac procedures which are recorded at the time of referral and includes percutaneous coronary intervention, coronary artery bypass graft surgery, valve replacement or repairs, and insertion of cardiovascular implantable electronic devices (including permanent pacemakers, cardiac resynchronisation therapy pacemakers, and implantable cardioverter defibrillators).
- *Psychosocial risk factors* were collected at the time of CR pre-assessment and, as such, are only available for those who commenced CR. Psychosocial risk factors included history of depression (yes/no to the question "Do you have a history of depression"), symptoms of anxiety and/or depression (as per the 4-item Patient Health Questionnaire [PHQ-4] [15] anxiety and depression screener), depression at pre-assessment (none, mild, moderate, severe) as per the 9-item PHQ (PHQ-9) [16], anxiety at pre-assessment (none, mild, moderate, severe) as per the 7-item Generalised Anxiety Disorder (GAD-7) [17] and social support (yes/no to the question "Do you feel supported, either by a family member or other social support person?"). GAD-7 and PHQ-9 were administered only to those who screened positively on the PHQ-4.
- *Behavioural risk factors* included cigarette smoking ('current': within 30 days of cardiac event, 'former': greater than 30 days prior to the event, and 'never'), physical activity at the time of the event as self-reported by the patient ('sufficiently active': report activity levels greater than the recommended guidelines for their age, 'insufficiently active': lower levels than recommended guidelines, 'inactive': no physical activity other than activities of daily living) [18], and body mass index (BMI) derived from height and weight collected at pre/post-assessments (recategorised into underweight/healthy [BMI 15–24.99], overweight [BMI 25–29.99], obese [BMI 30–60]).
- *Year:* The year of CR referral (2020, 2021, 2022) was also included as services had variable impacts due to the COVID-19 pandemic.

Statistical Analysis

Continuous variables were presented as means and standard deviations (SD) and categorical variables as numbers and percentages. Pearson chi-square tests were used to compare the characteristics of those who declined CR, commenced CR but did not complete, and completed CR. Adjusted residuals were inspected to identify significant differences between groups (residual >1.96). Unadjusted (bivariate) and multivariable logistic regression analyses were used to identify factors associated with CR commencement and CR completion. The selection of items for inclusion in the multivariable logistic regression analyses was based on both statistical and conceptual importance. In selecting variables to be included on *statistical* grounds, predictors with p-value ≤0.2 rather than p-value ≤0.05 were included in the multivariable analysis to reduce omitted-variable bias. Variables included on *conceptual* grounds were symptoms of anxiety and depression, based on PHQ-4 as per evidence determining that anxiety and depression are risk factors for poor prognosis among cardiac patients and impact participation [19,20]. We excluded cardiac procedures (e.g., percutaneous coronary intervention) from the main regression analyses because of collinearity with diagnosis and inclusion resulted in poor model fit. For each logistic regression analysis, adjusted odds ratios (aORs) and 95% confidence intervals (CIs) were estimated and reported. The Hosmer–Lemeshow test was used to check the model goodness of fit. A complete case analysis was performed as there was minimal missing data (<3.5% on any variable) [21]. All analyses were conducted with SPSS (version 28.0, IBM Corporation, Armonk, NY, USA) and Stata (version 18.0, StataCorp, TX, USA). A two-sided probability test was used for all statistical tests with significance levels set at $p<0.05$.

Results

Cohort Characteristics

The QCOR cohort comprised 33,055 patients from 56 CR programs during the study period. Of these, 12,152 (37%) declined CR, 11,621 (35%) commenced but did not complete CR (i.e., completed a pre-assessment but did not complete a post-assessment), and 9,282 (28%) completed CR (i.e., completed a post-assessment). A total of 101 patients died between hospital discharge and referral to CR and were excluded from the analysis. Missing data for the main outcome variables is reported in Supplementary Table 1. Patients' ages ranged from 18–100 years, with a mean (SD) of 65 (12.32). Other characteristics of the sample are presented in Table 1. As shown, the majority of patients were male (69%), approximately two-thirds were not in the paid workforce (63%), and approximately half resided in a major city (52%). These unadjusted results indicate multiple differences in the sociodemographic, clinical, psychosocial, and behavioural risk factors between those who declined CR, commenced but did not complete CR and completed CR.

Predictors of CR Non-Attendance

Figure 1 presents the results of the multivariable logistic regression assessing factors associated with CR non-attendance (i.e., those who declined vs completed an initial assessment) showing adjusted odds ratios. The strongest predictors of CR non-attendance were having a diagnosis of arrythmia (aOR 2.38; 95% CI 2.07–2.73) or heart failure (aOR 1.54; 95% CI 1.37–1.74), living remotely (aOR 2.33; 95% CI 1.92–2.82), or outer regionally (aOR 1.76; 95% CI 1.65–1.87), being Indigenous (aOR 1.65; 95% CI 1.50–1.81), and those aged over 75 years (aOR 1.51; 95% CI 1.42–1.61). As the study timeframe included periods of COVID-19-related restrictions, we included the year of referral as a separate variable. More patients were willing to attend CR in 2021 and 2022 compared to 2020 (aOR 0.88; 95% CI 0.83–0.93).

Reasons patients did not commence CR are depicted in Figure 2. The main reasons included: (1) patient declined (28%) (reasons provided included electing to self-manage, excessive travel, family commitments, no available transport and unsuitable program delivery times); (2) the patient is clinically unstable/inappropriate (21%); or (3) an inability to contact the patient/or patient failed to attend (14%).

Predictors of CR Non-Completion

As presented in Figure 3 the most significant predictors of CR non-completion included being a current (aOR 1.97; 95% CI 1.70–2.27) or former smoker (aOR 1.22; 95% CI 1.11–1.33), Indigenous status (aOR 1.60; 95% CI 1.29–1.98), having low social support (aOR 1.58; 95% CI 1.24–2.02), age <55 years (aOR 1.55; 95% CI 1.37–1.75), living regionally (aOR 1.29; 95% CI 1.12–1.48) and obesity (aOR 1.14; 95% CI 1.01–1.28). Regarding geographic location, while only the outer regional group varied significantly from others in the adjusted model, there was a trend for increasing effect size the more remote a patient lived, except for the very remote group which showed completion rates more akin to the regional subgroups. Similarly, there was a dose effect for anxiety and depression, with higher PHQ-4 scores showing larger albeit non-significant effect sizes for non-completion.

Subsidiary analyses of the regression models with procedures included instead of diagnoses are presented in Supplementary Table 2 (for non-attendance) and Supplementary Table 3 (for CR non-completion). These models had poorer model fit than the models presented in Figures 1 and 3. For completeness, these Supplementary Tables also provide the unadjusted ORs. Noteworthy variables that were significant in the unadjusted model for CR non-attendance but lost significance in the full model include female sex (OR 1.17; 1.11–1.22) and inner regional location (OR 1.14; 1.08–1.22) (Supplementary Table 2). Female sex was also a predictor of CR non-completion in the unadjusted model (OR 1.15; 1.07–1.22) as was anxiety (OR 1.45; 1.27–1.66) (Supplementary Table 3).

Discussion

In the current sample of >33,000 eligible patients referred to public CR services across Queensland, two-thirds (63%) commenced CR. Of those who commenced CR, 44% completed. Those who declined CR were more likely to be older (>75 years), Indigenous, living regionally or remotely and with arrhythmia or heart failure. Non-completers were more likely to be younger (<55 years), Indigenous, living regionally, obese, current or former smokers and to have low levels of social support.

Compared to a recent analysis of registry data in South Australia [4], the rate of CR commencement for those referred was much higher in the present Queensland cohort (63% vs 37%). Peters et al. [22] also reported a similar commencement rate to South Australia of 32%–39%, which is in line with other published rates internationally. The definition of commencement used in the present study (completing the pre-assessment) is comparable with other studies. However, a key difference in Queensland is the use of an electronic system (QCOR) for referral, quality incentives payments for timely referral and assessment during the early stages of QCOR use (2017–2018) and the employment of a dedicated professional to support quality improvement and data entry [11]. If a patient decides not to attend a CR program, the assessor provides an important service including a brief intervention and linkage to appropriate primary health care with options for re-referral if desired. Additionally, telehealth offerings are potentially a critical option for initial contact with patients, providing an opportunity for brief interventions and linkages to support for those who do not wish to attend in-person CR programs.

The CR completion rate in the present study (44%) was lower than the South Australian cohort (78%—which is very high internationally) [4]. In some instances, this may also be due to the model of care provided and gaps in completing post-assessments (given that the definition of completion did

Table 1 Characteristics of those who declined, commenced, and completed CR.

Variable	Total n=33,055	Declined CR n=12,152, n (%)	Commenced CR n=11,621, n (%)	Completed CR n=9,282, n (%)	p-value
Sociodemographic					
Sex					<0.001
Male	22,938	8,180 (36)[a]	8,038 (35)	6,720 (29)[a]	
Female	10,115	3,970 (39)[a]	3,583 (35)	2,562 (25)[a]	
Age group (yrs)					<0.001
<55	6,846	2,460 (36)	2,675 (39)[a]	1,711 (25)[a]	
55–64	8,704	2,897 (33)	3,206 (37)[a]	2,601 (30)[a]	
65–74	10,115	3,519 (35)[a]	3,379 (33)[a]	3,217 (32)[a]	
≥75	7,352	3,251 (44)[a]	2,352 (32)[a]	1,749 (24)[a]	
Interpreter required					0.748
Yes	199	77 (39)	65 (32)	57 (29)	
No	32,856	12,075 (37)	11,556 (35)	9,225 (28)	
Indigenous status					<0.001
Indigenous	2,348	1,163 (50)[a]	852 (36)	333 (14)[a]	
Non-Indigenous	29,526	10,606 (36)[a]	10,438 (35)	8,482 (29)[a]	
Workforce status					0.015
Employed	6,899	-	3,936 (59)[a]	2,963 (43)[a]	
Not in workforce	11,608	-	6,834 (59)[a]	4774 (41)[a]	
Geographic location					<0.001
Major city	17,166	5,672 (33)[a]	6,371 (37)[a]	5,166 (30)[a]	
Inner regional	8,578	3,070 (36)	2,902 (34)[a]	2,605 (30)[a]	
Outer regional	5,954	2,842 (48)[a]	1,853 (31)[a]	1,277 (21)[a]	
Remote	463	259 (56)[a]	114 (25)[a]	90 (19)[a]	
Very remote	770	283 (37)	359 (47)[a]	128 (17)[a]	
Clinical					
Primary diagnosis					<0.001
STEMI	5,488	1,647 (30)[a]	2,140 (39)[a]	1,717 (31)[a]	
NSTEMI	9,862	3,577 (36)	3,538 (36)	2,747 (28)	
Unstable angina	2,839	1,017 (35)	1,052 (37)	773 (27)	
Arrhythmia	1,081	575 (53)[a]	325 (30)[a]	181 (17)[a]	
Valvular disease	2,375	779 (33)[a]	881 (37)	715 (30)	
CHF	1,594	651 (41)[a]	536 (33)	407 (26)	
Stable angina	2,148	656 (31)[a]	784 (36)	708 (33)[a]	
Other[b]	7,668	3,269 (43)[a]	2,365 (31)[a]	2,034 (27)[a]	
Most recent procedure					
CABG	4,361	90 (21)[a]	1,767 (41)[a]	1,694 (39)[a]	<0.001
PCI	11,775	3,260 (28)[a]	4,754 (40)[a]	3,761 (32)[a]	<0.001
CIED	800	357 (45)[a]	294 (37)	149 (19)[a]	<0.001
Valve repair	2,955	807 (27)[a]	1,207 (41)[a]	941 (32)[a]	<0.001
Psychosocial and behavioural risk factors					
History of depression					0.001
Yes	5,189	-	3,116 (60)[a]	2,073 (40)[a]	
No	13,318	-	7,654 (58)[a]	5,664 (43)[a]	
Symptoms of anxiety or depression[c]					0.010
None	12,710	-	6,451 (51)	6,259 (49)	
Mild	1,173	-	1,173 (49)	1,222 (51)	
Moderate	840	-	447 (53)	393 (47)	
Severe	435	-	247 (57)[a]	188 (43)[a]	
Depression at pre-assessment[d]					0.334
Yes	1,125	-	590 (52)	535 (48)	
No	14,365	-	7,319 (51)	7,046 (49)	

Table 1. (continued).

Variable	Total n=33,055	Declined CR n=12,152, n (%)	Commenced CR n=11,621, n (%)	Completed CR n=9,282, n (%)	p-value
Anxiety at pre-assessment[e]					<0.001
Yes	1,004	-	577 (58)[a]	427 (43)[a]	
No	13,961	-	7,121 (51)[a]	6,840 (49)[a]	
Social support					<0.001
Yes	17,923	-	10,379 (58)[a]	7,544 (42)[a]	
No	584	-	391 (67)[a]	193 (33)[a]	
Smoking status					<0.001
Current	2,311	-	1,626 (70)[a]	685 (30)[a]	
Former	8,819	-	5,072 (58)	3,747 (42)	
Never	7,377	-	4,072 (55)[a]	3,305 (45)[a]	
Physical activity levels					<0.001
Sufficiently active	6,907	-	4,012 (58)	2,895 (42)	
Insufficiently active	7,986	-	4,472 (56)[a]	3,514 (44)[a]	
Inactive	3,614	-	2,286 (63)[a]	1,328 (37)[a]	
BMI					<0.001
Underweight/healthy	2,522	-	1,095 (43)[a]	1,427 (57)[a]	
Overweight	4,604	-	2,017 (44)[a]	2,587 (56)[a]	
Obese	5,256	-	2,525 (48)[a]	2,731 (52)[a]	
Year referred					<0.001
2020	11,741	4,564 (39)[a]	4,163 (36)	3,014 (26)[a]	
2021	11,411	4,074 (36)[a]	4,204 (37)[a]	3,133 (28)	
2022	9,903	3,514 (36)[a]	3,254 (33)[a]	3,135 (32)[a]	

Note. Statistical test=chi-square.

[a]Cells associated with adjusted residuals greater than ≥1.96 (a=0.05)

[b]"Other" included diagnoses not otherwise classified such as elective admissions, cardiomyopathy, and pericarditis.

[c]Symptoms of anxiety and depression based on Patient Health Questionnaire (PHQ)-4 scores.

[d]Depression determined as score ≥10 on PHQ-9.

[e]Anxiety determined as score ≥10 on the Generalised Anxiety Disorder-7 assessment.

Abbreviations: CR, cardiac rehabilitation; STEMI, ST-elevation myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction; CHF, congestive heart failure; CABG, coronary artery bypass graft; CIED, cardiovascular implantable electronic devices including permanent pacemakers, cardiac resynchronisation therapy pacemakers, and implantable cardioverter defibrillator; PCI, percutaneous coronary intervention; BMI body mass index.

not include the number or percentage of sessions completed). For example, home-based care options are typically less likely to result in post-assessments. From 2023 onwards, QCOR has been collecting the number of sessions attended and model of care data, so greater exploration of this will be possible in future studies. Internationally, completion rates vary, and program lengths are often much longer than the 6–12 sessions provided in Australia. For example, completion rates of 27% have been reported in the United States but programs are >36 sessions [23].

Regarding diagnosis, the present study highlights large gaps for the arrhythmia population—the strongest predictor of CR non-attendance (aOR 2.38; 95% CI 2.07–2.73). This patient cohort also displayed a trend towards non-completion (although not significant in the adjusted model). This cohort is less likely to be acutely unwell—potentially reducing the desire to attend CR. Australian [24] and international guidelines [25] for atrial fibrillation recommend integrated, patient-centred management via a coordinated multidisciplinary team [25]. To achieve this, individualised risk-factor management (as demonstrated in foundational studies) may be preferable than group-based programs, however, this warrants further investigation. A diagnosis of heart failure was also a predictor of CR non-attendance. These data do show that heart failure patients are being referred to CR which is the primary barrier to attendance in this population reported in the literature [26]. Queensland also has 23 heart failure-specific support services and heart failure patients who decline CR may potentially take up these services instead [27].

To the best of our knowledge, this is the first Australian study of CR participation to include Indigenous status within the analysis. First Nations patients were significantly less likely to participate in CR (i.e., more likely to decline and, for those who did attend, significantly less likely to complete).

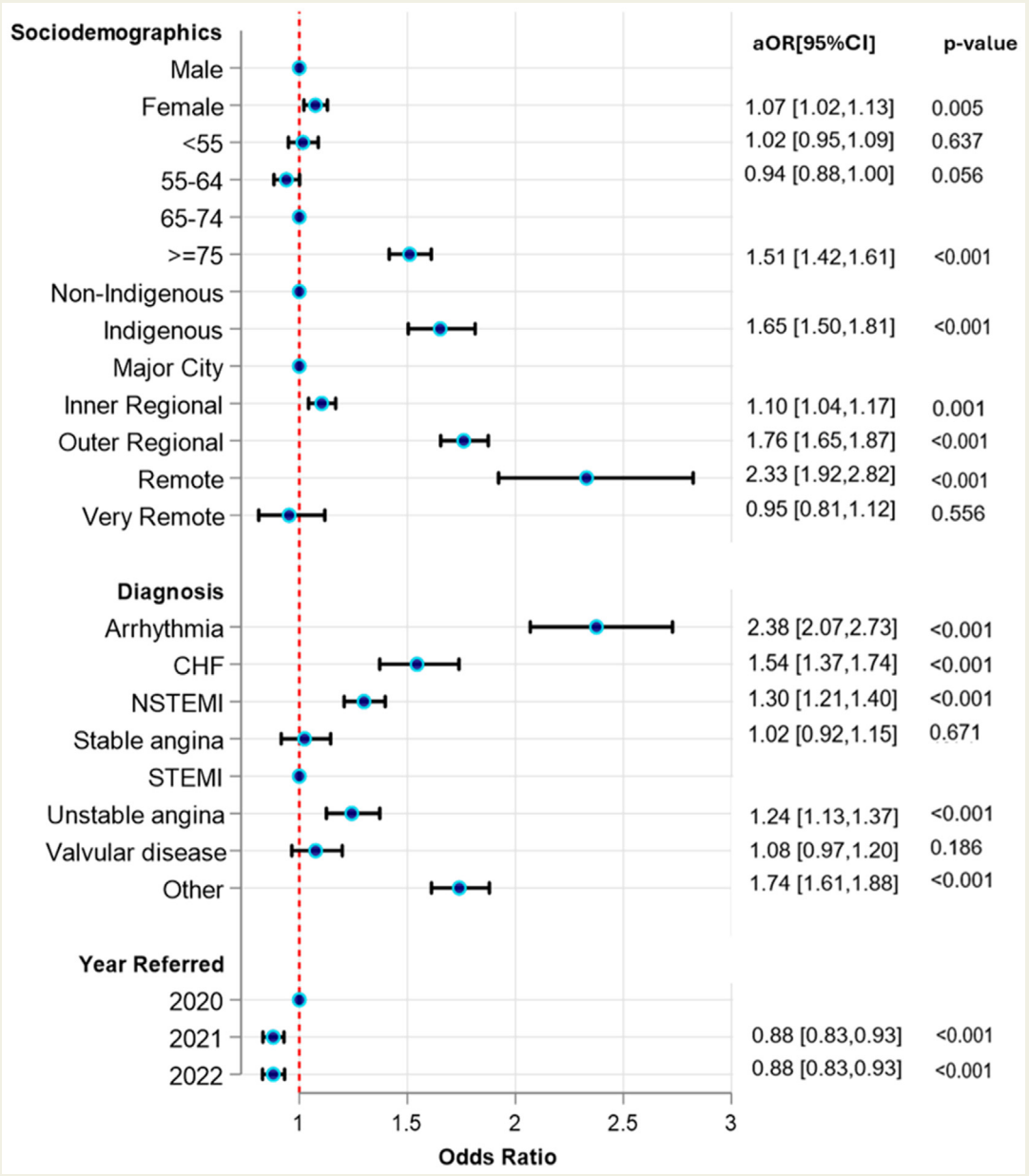

Figure 1 Multivariable analysis of predictors of cardiac rehabilitation non-attendance (n=31,722). 95% confidence intervals in brackets.
Abbreviations: aOR, adjusted odds ratio; CHF, congestive heart failure; CI, confidence interval; NSTEMI, non-ST-elevation myocardial infarction; STEMI, ST-elevation myocardial infarction.

As cardiovascular disease is a leading cause of death for Indigenous Australians and the leading cause of the gap in death rates between Indigenous and non-Indigenous patients, finding culturally appropriate ways to enhance engagement with secondary prevention care is critical [28]. Agreed measures to enhance cardiac care and coordination among First Nations populations have been developed and are reported annually at the Australian National Better Cardiac Care for Aboriginal and Torres Strait Islander People Forum [29]. Using these agreed approaches, a recently published study has shown promising results in enhancing cardiovascular outcomes among Indigenous patients using a dedicated, culturally informed model of care targeting access, education, and care transitions within an Australian hospital setting [30]. Aboriginal Medical Service-based CR has also been shown to be feasible, well-attended and to decrease cardiovascular risk [31]. Wider implementation of such models of care is required.

Our results show an interesting trend regarding geographic location. Largely, those living further from metropolitan areas were more likely to decline and less likely to complete CR. However, those living in *very remote*

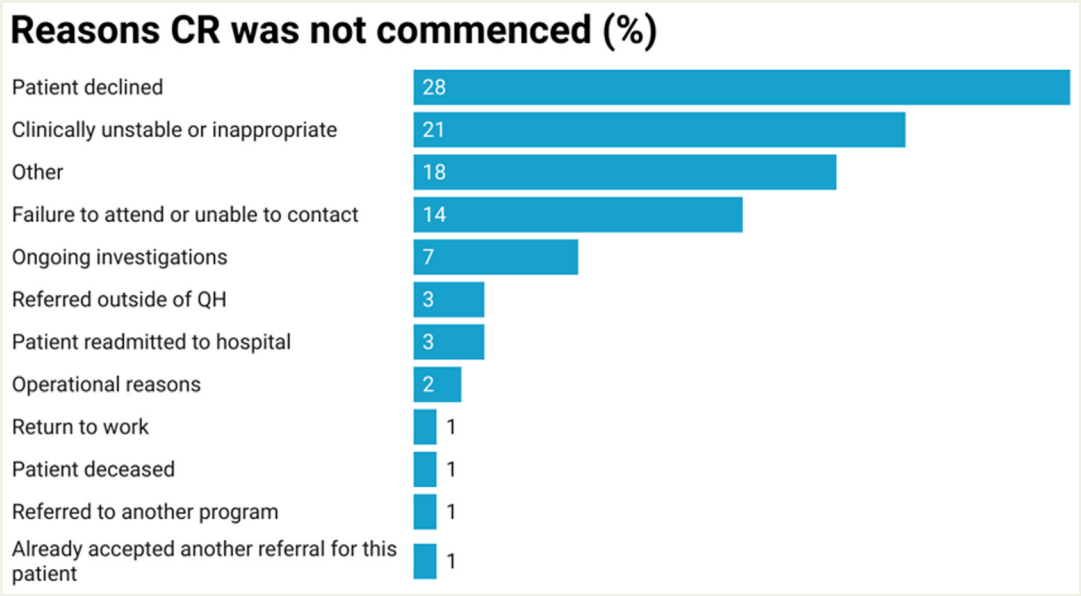

Figure 2 Reasons CR was not commenced with percent of declined assessments. Total n=12,164 including those removed from the main analysis such as those due to death.
Abbreviations: CR, cardiac rehabilitation; QH, Queensland Health.

locations were less likely to decline than their metropolitan counterparts. There was also wide variability in this subgroup in relation to completion rates. Again, telehealth is likely to be a factor in these results. In Queensland, the Self-Management of Chronic Conditions service delivers the Coach Program [32] entirely via telephone and has a specific focus on rural and remote areas. Potentially, this phone-based service has enabled this cohort to access secondary prevention care—and when provided with the opportunity, this cohort appears very willing to engage and participate. Indigenous Australians living in remote areas also report higher rates of cardiovascular disease [28] than those living in non-remote areas. Therefore, culturally informed options also need to be able to be delivered across geographic locations, including remote locations. Mobile health interventions are increasingly being shown to be feasible and acceptable within Indigenous populations when culturally relevant and accounting for digital and health literacy [33].

In regard to individual risk factors, age (both younger and older), smoking status and social support were key factors influencing engagement and participation in CR. Older age has been widely reported as a factor associated with non-participation in CR [34]. It has also been shown in other states of Australia that older patients are also less likely to be referred [35]. In the present study, older patients who did attend often completed. Therefore, greater support and encouragement to attend is likely required. Younger age has also been reported as a factor associated with CR dropout [34]. Flexible, out-of-hours sessions are important for those within this cohort who have returned to paid employment.

Being female had a small significant effect on non-attendance but was not retained in the adjusted model predicting CR completion. Female sex has traditionally been associated with lower referral and attendance—with up to four times higher odds of non-participation [34]. Pleasingly this was not observed in the present study. This may be due to increased awareness of the prevalence of cardiovascular disease in women. Continuing to support participation among women is important. Women-only programs, having exercise options for women (i.e., Yoga programs [36]) or the option to undertake CR at home [37], may be beneficial [38].

Being a smoker is a well-documented predictor of CR non-attendance and non-completion [34]. Smoking increases mortality over the long term, so it is critical that smokers are encouraged and supported to undertake CR (with endorsement from their cardiologist and encouragement from staff prior to hospital discharge) to enhance participation in this high-risk group [39]. Low practical and social support have also been previously identified as factors associated with non-participation [34]. This is an area that requires greater testing of innovative solutions, especially for isolated patients who typically complete CR programs remotely. Digital solutions [40,41] are beginning to be explored to provide patients with remote peer support which is important as peer support is often cited by patients as a key part of a CR program.

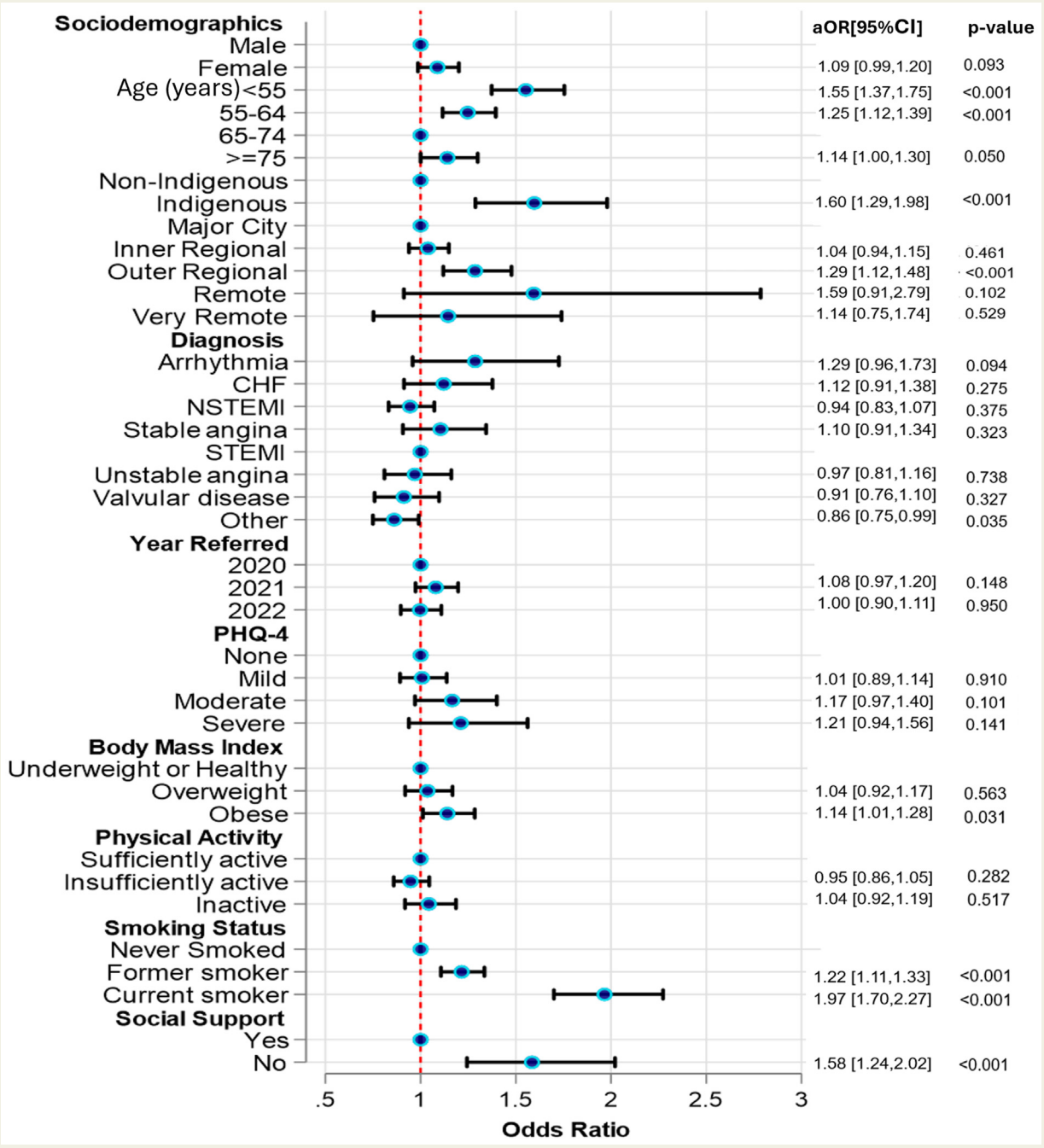

Figure 3 Multivariable analysis of predictors of non-completion of cardiac rehabilitation (n=9,336). 95% confidence intervals in brackets.
Abbreviations: aOR, adjusted odds ratio; CHF, congestive heart failure; CI, confidence interval; NSTEMI, non-ST-elevation myocardial infarction; PHQ-4, Patient Health Questionnaire 4; STEMI, ST-elevation myocardial infarction.

Overall, the present data provide an important overview of who is and is not accessing secondary prevention services in Queensland. As countries face ageing populations with growing rates of hospital readmissions due to cardiovascular disease, it is critical to understand how patients can be supported to manage their cardiac condition and prevent future events. Currently, a picture of the comprehensive cardiac patient journey is only provided in two Australian states (Queensland and South Australia). However, there is momentum and recent important funding to facilitate all Australian states and territories towards the collection and reporting of national standardised data.

Strengths and Limitations

This study is strengthened by the large data size capturing services from across the state of Queensland. These data may

not be generalisable to other jurisdictions. However, they provide important data to guide quality improvements. Further, private CR services are not captured within QCOR currently. Additionally, we were unable to report on the overall number of cardiac events across the state and hence the percentage of eligible cardiac conditions referred to CR due to challenges with accurately determining the denominator; this is an active area of work within QCOR. Similarly, as this is real-world data and those who decline CR do not complete an initial assessment, we are unable to report on the psychosocial and behavioural risk factors of non-attenders. We also did not have access to data regarding those who had completed CR previously which may be an additional reason for declining. Further, as these data are collected from 56 services it is impossible to know exactly how CR is introduced at each site. There is likely wide variation. However, all services are encouraged to refer within 2 calendar days and have patients enrolled within 28 calendar days (as per Australian quality indicators). The definition of CR completion used for this study may differ from others. Without access to CR session attendance, CR completion was defined as patients who had completed a post-assessment. Some Australian studies define completion as attendance at >70% of available CR sessions [42], however, this was not possible in the present study. Future QCOR data will collect more information on the number of sessions attended, enabling greater analysis of CR 'dose' in the future.

Conclusions

This is one of the largest studies of CR attendance undertaken to date. The QCOR registry provides a unique opportunity to apply a data-driven approach to enhancing CR uptake, access and equity. These findings can now be applied to develop tailored, co-designed initiatives to enhance CR participation, especially among First Nations populations, smokers, those with limited social support, people living regionally and remotely, patients with arrhythmia, and those in the youngest and eldest age groups.

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Author Contributions

The authors confirm their contribution to the paper as follows: study conception and design: E.E.T., M.L.G., S.P., B.M.; analysis and interpretation of results: All authors; draft manuscript preparation: E.E.T., M.L.G., B.M., S.P., S.C. All authors reviewed the results and approved the final version of the manuscript.

Data Availability

The data underlying this article cannot be shared publicly due to ethics requirements. The data can be accessed via a reasonable request to the Queensland Cardiac Outcomes Registry.

Appendices

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.hlc.2024.08.002

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